STEM Literacy Project

Citizen Science – Climate Change & Avian Migration

Lesson Overview:

The average temperature global temperature increase has risen by about 0.8°C or 1.4°C since 1880 according to the January 2014 analysis by Goddard Institute for Space Studies. There are ramifications for life on earth resulting from this increase in temperature. Evidence suggests that the pace of warming in the United States has increased over the past 50 years. It is important to note that the change in temperature coincides with the dramatic increase in atmospheric greenhouse gases.

Changes in atmospheric temperature have the potential to have a negative impact upon ecosystems. For example, changes in climate can alter the life cycles of both plants and animals. As atmospheric temperatures warm, plants are growing and blooming earlier in the spring and surviving longer into the fall. Hibernation and migration times are also changing.

The goal of this lesson is to explore migration times for many common avian species in conjunction with temperature changes. Migratory birds may be more strongly influenced by global warming because migratory birds tend to fly north in the spring as temperatures warm and fly south in the winter as temperatures cool. Hence, if seasonal temperature cycles change, the expectation is the migration times may also change.

Standards:

HS-LS2-1. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.

- **Science & Engineering Practices:** Use mathematical and/or computational representations of phenomena or design solutions to support explanations.
- **Crosscutting Concepts:** The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.
- **Disciplinary Core Ideas:** Ecosystems have carrying capacities, which are limits to the number of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance [number of individuals] of any species in any given ecosystem.

HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

- **Science & Engineering Practices:** Use mathematical representations of phenomena or design solutions to support and revise explanations.
- **Crosscutting Concepts:** Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.
- **Disciplinary Core Ideas:** A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of an ecosystem in terms of availability of habitat and resources.

HS-LS2-6. Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

- **Science & Engineering Practices:** Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.
- **Crosscutting Concepts:** Much of science deals with constructing explanations of how things change and how they remain stable.
- **Disciplinary Core Ideas:** A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of an ecosystem in terms of availability of habitat and resources.

Framing Questions:

Essential Question:

- The Cornell Ornithology Laboratory engages ordinary citizens with data collection. This project will use citizen science data to address and explore the following Essential Question:
    - What does data related to the appearance of specific migratory avian species indicate about the intersection of changes in the environment resulting from global warming and avian migratory patterns? How will you determine if there has been a change in bird migration over time?

Driving Questions:

- How can climate change be correlated with changes in avian migratory cycles?

Content Questions?

- How might plant life cycles be affected by climate change?
- What changes might occur within avian habitat in response to climate change?
- How might changes in habitat and food availability impact inter and intra species competition?
- What detectable changes would be indicative of climate change within an ecosystem?

Authentic Connection(s):

This task has multiple authentic connections:

- Climate change is consistently in the news. This lesson provides opportunities for students to explore changes in climate and the potential impact of those changes upon living things within the ecosystem. Birds are part of the students' real-world experience and provide important links to everyday life.
- In the Midwestern US, seasonal change guides many activities from planting crops to finding summer jobs. Exploring changes in the climate brings the timing of seasonal change into focus. For instance, warmer temperatures during the November through December holiday seasons, changes in snowfall patterns, and changes in vegetation through the seasons have the potential to change environmental conditions and enhance earlier during the
- Engaging students with citizen science data allows students to view scientific data from the viewpoint of the average person and gain greater insight into the manner in which data is utilized by the scientific community.

Literacy Connections:

Students will experience multiple connections to literacy through this lesson. Students will:

- Read articles focused on avian migration published through the Audubon Society, the Society for Science, and the University of Arizona Extension Service.
- Identify reliable citizen science data through the Cornell Ornithology Laboratory and other NASA and NOAA as well as other venues.
- Collaborate with peers to organize, analyze, and interpret data to generate evidence.
- Develop a coherent claim supported by evidence.
- Defend a claim with an evidence-based explanation.

Evidence Statements: Evidence of Learning:

Evidence of student learning is based upon the observable features of student performance identified within the NGSS evidence statements.

HS-LS2-1.

- Students identify and describe the components in the given mathematical and/or computational representations [e.g., trends, averages, histograms, graphs, spreadsheets] that are relevant to supporting given explanations.
    - Students will analyze and interpret data [creating graphs, histograms, charts, etc.] to formulate evidence.
    - Students will draw upon evidence to support claims related the correlation between climate change and avian migratory patterns.
- Students analyze and mathematical and/or computational representations.
    - Students will draw from the data to note the factors which have the greatest impact upon avian migration.
    - Students will define and relate migration to habitat preferences of individual bird species.

HS-LS2-2.

- Students identify support for claims of factors affecting biodiversity and population levels:
    - Students will draw from evidence to support claims related to the interaction between diverse populations within an ecosystem and explain how relationships can change between and within populations on both a macroscopic and microscopic level.
    - Students will identify evidence to support at least two factors which have the potential to impact changes within animal populations over time.

HS-LS2-6.

- Students develop an evidence-based explanation which draws from supporting evidence focused on the complex interactions within and between populations. Students will also provide reasoning which identifies the connection between a claim and the supporting evidence.
    - Students will evaluate the validity of claims
    - Students will evaluate supporting evidence for claims
    - Students will evaluate the reasoning validating the connection between the claim and supporting evidence.

Materials and Resources:

Students will conduct investigations by exploring websites and identifying the data to be used from one or more websites. The websites are:

- All About Birds [Cornell Lab of Ornithology] www.allaboutbirds.org
    - Learn about migratory birds at this site.
        - https://www.allaboutbirds.org/mesmerizing-migration-watch-118-bird-species-migrate-across-a-map-of-the-western-hemisphere/
            - Focus on migratory patterns. The migratory patterns of multiple species are shown.
- eBird: http://ebird.org
    - Click on 'Explore Data' at the *eBird* site.
        - At the Explore Data site, students will first identify a region of interest [North America]; next, students will find the data which includes: Species Name; Last Seen; First Seen; and High Counts.
            - This site allows students to consider numbers of specific species observed; the last date on which the species was observed; the first date on which the species was observed and the High Count for the species.
- http://feederwatch.org/pfw/top25
    - This citizen science site at the Cornell Ornithology Lab site provides data from multiple years gathered from multiple sites across the nation. This project is a winter-long survey of birds which visit backyard bird feeders across the nation. Citizen scientists watching bird feeders periodically count the birds observed at their feeders from November through April. This data supports research focused on the movement of winter bird populations and long term distribution of birds as well as the relative abundance of different species. Specific sites can be selected over multiple years. At each site the top 25 birds are identified for each year.

- NOAA National Weather Service [www.weather.gov]
    - This site provides data about current weather conditions
- NOAA National Climatic Data: www.ncdc.noaa.gov and http://www.ncdc.noaa.gov/IPS/cd/cd.html
    - These sites provide climate information by the month. Students could select the same month for multiple years and the same location within the state of Missouri to access climate data
- Missouri Mesonet: http://agebb.missouri.edu/weather/stations/
    - Access historical weather databases at this site.

Engage:

Initiate the lesson with a discussion. The guiding questions for the discussion are listed below:

- What is meant by seasonal migratory behavior?
- What animals undergo seasonal migratory patterns?
- Why do you think migration evolved as a means of survival?
- Do you think migratory patterns ever change? If so, what conditions do you think might stimulate a change?

Use the YouTube video from the Cornell Ornithology Lab to engage students in thinking about migration and migrating birds. **https://www.youtube.com/watch?v=CwIT9pv4khw**

Introduce the Essential Question for the lesson:

- What does data related to the appearance of specific migratory avian species indicate about the intersection of changes in the environment resulting from global warming and avian migratory patterns? How will you determine if there has been a change in bird migration over time?
- Where does the data which we will use for this lesson originate? Introduce the idea of citizen science and explain that the data on bird migration is from a massive database supplied by ordinary citizens and is based upon their observations of birds. The strength of this database is derived from the multitude of

Background Information:

- Before students can address the essential question posed in this lesson, they must learn more about migrating birds. The Cornell Lab of Ornithology [www.allaboutbirds.org] will provide critical background information.
- There are multiple online publications from several reliable and valid sources listed in the Resources section of this lesson. These resources along with the YouTube video will be important sources of information for your students. Before they can design and conduct an investigation of the data, they must first have an understanding of:
    - Environmental conditions driving migration
    - Purpose of migration as a survival strategy
    - Requirements for survival: appropriate habitat, reliable food resources, appropriate conditions for breeding and raising young
- Next, brainstorm with students to identify conditions that drive migratory behaviors (predation, competition, overcrowding, disease, temperature, etc.

Explore:

Introduce students to the internet resources which they will have access to as they collaborate in teams to answer the Essential Question. Challenge student teams to think about how they will determine if migrating patterns have changed for a specific species.

- What criteria will they use to determine if there has been a change in the migration pattern?

Using the databases:

- Introducing the databases:
    - Students can work in teams to explore the databases. One suggestion would be to assign an online resource for each team. The teams would investigate the resource and develop a set of simple instructions for using the database to be shared with the rest of the class.
- **Exploring the data:**
    - Once student teams have learned to use the databases and shared their ideas with the rest of the class, discuss the following questions with the class to support students with their research:
    - What will serve as your Independent Variable or driving force for migration?
        - appropriate environmental conditions for breeding and raising young
        - availability of food
        - competition for resources
        - predators
        - appropriate temperature
        - habitat
    - What information will you need to link migratory patterns to environmental conditions? What databases will be most useful?
    - What type of comparisons will you make:
        - Birds in different regions
        - Different bird species
        - Current conditions vs. Past conditions
- Discuss the means that students will use to link or connect data – this would be an important question to pose to the jigsaw teams:
    - Where in eBird and NOAA databases will students search to gather the necessary information?
    - What tools in eBird and NOAA databases will be useful in gathering data?
    - How will you organize your data so that data can be analyzed and interpreted later to gain greater insight into migratory patterns?
- Discuss means of analyzing the data:
    - How will you determine if there is a relationship between a change in climate and a change in migratory patterns?
    - How will you quantify a difference or degree of change?
    - What type of graph or histogram would you use to analyze the data?

Explain:

The explanation provided by the team should be in the form of an assertion or claim which is supported by evidence generated from the analysis and interpretation of data. Throughout the explanation segment, teachers should stress the importance of

- identifying patterns within the data
- focusing on an underlying cause for the outcome
- emphasizing differences between data and evidence.

Explanations could be provided through:

- Team presentations to the class followed by individual essays explaining the findings of the research conducted by the team.
- Posters developed by each team identifying a specific claim, providing evidence to support the claim, and linking the evidence to the claim to demonstration a correlation between the two.
- An argumentation session in which each team argues in support of a specific claim, provides supporting evidence, and demonstrates a clear correlation between the claim and the evidence by connecting the claim to the evidence.

Extend:

Invite a local expert into the classroom to discuss migration patterns in light of climate change and provide greater insight into the impact of environmental changes on migrating birds.

Evaluation:

Evaluation should be ongoing. The teacher must focus on student work by interacting with each collaborative team to provide guidance, support, correction, etc. Exit slips for each day of the lesson would be a good idea.

Teacher Background Information:

Birds migrate for many reasons. One of the drivers of bird migration is the availability of food, another is availability of habitat, and a third is availability of breeding sites sufficient to support growing numbers of birds as eggs hatch creating increases in population. Think about the importance of reliable food sources from the standpoint of the birds. An avian species reliant upon insects as a food sources is faced with a difficult challenge when the season changes, temperatures drop, and insect meals become more difficult to find. Researchers at the University of Arizona note that major driver of bird migration is the reliability of food. Seasonal food scarcity, such as the limited availability of insects during the winter in Missouri, drives birds to migrate to regions where food is more plentiful and reliable.

Migration developed as a successful strategy for dealing with seasonal changes in food availability. Birds often migrate in groups, when birds band together there is a greater likelihood that they will locate a reliable food supply.

Migration involves leaving winter habitats to breed and leaving breeding habitats to winter. In both cases there must be an increase in the fitness of the species for migration to evolve within a species. Bird species migrating to breed are reducing competition for food and breeding habitat, as well as a reduction in nest predation. Adults migrate to winter avoid increased competition for food and, therefore, migration makes survival more likely. In summary, migration allows species to exploit seasonal abundance of food.

What would happen if birds did not migrate? Without migration there would be a decrease in the reliability of food supplies within breeding regions, competition for nesting sites would greatly increase, and predators would be attracted to nests and the prevalence of easy meals provided by eggs and young. The key point is that birds have evolved different migrating patterns, timing, and destinations. These variations in migration has the effect of dispersing populations around the world to take advantage of the availability of food and nesting sites to raise the young. Because ideal conditions vary between different species, migration provides opportunities for enhanced survival.

Reasons for Migration:

- **Climate:** Avian species have evolved variations in plumage to survive in specific climates. When there are changes in the climate within a region, those adaptations may no longer be effective protection. Hence, migration may serve to enhance survival by moving to a different climate with a more temperate habitat. For example, many species leave the Arctic breeding grounds with the onset of the winter season when temperatures begin to drop and ultimately threaten survival. Conversely, species adapted to tropical climates may seek cooler breeding regions to reduce the impact of heat and the prevalence of predators.

- **Predators:** Favorable habitats with significant food stores can create an environment which is attractive to predators. Migrating to a different breeding habitat may reduce predation and enhance the survival of the young.
- **Disease:** The spread of disease can be enhanced as the number of birds within a region increases. The opportunity for the disease to be transferred from bird to bird is enhanced. Disease has the potential to destroy breeding colonies and severely decrease the rate of survival for the young. Migration has the potential to move from a more to a less congested area.
- **Competition:** The competition between species for habitat within a specific niche can be a reason for migration. It is important to note that not all migrations are over extreme distances. Many species migrate to nearby areas to locate habitat and a reliable food supply.

Hurlbert, A. H., & Liang, Z. (2012). Spatiotemporal variation in avian migration phenology: Citizen science reveals effects of climate change.
http://www.plosone.org/article/fetchObject.action?uri=info:doi/10.1371/journal.pone.0031662&representation=PDF

- Hurlbert and Liang note that under natural conditions birds may synchronize migration patterns to seasonal change which are determined by environmental cues including photoperiod and temperature. The photoperiod is thought to be the most consistent cue for migration patterns. Simply put, increases in hours of sunlight in the spring stimulates plant growth and increased availability of food. Temperature is also a major determinant for the availability of food in different latitudes and, as a result, migratory patterns are largely influenced by temperature which, in turn, influences food availability. Key behaviors, such as breeding are also influenced by migration times as birds migrate to warmer climates and greater food availability. Differences have been noted in migratory shifts migrants traveling longer vs. shorter distances. There appears to be less variability among migrants which migrate over longer distances.

Resources for Students & Teachers:

https://student.societyforscience.org/article/news-brief-tiny-songbird-mega-flier

- This article is focused on the Blackpoll Warbler, a tiny songbird capable of traveling nonstop, over the ocean, each fall when migrating from North America to South America.

https://student.societyforscience.org/blog/eureka-lab/finding-out-why-birds-are-out-range

- Citizen science is the focus of this article. Students can read about Max Pine's research in bird migrations. Read about Max's research and the resources used to correlate bird changes in bird migrations with climate change.

https://www.audubon.org/news/what-birds-tell-us-about-climate-changes-threats

- This Audubon article focuses on bird health and climate change. Learn more about how birds from seven different continents may be impacted by changes in the global climate.

http://climate.audubon.org/

- This Audubon site focuses on 314 species of birds which are being negatively affected by shrinking and shifting ranges which speak to changes in habitat and food sources.

http://climate.audubon.org/article/audubon-report-glance

- The Audubon Report at a Glance provides those interested in ways in which the changing climate may change habitat and food sources for birds throughout the world.

http://climate.audubon.org/sites/default/files/NAS_EXTBIRD_V1.3_9.2.15%20lb.pdf

- This site provides a full report on birds and climate change developed by the National Audubon Society. The report is current, created in September of 2015.

https://extension.arizona.edu/sites/extension.arizona.edu/files/resources/2013apr.pdf

- The focus of this article from the University of Arizona is on hummingbirds overwintering rather than migrating during the winter months.

Lesson 1: All About Birds

Purpose:

If you have a bird feeder in your backyard, you might notice that there are changes in the behavior of the birds when the environment changes. For instance, greater numbers may be attracted to the feeder when during the winter months the weather is colder and many of the natural food sources are limited. Our focus today is to think about birds and how these unique animals respond to environmental change.

Introduction

Think about the requirements for life for all animals. Animals are dependent upon food sources within their environment. Work with a partner to answer the questions below.

Identify three adaptations observed in birds which make the birds more likely to survive:

_____ _____ _____

Think about the table below. What are some examples of natural sources for basic requirements for life among birds? Think about behaviors which might become apparent when natural sources are lacking. What behaviors are likely to appear within bird populations when natural sources are insufficient? For instance, when food availability is low, birds might go to backyard feeders.

Birds and Survival		
Basic Requirement	**Natural Sources**	**Behavior – Requirements not met**
Food		
Water		
Shelter		
Habitat		

Your Challenge:

During this portion of the lesson we will observe birds around the school. To attract birds, we will place several feeders in an area which is easily observed. The next question is: What types of seeds should we place in the feeders. The Cornell Ornithology Lab is an excellent resource. Go to the following site in the Cornell Ornithology Lab to find *Bird Notes*: **http://www.birds.cornell.edu/AllAboutBirds/notes/BirdNote01_WinterFeeding.pdf** to learn about the types of bird feed to use. Your teacher will provide the seed types you discover in your reading.

Your class and your teacher will make observations of birds coming to the feeders. You can actually take part in the Citizen Science aspect of the Cornell Ornithology Lab. Your class can submit observations of birds and bird counts within your region to Cornell.

When you are making observations, remember that birds are easily frightened remaining quiet is very important. Also be certain to have paper and pencil to record your observations. You can use the Bird Count Sheet on the following page.

The Bird Count sheet is designed for you to identify type of bird, the number of that type of bird observed during the observation time, and the food type the birds were attracted to when feeding. The Cornell Lab of Ornithology Bird Identification information will prove very useful. Go to this site **http://www.birds.cornell.edu/AllAboutBirds/birding123/identify/index_html** and read about the characteristics which will be helpful in identifying birds. The site focuses on the following features as identification cues: silhouette, field marks [observable characteristics common to specific bird types: color, color patterns, etc.], posture, size, flight pattern, habitat.

Take the time to prepare yourself not only to observe the birds but to use the features described by Cornell scientists to identify the birds. Also be sure to note what type of food each bird type is attracted to when feeding.

Bird Counts		
Date:	**Start Time:**	**End Time:**
Identify the Types of Birds Observed	**Number of Birds Observed**	**Food Type**
[Example] Black Cap Chickadee	3	Sunflower seeds
Total Number of Birds Observed:		

Final Thoughts:

Which birds did you see most often? _____

What was the most popular food [multiple bird species were attracted to this food type]

How many types or species of birds did you observe? _____

http://www.audubon.org/magazine/september-october-2014/a-storm-gathers-north-american-birds

Lesson 2: Birds and Migration

Purpose:

The purpose of this lesson is three-fold. First, you will be engaged in using citizen science data gathered by people of all ages throughout the United States and the world. You will learn how to access the data and analyze and interpret the data to gain insight into migratory patterns. Secondly, you will utilize the data to think about the nutritional and habitat requirements of these species and the manner in which migration is utilized to access appropriate nutrition, habitat, and breeding sites. Finally, you will use the eBird data from the Cornell Ornithology Lab to explore changes in migratory patterns over periods of time.

Introduction:

During this activity, you will be using citizen science data from the Cornell Ornithology Lab. During Lesson 1, your class observed birds coming to an outdoor feeder and gathered data on the types and numbers of birds observed as well as the food preferences of the birds. Remember that citizen science refers to observations made and submitted to a formal database by volunteers. Citizen science is encouraged by the Cornell Ornithology Lab which is funded by the National Science Foundation and records data from bird observers throughout the world. The citizen science provided by Cornell is recorded in a huge database and is used by scientists to explore bird population dynamics, migratory patterns, and relationships of migratory patterns to habitat. In class today, we will use the data from this database to answer the following questions:

- What birds live in our area?
- Which of these species remain in our area throughout the year?
- Which of these species migrate?
- What conditions might result in a change to migratory patterns?

Guiding Question: How has climate change affected bird migration?

Video:
You will watch the YouTube video **https://www.youtube.com/watch?v=CwIT9pv4khw** which is focused on citizen science and how and why observations are made. This video will help you understand how citizen science data is gathered through programs at Cornell Ornithology Lab and National Oceanic and Aeronautic Administration.

Accessing Data:

We will use the Cornell Ornithology Lab - eBird: http://ebird.org/content/ebird/news/ebirding-your-cbc/ site to find answers to the questions above. Follow the steps below to access the data:

1. Go to the - eBird: http://ebird.org/content/ebird/news/ebirding-your-cbc/ site
2. Click on the **Explore Data** tab at the top of the page
3. Once on the Explore Data page, students should scroll down the page to **Bar Charts**
    a. Select the United States [remember data collection is world-wide]
    b. Select Missouri
    c. On the left side of the page – select a sub-region
        i. Identify **Counties** as the sub-region
        ii. Select the county of your choice
        iii. Click on '**Continue**' at the bottom of the page
        iv. A page of bird observations will appear [see the example on the following page]
    d. Bar Charts
        i. The bar charts are made up of observations submitted by volunteer observers in Boone County, Missouri

Figure 1: The Bar chart below shows monthly occurrence of bird species in Boone County, Missouri. Only a small portion of the data is shown. The month is shown in the blue band at the top of the chart and bird species are shown on the left. The map function shows the location of the siting on a map of Missouri. The green bars indicate the time of the year the bird species spends in Missouri. Note that the Blue Jay, the American Crow, and the Horned Lark are three species shown on the chart with solid lines of green bars. Green bars throughout the year indicates that the birds are not migratory and remain in Missouri throughout the year. Note the patterns of the other bird species. What do these observation patterns indicate?

Compare Species:

Study the data in Figure 1 and think about the questions below:

What patterns do you observe in the 15 species shown?

Which species remain in Mid-Missouri throughout the year?

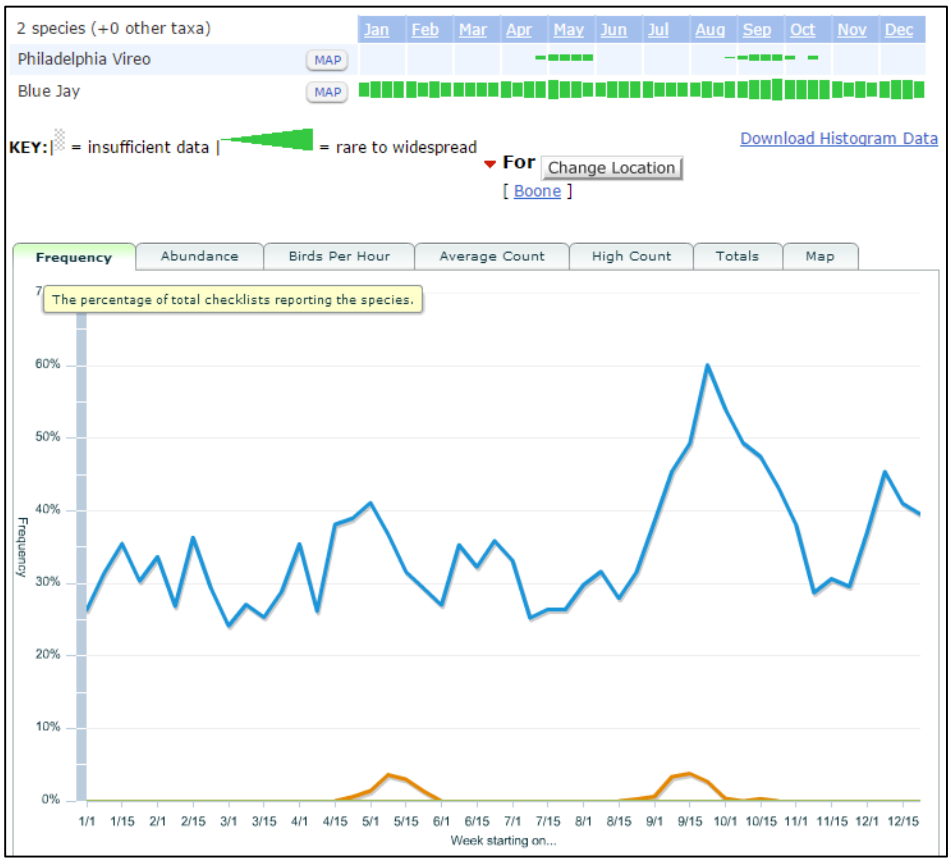
Which species are likely to winter in Mid-Missouri?

Are there any other patterns shown in the data?

Line Graphs:

Compare two species in a line graph by clicking on one species. A line graph showing the frequency of observations for that species will appear. Add a second species for comparison by clicking on the **Change Species** button at above the line graph. Select a second species by typing the name of the new species for comparison. Next, click Continue and observe the graph showing a comparison of observations for the two species identified.

Figure 2: The line graph comparison shown below compares observations of the Philadelphia Vireo with the Blue Jay.



Note that the Philadelphia Vireo is observed only in May and September, whereas the Blue Jay is observed throughout the year.

Analyzing the graphs:

- Why is there a difference in the observation data submitted for the Blue Jay and the Philadelphia Vireo?
- Does the appearance of the Philadelphia Vireo remain consistent over time? Think about answering this question by comparing different date ranges [2000-2010 vs. 2010 - 2016]

Thinking about Data:

Keep in mind that this data you see in the graphs show observations of birds in Boone County submitted to eBird from 2000 through 2010. Think about different ways to analyze the data. For instance, you could compare annual migration patterns for multiple species for two different periods of time. Think about comparing annual migration data from 2000-2010 to annual migration data from 2010-2016.

- Note to change the focus of the data to annual migration data:
    - First Step: go to the eBird site [you can just Google eBird]
    - Second Step: click on Explore Data at the top of the page
    - Third Step: select state and county
    - Fourth Step: select Change Date
    - Fifth Step: at the eBird Observations – Change Date menu, select the time of year [choose from entire year, Spring migration [March-May], Breeding season [June-July], Fall migration [August – November] or Winter [December - February
    - Sixth Step: select the appropriate date range and click on the 'Continue' button

- Suggestion: Arrange to have the different dates for comparison on two different laptops, this will allow for a direct comparison. You can select two bird species for comparison or compare several species creating more robust data.
- Compare the patterns observed in the eBird data by studying data from two different time frames. For instance, identify several species and set the dates to note changes in data [bird sightings within the county].

Briefly summarize your observations and address the following questions:

- Can you observe a change in migratory patterns over time?
    - What criteria will your team use to determine if there has been a change in migration?
    - How will you make connections between the criteria your team selected?
    - What type of comparisons will you make?

Lesson 3: Birds, Migration, and the Impact of Climate Change

Purpose:

If you have a backyard feeder or enjoy watching birds in the environment, you might have noticed that the bird population changes over time. Some birds can be observed throughout the year while others are only present at certain times of the year. Some birds overwinter in warmer locations to access a specific food source, breeding habitat etc.

This lesson will challenge you to think about birds within the environment, those which migrate from region to region and how climate change might impact migration patterns.

Introduction:

Climate change is consistently in the news, but what does climate change actually mean for animals and plants? During this lesson we will link the eBird data to weather and climate data taken from a massive database [Missouri Mesonet]. You will select specific species and compare migratory patterns over time with climate data. This comparison has the potential to reveal the impact of climate change on all life within a specific region. As temperatures warm, the landscape changes with plants blooming and growing and breeding conditions becoming favorable at earlier dates.

Birds and Migration:

In terms of migration, birds can be placed into four different categories:

- Non-migrating birds are permanent residents within a certain region. These birds can be observed in Mid-Missouri throughout the year.
- Summer migrators are birds that fly north in the spring to nest in cooler climates. These birds will fly south in the winter into a region with a warmer climate.
- Winter migrators are birds that fly south in the fall to nest in warmer climates in the winter. These birds will fly north in the spring.
- Transient migrators are species which stop during their migration to rest and feed. These birds are only present for brief periods of time. After resting and feeding, they will continue on their migratory path.

As you review the data you studied in Lesson 2, you will note that the data reflect birds that exhibit each of the migratory patterns.

Guiding Question:

How is earth's climate changing and how will the changes in climate affect migratory patterns in birds?

Your Challenge:

You will collaborate as teams to conduct your investigation of migratory species with the goal of determining if changes in the climate have altered migratory patterns.

Step 1: Begin by accessing the data using eBird data through the Cornell Lab of Ornithology. If you do not remember the pathway for accessing data, use the instructions below:

Accessing Data:

Follow the steps below to access the data:

1. Go to the - eBird: http://ebird.org/content/ebird/news/ebirding-your-cbc/ site
2. Click on the **Explore Data** tab at the top of the page
3. Once on the Explore Data page, students should scroll down the page to **Bar Charts**
    a. Select the United States [remember data collection is world-wide]
    b. Select Missouri
    c. On the left side of the page – select a sub-region
        i. Identify **Counties** as the sub-region
        ii. Select the county of your choice [Boone County has the most reliable data of the Mid-Missouri counties]
        iii. Click on '**Continue**' at the bottom of the page
        iv. A page of bird observations will appear
    d. Bar Charts
        i. The bar charts are made up of observations submitted by volunteer observers in Boone County, Missouri

Step 2: Study the bar graphs and identify up to five species that are found in the county only during the summer months or transient species that are found in the area in the spring and fall but are not as prevalent during the summer months. Be sure to record the common name for each species as listed.

Step 3: Using two laptops, follow the directions listed below for each laptop:

- Return to the eBird site, click the Explore Data button and, next, scroll down the page and click on Line Graphs
- Type the common names for the species you identified in Step 2 into the Select Species box. You can enter multiple species one at a time. Click the continue button and you will find the data in the form of a line graph. Follow this direction for each computer.
- You will find a Change Date button above the line graph:
    - Laptop 1: change the date to 1900-2001, next, click the continue button
    - Laptop 2: change the date to 2002-2016, next, click the continue button
- Now that you have the same group of species tracked during different dates, manipulate the graphs using the buttons directly above the graph. Study the line graph when you click on Frequency, Abundance, Birds per Hour, Average Count, High Count,

and Total. Study the two line graphs on laptops 1 and 2 and look for differences in timing [arrival and departure times], numbers, birds per hour, etc.

- Study the two line graphs showing the species you identified. and respond to the questions below:

1. How are the two graphs showing the same species over different times alike?
2. How are the two graphs different?
3. What do you think might explain any changes you observe?
4. Identify at least two factors which might impact bird migration patterns.

Step 4: You will now explore climate by observing minimum temperature daily throughout the period. We will be using the Missouri Mesonet site which is maintained by the University of Missouri Extension. Follow the steps below to access the Historical Database through Missouri Mesonet.

1. Google Missouri Mesenet
2. Click on the Columbia – BREC Weather Data Archive
3. The BREC Weather Data Archive offers several data sources, scroll to Sanborn Field – University of Missouri and click on Historical Archive – Sanborn Field – University of Missouri
4. The Missouri Historical Agricultural Weather Database page will appear.
    a. Identify the date, you can search years from 2000 to 2016 and select Field Elements from a menu which includes multiple weather features.

Step 5: Study the weather data, select time during each year [months are numbered]. Compare weather data with migration data.

Step 6: For additional evidence of climate change go to the following NASA sites: http://climate.nasa.gov/evidence/

- This website provides an online graph showing climate change as the global temperature continues to rise.

Your Challenge:

Evidence:

What evidence did you find for changes in the pattern of the migratory patterns of selected bird species?

- What species did you select for your investigation? Please list the selected species below:

- Use the Snipping Tool function to capture the line graph of the species you collected for each of the climate change ranges you identified in the data:

Line Graph #1 - Date range:

Line Graph #2 – Date Range:

What do the graphs indicate in terms of changes in the migratory pattern of the selected species?

Was it possible to link changes in migratory behavior to changes in the minimum and maximum temperatures during the same periods?

What environmental factors do you think are driving changes in migratory behavior? Please explain your response.