Lesson 1 Overview

This lesson covers the basics of what climate and weather are. It also addresses why multi-year datasets are important in climate study. As always, when looking at data represented in graphs, make sure the students know the meaning of the x-y axes. Another theme we'll be examining throughout this week is signal vs. noise, to help students understand how to determine when an apparent trend is real.

If you want to start with some more basic activities relating to taking temperature and the concept of "average temperature," see the Climate Lab "Long Curriculum," which is available on the project website.

Key Ideas

- **Activity 1: Introduction to Signal vs. Noise**

  This is part one of a five-part activity series on this subject — there's one short activity in each lesson — so it's designed to start the students thinking about the ideas, and build towards a better understanding of the signal and noise in a dataset; it also connects to the process of data analysis. This activity in particular is the first half of a two-part activity, the second half being the Signal vs. Noise activity at the beginning of Lesson 5.

- **Activity 2: Overview of weather and climate**

  This activity should give students a basic understanding of the importance of datasets that cover a long period of time, when trying to see what's going on in a region's climate.

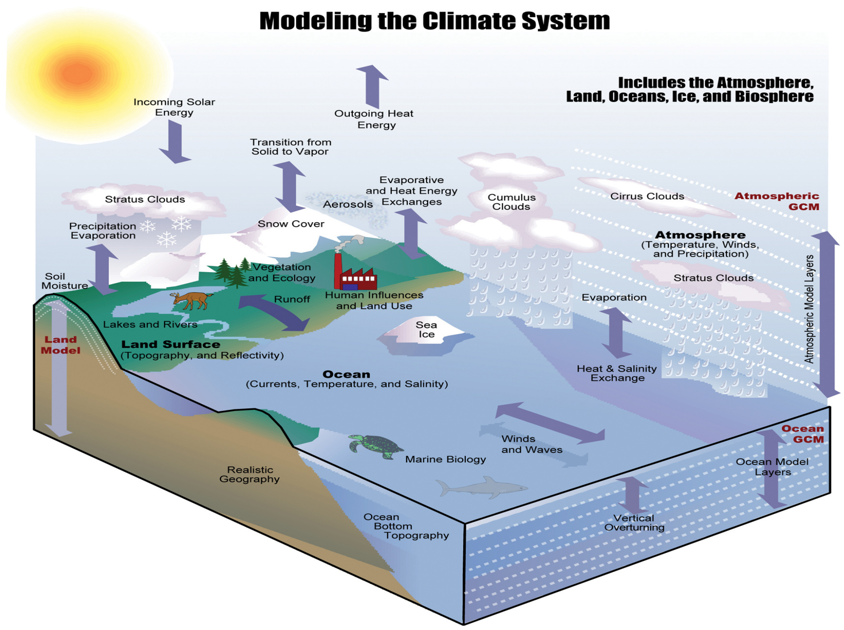
- **Activity 3: Temperature and Transpiration**

  This activity gives a short overview of what transpiration is, and looks into how the rise in temperature in Activity 2 might affect plant life.

Materials

- Student sheets
- Projector
- Computer

Students should be prepared to take notes, either in a paper journal or on a computer. These activities include individual work, small-ground work, and whole-class discussion. For convenience, you can divide your class into groups of 3-5 students.at the start.


Modeling the Climate System
Includes the Atmosphere, Land, Oceans, Ice, and Biosphere
Incoming Solar Energy
Outgoing Heat Energy
Transition from Solid to Vapor
Evaporative and Heat Energy Exchanges
Aerosols
Stratus Clouds
Precipitation Evaporation
Snow Cover
Cumulus Clouds
Cirrus Clouds
Atmospheric GCM
Atmosphere
(Temperature, Winds, and Precipitation)
Stratus Clouds
Soil Moisture
Vegetation and Ecology
Human Influences and Land Use
Runoff
Lakes and Rivers
Land Model
Land Surface
(Topography, and Reflectivity)
Sea Ice
Evaporation
Atmospheric Model Layers
Ocean
(Currents, Temperature, and Salinity)
Heat & Salinity Exchange
Ocean GCM
Winds and Waves
Marine Biology
Ocean Model Layers
Realistic Geography
Vertical Overturning
Ocean Bottom Topography

Activity 1: Signal vs Noise; Where's Waldo? [5 minutes?]

Context for the teacher

This activity is the first of a series designed to get students in the habit of looking for the signal, or trend, in a dataset. The purpose is to train skills and thought processes, and to make students comfortable with the basic ideas of "signal vs. noise", so the subject matter is deliberately *not* relevant to the informational content of the unit. Towards the end of the unit, the class will be revisiting this activity in particular, to address the question of predicting where Waldo might be, as you go over why it's important to have a large body of data to analyze, in order to get a clear picture. One "Where's Waldo?" puzzle only answers the question, whether Waldo is present in a given picture, and, if so, where. In order to predict where Waldo *is likely to be* in a puzzle we've never seen before, we will need more data. Fortunately, that analysis has been done for us, and we'll be able to go over those results in Lesson 5 of this unit as we bring the unit together to form a context for the data collection the students will be doing in the field.

Understanding goals

Students get a basic understanding of the ideas of "signal" and "noise." They will see that "signal" refers to meaningful information (meaningful to the person asking the question or doing the investigation), while "noise" means interfering or irrelevant data. This very basic understanding will get elaborated over the course of the week.

Flow of the activity

This is a small group activity, questions and student context in student sheet.
To begin with, look at an image from "Where's Waldo?". Have the class look for Waldo for a bit, and then have them consider the following questions.

- What is the purpose of the game? *(Answer - to find Waldo)*
- What is the purpose of everything in the puzzle that is *not* Waldo? *(Answer - to make it hard to find Waldo)*
- What help do we have in finding Waldo? *(We know what he looks like, and we know he's there)*
- Based on this picture, would you be able to predict Waldo's location in other pictures?

Activity 2: Weather vs. Climate [20 minutes?]

Context for the teacher

This activity is a second look at Signal vs. Noise, this time with real data related to the Climate Lab. It's based on a graph showing the average annual temperature of Massachusetts over a period of 50 years. In the first part, students look at a 10-year segment of the graph, in which temperatures show some variation around a more or less level trend. From that small dataset, students are then invited to predict future average temperatures, before being shown the full dataset, which has a clear warming trend. The intended lesson here is that when you're dealing with something like climate, which is defined by temperature and precipitation over time, it's important to have as big a period of time as possible, or you'll miss things.
Note for Teachers: This unit is designed to take only one week, but if you have more time, and wish to, you can dip into the temperature activities in the Climate Lab "long unit," which involve actually taking temperature measurements around the school grounds, and discussing how one reaches an "average" temperature.

Understanding Goals

By the end of this activity, students should have a basic understanding of the importance of datasets that cover a long period of time, when trying to see what's going on in a region's climate.

Flow of the activity

This is a small group activity, questions on student sheet.
Have the students look at Figure 1. This figure represents average temperatures in Plymouth, Massachusetts from around 1965 to around 1973. As the students are looking at it, have them consider the following questions:

- Approximately what was the average temperature in Plymouth during the time period shown? (*47˚F to 47.5˚F*)
- If that's the average, what does it say about temperatures in different seasons? (*Summer will be warmer than that, winter will be colder*)
- Based on this graph alone, what would we expect the average temperature to be in the year 2020? (*Probably not much different, since it starts cooling after 1970*)

Now have them look at Figure 2. This is the full graph from which Figure 1 was clipped, showing mean temperatures in Plymouth from 1950-2010.

- Have the students orient themselves — Where does Figure 1 fit into this picture?
- Based on this graph, do they have a different prediction for the average temperature for the year 2050?
- What made you change your prediction? *(Answer we're looking for - more data changes the outlook).*
- Is this graph showing us weather data or climate data? *(Climate data)*

- Why? *(Because it's an average temperature over time, not day-to-day or hour-to-hour)*

Activity 3: Temperature and Transpiration

Context for the teacher

This activity investigates how the rise in temperature discussed in Activity 2 might affect local plant life. This looks at the relationship between temperature and consumption of water, and helps lay the groundwork for the Modeling Ecosystems activity in Lesson 4. This also is a good feed-in to Activity 1 of Lesson 2.

Understanding Goals

By the end of this activity, students should have a basic understanding of what transpiration is, the role it plays in cooling plants, and what that will mean for plants and their need for water in a warming world.

Flow of the activity

This is a whole-class discussion activity with a 1:16 video to start it off.

Present the video as a transition to how the temperature rise they looked at in Activity 2 will affect local plants.

Play the video: Transpiration and its Significance to Plants (provided by Climate Lab, but also available on Youtube at https://www.youtube.com/watch?v=_cfwK1q3QLc)

Follow this up with a brief discussion:

- Based on this video, what happens to plants when the temperature rises? (*they lose more water through transpiration to keep their leaves cool*)
- So if the temperature rises, and precipitation doesn't rise with it, what will happen? (*The plants will either make do with less water, or die.*)

Ask the students to keep this in mind for their next lesson.

Homework: Climate and Birds [20-30 minutes]

Context for the teacher

This reading assignment is intended as advance review for Lesson 2, which looks at how plants and animals experience climate, begins to look at how New England species are responding to climate change.

Understanding goals

After doing this reading, students should have an idea of what "ecological mismatch" means, and how climate and climate change affect wildlife.
Have the students read the climate change brief, and the two bird profiles in the student packet.
To guide their reading, have them consider the following (Questions included in student materials):

Questions

- The science brief talks about ecological mismatch, when there are changes in seasonal patterns with the result that seasonal behaviors that would normally happen at the same time, to happen at different times. One common example of this is the European Pied Flycatcher, whose migration timing has not changed as much as the climate in its summer breeding grounds. As a result, the birds are missing the springtime insect boom they rely on for feeding their young, and the young starve. Which of the two species is most vulnerable to ecological mismatch, and why?
- Which species is *least* vulnerable, and why?
- The information in these examples is presented as evidence of the effect that global warming is having on migratory birds. How could changes in seasonal behavior be used to tell us about changes in climate, even without a temperature record? How could we use bird data like this as "bio-indicators" of what is happening in Earth's climate?

Lesson 1 Review and Vocabulary

Context for the teacher

These are questions and terms you may find useful either for homework, for reviewing the lesson, or as part of a review of the whole unit for students. Use them or not as you see fit.

Review Questions

- What is the value of having a large data set?
- What factors make up a regional climate?
- What parts of human life are affected by climate?

Vocabulary

Biome: A regional ecosystem type, defined by climate, flora, and fauna.
Weather: The temperature, precipitation, and wind of a defined area over a very short period of time.
Climate: Typical weather conditions (temperature and precipitation) in a defined area over a long period of time.
Data: Information (data is plural - the singular is datum).
Data set: A collection of related information.
Temperate: The latitudes, on Earth, that lie between tropical and polar regions.
Ecological Mismatch: Ecological mismatch is what occurs when a species changes its behavior, but the other species that interact with it do not. Some examples would be – insects emerging earlier in the year in response to warmer temperatures, while birds migrating from far away come at the same time as usual. The result is that the birds miss out on an important food source, because they arrived too late.

Activity 2

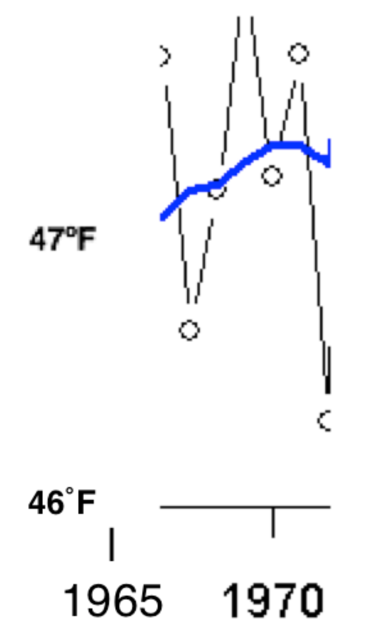


Figure 1

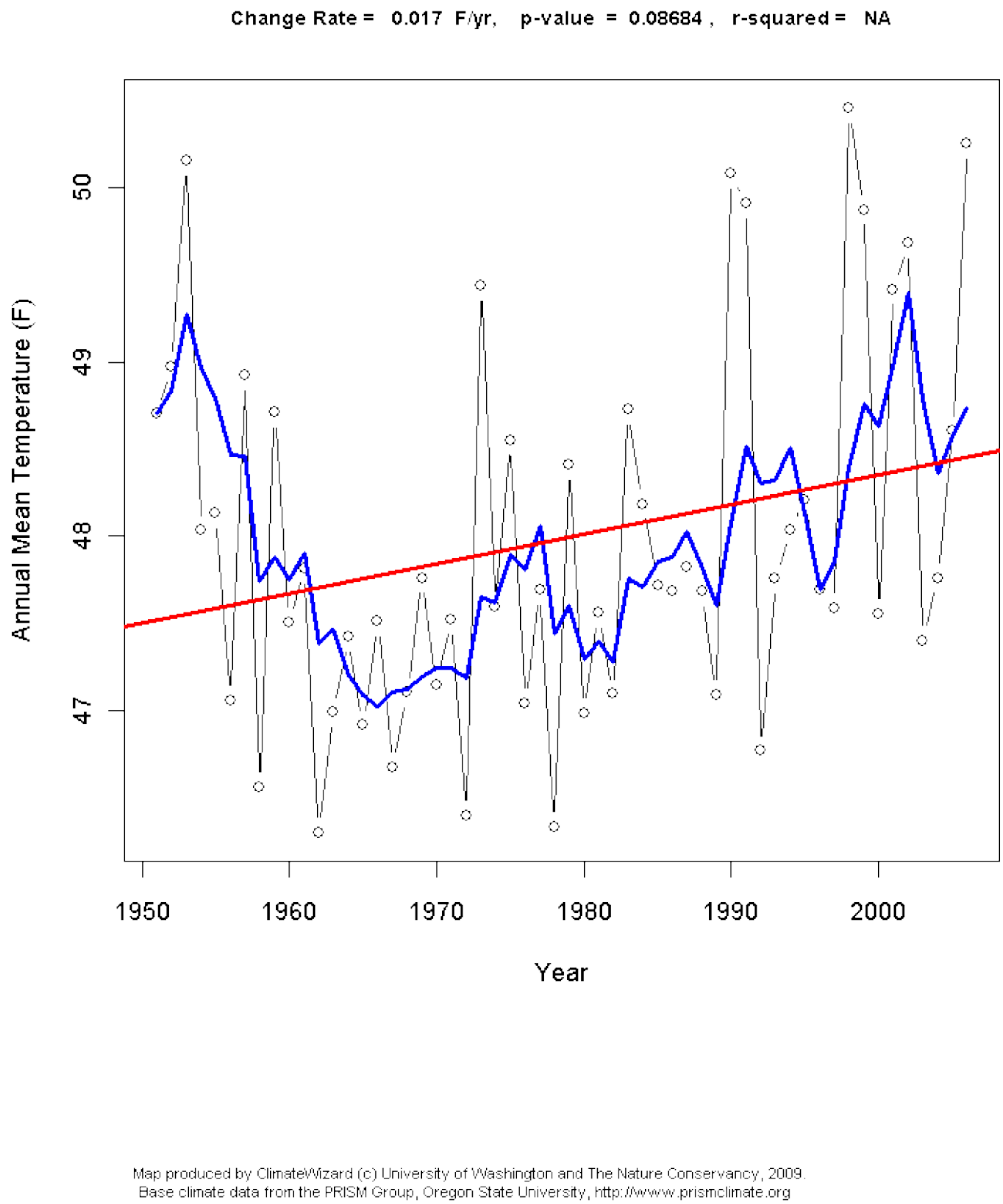

Change Rate = 0.017 F/yr, p-value = 0.08684 , r-squared = NA
Annual Mean Temperature (F)
47
48
49
50
1950
1960
1970
1980
1990
2000
Year
Map produced by ClimateWizard (c) University of Washington and The Nature Conservancy, 2009.
Base climate data from the PRISM Group, Oregon State University, http://www.prismclimate.org

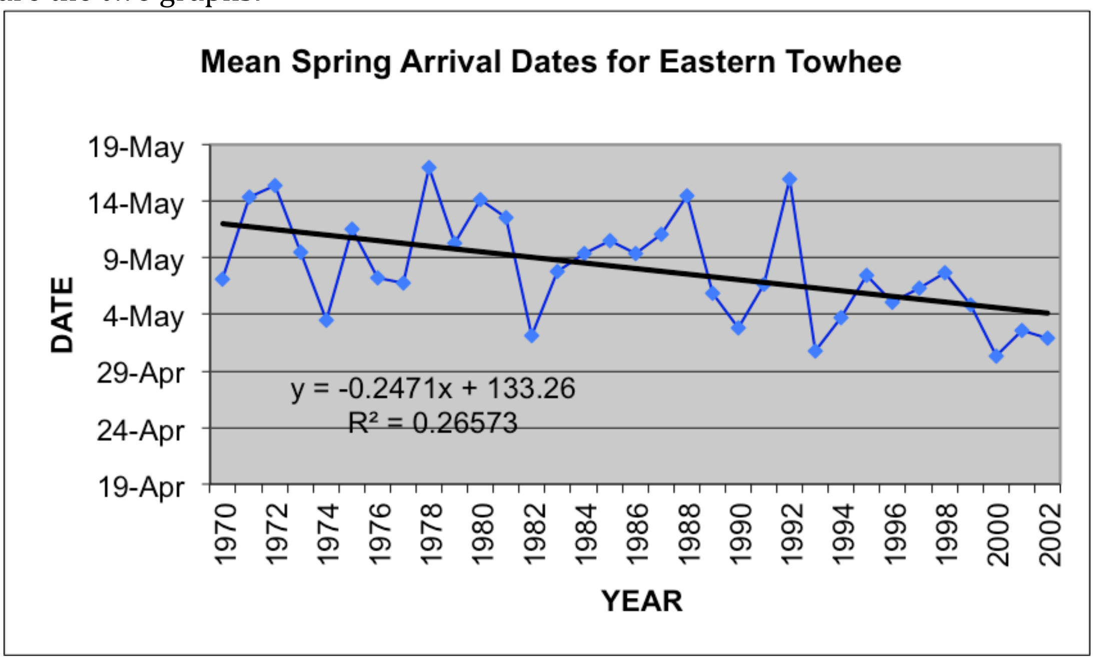
Figure 2

Reading Materials [in Student packet]

Eastern Towhee (Pipilo erythropthalmus)

Photograph by William H. Majoros

The Eastern Towhee lives in the United States. In some areas in the Southeast, the towhee lives in the same place all year. Others live in the Northeast during summer, migrate to the southern states for the winter, and come back north in the spring.
Towhees eat a variety of things like seeds or insects. They will even eat small salamanders or snakes, if given the chance.
Their lives and migration patterns are strongly affected by seasonal changes in daylight and temperature. Because of this, we expect them to show the biggest changes of the two bird species you are reading about. They do, if you compare the two graphs:



Compared to the species described next, they migrate a relatively small distance. This could be a good thing for this species. It would enable them to change the timing of their migration from year-to-year. This would allow them to benefit from the "boom" in food that happens every spring when spring arrives earlier. In fact, the change in migration time (about 8 days earlier on average) suggests that the Eastern Towhee is already adapting to climate change by adjusting its migration time.

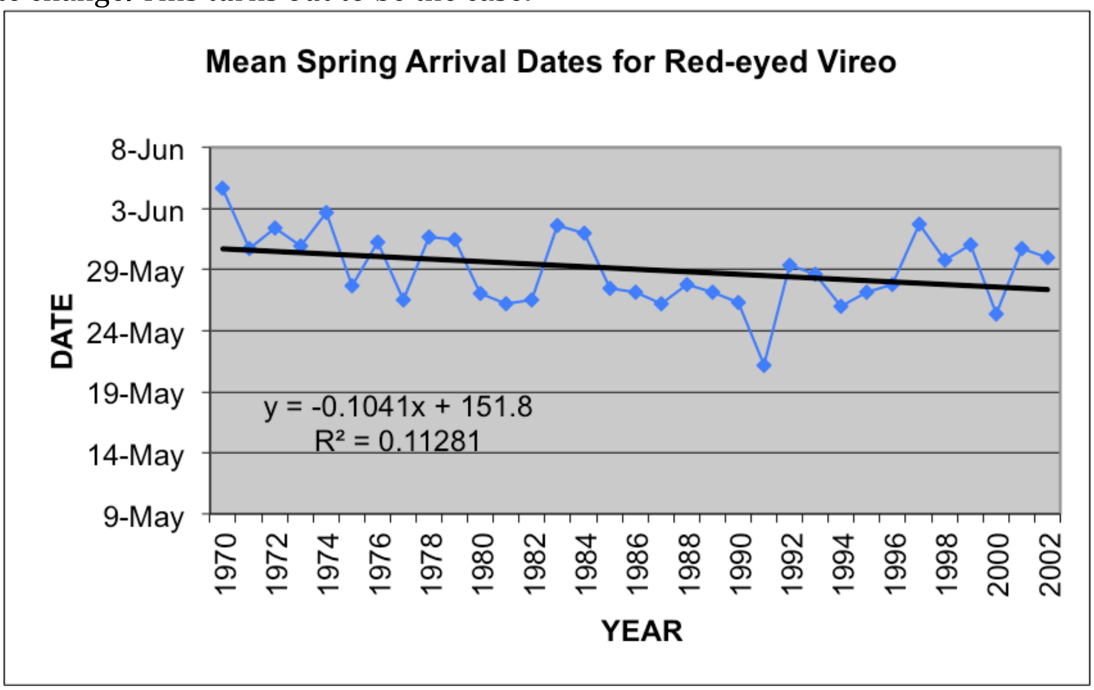
Red-Eyed Vireo (*Vireo olivaceus*)


Photograph by William H. Majoros

The Red-eyed Vireo spends its winter in South America's tropical forests. Like the towhee, they migrate north into the United States and Canada to feed on the explosion of life that occurs in spring.

The abundance of caterpillars and other insects provides them with enough food for breeding and for raising their young.

Because tropical day length and temperatures are always more or less the same, they rely on an internal clock to tell when it is time to migrate. Birds that winter in the tropics try to fly towards the north in the spring even when in closed rooms where they cannot tell what's happening outside! Since they rely on an internal clock, we would expect them to show the least response of our two species to climate change. This turns out to be the case:



You can see that they *are* arriving earlier in the year as time goes by. However, the change (about four years on average) is not as large as it is in the species that winter in North America. One possible explanation for this is that any individuals in the population that happen to arrive earlier might be more successful at reproduction. As a result, their young are beginning to make up a larger portion of the population.

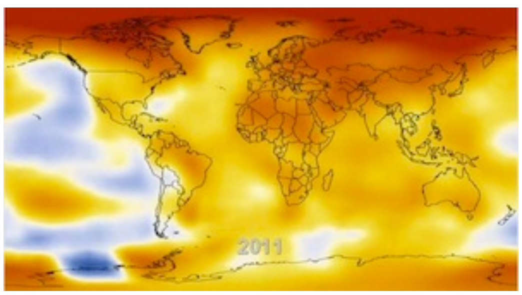
Climate and the New England Biosphere

How can plants and animals respond to climate change?

Earth's climate system is changing, and New England's climate is showing the effects. The organisms of our backyards, forests, and coastlines are starting to make this very clear. What are the options for plants and animals in a fast-changing climate? How will their responses shape New England's landscape in the future?

What climate scientists are telling us

The number of Americans who accept the reality of climate change is increasing. However, many think the change will come in a few years, and will affect other parts of the world. But changes in the climate here in New England have already been seen.



For example: Since 1970, the yearly average temperature has risen about 0.54°F each decade—more than 2° so far. During the same time, the growing season has expanded by 2.5 days per decade. Ice-out, the dates when the ice cover on ponds and lakes breaks up, now comes 8-10 days earlier in New Hampshire. There have also been significant changes in precipitation.

How organisms respond to climate changes

Climate change is a constant feature of Earth's history. It is an important part of the history of life as well. Present climate change, driven by humans, is unusual because it is happening so fast. Changes of a few degrees in average temperature have happened many times. However, until now, they have happened over thousands or tens of thousands of years. The climate change we are now experiencing has happened over a few decades. Organisms have the same 4 options they have had throughout the history of life on earth. Many of the options described below have not been recorded in New England yet. However, they have been seen elsewhere, and are likely to be happening here as well.

a. **Change behavior**. Plants are flowering earlier, and many bird species are arriving at their northern nesting ranges earlier. However, ecological mis-matches are happening for some species. For example, plants may now be flowering before their insect pollinators start to fly, or bird nestlings hatch much later than the caterpillars they feed on have hatched.

b. **Change range**. Many bird species have expanded their breeding ranges. The breeding ranges of others have moved northward. Mountain mammal species, such as the pika, are moving higher up their mountains to avoid the stress of rising temperatures.

c. **Evolve.** Some insect and bird species have evolved in response to climate change.

d. **Go extinct.** Climate change can lead to local extinctions. For example, if the range of a species has moved northward, populations of the species in the southern edge of the range can go extinct.

Open questions

The climate of New England is changing. Climate scientists can predict what our temperatures and precipitation may be like in 10, 20, 75 years. It is harder to predict how the plants and animals will respond. What the changes will mean for the quality of life for New England's people is not at all clear, either. However, we can all contribute to a better understanding by paying attention to the landscape we live on, and the organisms that share it with us. In other readings, we'll provide up-to-date science behind the changes that you are tracking in your own area.