Amphibians on the Move: Predicting Why and When

Lesson Plan for Secondary Science Teachers

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Why Teach About Amphibian Migration?

Amphibians are fascinating to people of all ages, and captivate the interest of young students in particular because they possess many unique characteristics – they are capable of regeneration and metamorphosis, they can survive freezing temperatures, and members of some species can change sex. Many amphibians also have beautiful, bright coloration and other unique morphological features, such as external gills. In this lesson, the natural interest that students have about amphibians can be used as a springboard to teach about the scientific method, principles of data assessment, basic graphing skills, and the relationship between biological cycles and climate.

While amphibians are generally quite reclusive, their spring migration event provides an opportunity for people of all ages to encounter them. This remarkable natural history event is something that can be observed locally, and can provide an opportunity for real world investigation and hands-on participation. By taking a class field trip to a vernal pool, students can engage in citizen science and record evidence of amphibian migration to contribute to the scientific community. They may also have the opportunity to practice environmental stewardship by helping amphibians cross the road during their migration.

Amphibians are vulnerable to changes in their environment. Many species are facing multiple threats and are considered endangered or at risk for extinction. The health, behavior and distribution of amphibians may indicate changes in climate or the presence of pollutants. In this lesson, students will consider how biological events can be used to infer information about the environment. This lesson can also be used to facilitate discussion about environmental issues such as climate change, water quality, and habitat loss.

I. Education Standards

This Lesson Plan meets the following **National Science Education Standards** (NSES):

Science as Inquiry, Content Standard **A**

> Abilities necessary to do scientific inquiry: Formulate and revise scientific explanations and models using logic and evidence. These discussions should be based on scientific knowledge, the use of logic, and evidence from their investigation.

Life Science, Content Standard **C** (9-12)

> The Behavior of Organisms: Organisms have behavioral responses to internal changes and to external stimuli. Responses to external stimuli can result from interactions with the organism's own species and others, as well as environmental changes; these responses either can be innate or learned. The broad patterns of behavior exhibited by animals have evolved to ensure reproductive success.

II. Objectives

1. Students will use climate data and knowledge of amphibian migration behavior to predict amphibian migration events.

2. Students will use amphibian sighting data to evaluate their predictions for accuracy and to identify environmental variables that cue amphibian migration events.

3. Students will create a graph in order to identify relationships between amphibian migration, latitude and temperature.

4. Students will describe potential applications of amphibian sighting data to scientific research on climate change and amphibian conservation efforts.

5. *Optional*. Students will write a lab report explaining their analysis and communicating the significance of their findings.

III. Materials

1. Access to computers with internet access for student use.

2. Excel spreadsheet and access to computers with Microsoft Excel; or printed copies of data if Excel is not available for every student.

3. Printed copies of student instructions packet.

IV. Considerations

This lesson plan is designed for use in a 9 – 12 grade classroom. The activity takes approximately one hour and thirty minutes to complete in its entirety, so you may wish to assign the background readings prior to class or assign some questions to be completed as homework. Versions are available for use with or without Microsoft Excel. The activity is designed for students with minimal familiarity with Microsoft Excel. Directions for an optional written lab report have been included for use with more advanced students. A grading rubric for the report is available for download on the lesson plan website. Links to materials for further reading are also provided.

V. Learning Activities

You may wish to assign the Background Information reading prior to class. When students begin working on the activity, they will need access to a computer with internet access. Each student should have a printed packet that contains the directions for the activity and associated guided questions. Students will use provided climate data to predict amphibian migration. The background reading (pdfs provided on lesson plan website) that they have completed should prepare them to make an educated guess involving environmental characteristics that are known to influence the timing of amphibian migration. Students will then input information regarding latitude, temperature, and actual sighting date. In the version of the lesson using Microsoft Excel, information that students enter into the *Data* worksheet on Microsoft Excel will automatically appear on the *Summary* worksheet, but students do not need to refer to this worksheet until the end of the activity.

When students discover whether or not their initial prediction was consistent with the actual sighting, they may be surprised at the results. They may not immediately understand why, in some cases, the warmest day did not necessarily cue an amphibian migration. The goal is for the students to understand that both temperature and precipitation are important, and that either variable alone may not be sufficient to cue migration. You may wish to address this during the activity to avoid misconceptions.

It may make sense to bring class to a pause once all students have evaluated their prediction for accuracy and facilitate a brief discussion. Suggested discussion questions might include:

- Did anyone make a prediction that was not accurate?
- Were you surprised? Why?
- Why do you think a different date cued the migration event?
- Was either variable more important than the other?

There are also questions within the packet that are intended to guide students to understand this concept.

The latter part of this assignment directs students to interpret a graph relating amphibian sightings to latitude and temperature. The goal is for students to observe that there is a relationship between the timing of migration events and latitude: specifically, that migration occurs earlier at low latitudes. In addition, across all latitudes, migration tends to occur at approximately the same minimum temperature.

Finally, students will consider how the projected impacts of global climate change may affect amphibian migration in the United States. Changes in temperature and precipitation may result in earlier amphibian migration events as spring conditions arrive earlier in the year.

Student Instructions – Excel Version

Background Information

In the spring, many amphibians emerge from their hibernation sites and migrate to a special temporary habitat called a vernal pool to breed. Read the provided article[1] "An Ecological Spring Awakening in Our Vernal Pools" by Dr. Jonathan Richardson and Hank Gruner.

The journey from hibernation sites to vernal pools may be quite long and perilous. The migration path may traverse roadways, where amphibians can be killed by cars. They must also face the threat of predation, desiccation, and disease as they travel. The migration event is also a seasonal opportunity for human beings to observe amphibians that are usually reclusive. Certain environmental cues, such as rainfall and warming temperature, are believed to trigger migration. Those who are interested in protecting amphibians or observing their fascinating journey to the vernal pools might want to predict when a migration event may occur in their location. For example, in East Brunswick, New Jersey, the Friends of the East Brunswick Environmental Commission[2] consult many factors in order to predict the timing of migration events and close roadways to protect the salamanders and allow the community to view their migration. Read more about the East Brunswick amphibian community in the provided article[3].

The Amphibian Tracker[4] is a Google map maintained by Mark Urban's lab at the University of Connecticut that tracks the spring migration and breeding of amphibians in the Eastern United States. Each point on the map represents an amphibian sighting. The sighting data is collected from a variety of sources, including e-mails, blogs, and entries in Herpetological Education & Research Project[5] records. Sightings are submitted not only by scientists, but also by the general public – folks who take notice of amphibians in their own backyards and local community. The points are color-coded by date so that it is easy to observe overall trends in the timing of migration events.

[1] http://hydrodictyon.eeb.uconn.edu/people/urban/teachers/RichardsonGruner.pdf

[2] http://www.friendsebec.com/salamandercrossing.htm

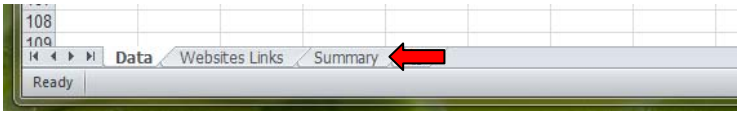
[3] http://hydrodictyon.eeb.uconn.edu/people/urban/teachers/Beekman.pdf

[4] http://hydrodictyon.eeb.uconn.edu/people/urban/tracker.html

[5] http://www.naherp.com/

Using the Excel Workbook

The provided Excel Workbook consists of three worksheets: **Data**, **Website Links**, and **Summary**. These tabs are located at the bottom of your workbook.



The **Data** worksheet contains the climate data needed to complete your task. This is also where you will enter data from other resources.

The **Website Links** worksheet contains links to all of the outside resources needed to complete your task. The footnotes in this instruction packet correspond to the footnotes on the Websites worksheet for easy reference.

The **Summary** worksheet will be used in the latter part of this assignment to test predictions and generate a chart.

Your Task

Imagine that you are a scientist working for an environmental organization that aims to protect local wildlife. Mortality associated with road kills has been identified as a threat to the local amphibians (frogs and salamanders) during spring migration. The environmental organization would like to temporarily close roads that cross a known migration path of amphibians. To minimize disruption to traffic and inconvenience to travelers, the organization hopes to close the roads only during the period of time when it is most likely that the amphibians will be migrating. The organization has asked you to predict when a migration event is likely to occur in the area.

The timing of amphibian migration events depends upon local climate and environmental variables. To make your prediction, you will need to consider the local weather conditions that might cue the amphibians to begin their migration.

In the scientific method, a hypothesis is a guess that may explain a phenomenon. Predictions are then derived from the hypothesis and tested. If the results of the test fulfill the prediction, the hypothesis is supported by the data. It is hypothesized that amphibian migration is cued by a combination of temperature and precipitation cues. The predictions that you make are derived from this hypothesis, and can be tested by comparing your predictions with data from the Amphibian Tracker. If your predictions hold true, then your work contributes to the body of evidence in support of the hypothesis. Of course, a test should be repeated more than once to decrease the likelihood that the prediction was fulfilled simply by chance alone.

Directions and Data Collection

You have been provided one week of climate data (temperature and precipitation) from Weather Underground[6] for five locations in the eastern U.S.

1) Use the data provided and the information you learned from the provided background reading articles to make a prediction about when you think the amphibians in each location will migrate. Record your Prediction Date in the table below. For each location, why did you choose the date that you did? Record your reason in the table, and enter your prediction date in the appropriate box on the Data worksheet in Excel.

Location	Prediction Date	Reason
Warren County, NJ		
Arlington, VA		
Fitzwilliam, NH		
Clinton, MS		
Bartow County, GA		

2) Look up the Latitude of each location using the Latitude Finder[7] and record it in the table below and in the appropriate box on the Data worksheet in Excel.

3) Using the Amphibian Tracker Map[8], look up the **actual** amphibian Sighting Date for each location and record in the table below and in the appropriate box on the Data worksheet in Excel. For some locations, there may be multiple amphibian sightings listed. Be sure to *look through all of the results for each location* and choose the sighting that occurred within the week of provided climate data.

[6] http://www.wunderground.com

[7] http://www.latlong.net

[8] http://goo.gl/maps/ubix6

4) Using the climate data provided in the Data worksheet, look up the Temperature on the actual sighting date for each location and record in the table below in the appropriate box on the Data worksheet in Excel.

Location	Latitude	Actual Date	Prediction	Temperature
Warren County, NJ				
Arlington, VA				
Fitzwilliam, NH				
Clinton, MS				
Bartow County, GA				

5) For each location, was your prediction correct? Why or why not?
Warren County, NJ:

Arlington, VA:

Fitzwilliam, NH:

Clinton, MS:

Bartow County, GA:

6) Examine the climate data for each site. On the sighting date, was the temperature and precipitation the highest value for that seven day period? In the table below, write yes if so; no if not.

Location	Yes / No
Warren County, NJ	
Arlington, VA	
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Bartow County, GA	

a. Does it appear that one variable is more important than the other for predicting amphibian migration, or are both equally important?

7) The data you entered in Excel will generate a graph of Latitude and Sighting Date on the Summary worksheet. Examine this graph.
    a. What is the relationship between latitude and migration date? Why do you think this is?

    b. Based on your latitude, when would you predict amphibians to migrate?

8) Use the provided instructions to import Temperature Data into the graph of latitude and sighting data on the Summary worksheet in Excel.
    a. What is the relationship between temperature and migration date?

    b. If a week of unusually warm weather occurred early in the year at a high latitude location, how might this affect amphibian migration?

    c. What might be more important to amphibian migration: maximum or minimum temperature?

9) What do you think are the most important environmental variables that cue migration events in amphibians?

10) It is projected by the United States Global Change Research Group[9] that the average U.S. temperature will increase by 4–11˚C by the year 2100. How might this change affect the timing of amphibian migration in the eastern United States?

11) How might data collected about amphibian migrations be used by scientists studying climate change?

[9] http://globalchange.gov/what-we-do/assessment/previous-assessments/global-climate-change-impacts-in-the-us-2009

Student Instructions – Print-Out Version

Background Information

In the spring, many amphibians emerge from their hibernation sites and migrate to a special temporary habitat called a vernal pool to breed. Read the provided article[1] "An Ecological Spring Awakening in Our Vernal Pools" by Dr. Jonathan Richardson and Hank Gruner.

The journey from hibernation sites to vernal pools may be quite long and perilous. The migration path may traverse roadways, where amphibians can be killed by cars. They must also face the threat of predation, desiccation, and disease as they travel. The migration event is also a seasonal opportunity for human beings to observe amphibians that are usually reclusive. Certain environmental cues, such as rainfall and warming temperature, are believed to trigger migration. Those who are interested in protecting amphibians or observing their fascinating journey to the vernal pools might want to predict when a migration event may occur in their location. For example, in East Brunswick, New Jersey, the Friends of the East Brunswick Environmental Commission[2] consult many factors in order to predict the timing of migration events and close roadways to protect the salamanders and allow the community to view their migration. Read more about the East Brunswick amphibian community in the provided article[3].

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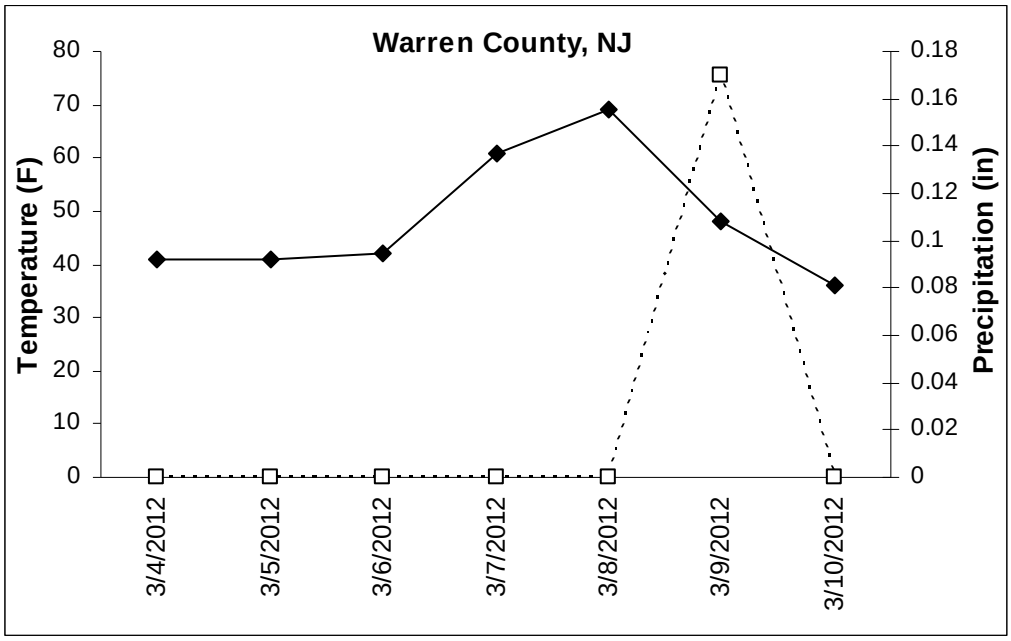
The timing of amphibian migration events depends upon local climate and environmental variables. To make your prediction, you will need to consider the local weather conditions that might cue the amphibians to begin their migration.

In the scientific method, a hypothesis is a guess that may explain a phenomenon. Predictions are then derived from the hypothesis and tested. If the results of the test fulfill the prediction, the hypothesis is supported by the data. It is hypothesized that amphibian migration is cued by a combination of temperature and precipitation cues. The predictions that you make are derived from this hypothesis, and can be tested by comparing your predictions with data from the Amphibian Tracker. If your predictions hold true, then your work contributes to the body of evidence in support of the hypothesis. Of course, a test should be repeated more than once to decrease the likelihood that the prediction was fulfilled simply by chance alone.

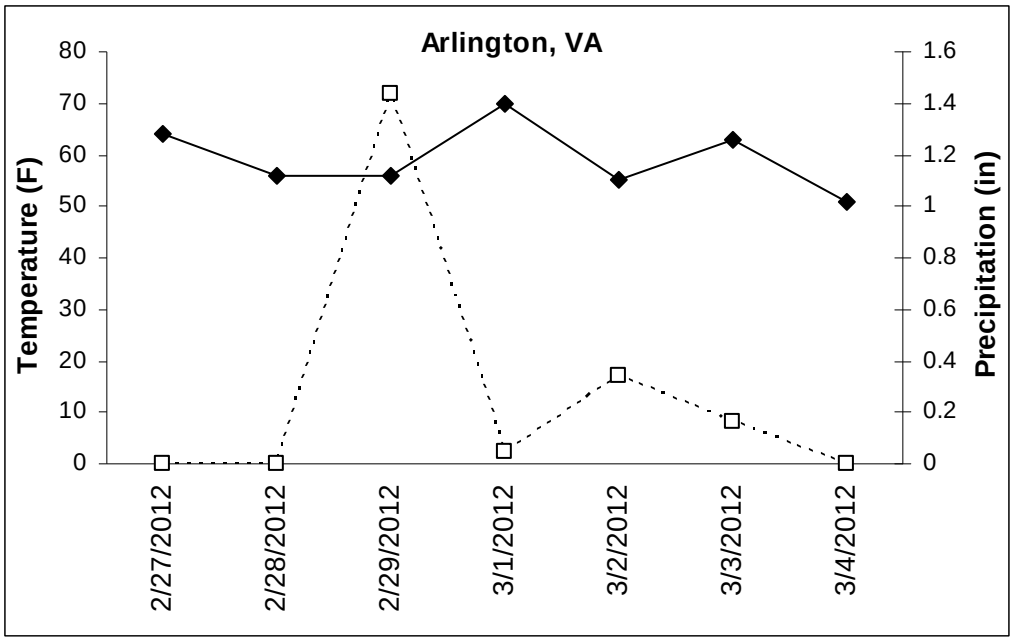
Climate Data

Below are graphs and tables of corresponding climate data for five locations in the eastern United States. For each graph, Temperature is plotted on the left y-axis and represented by filled diamonds, and Precipitation is plotted on the right y-axis and represented by open squares.

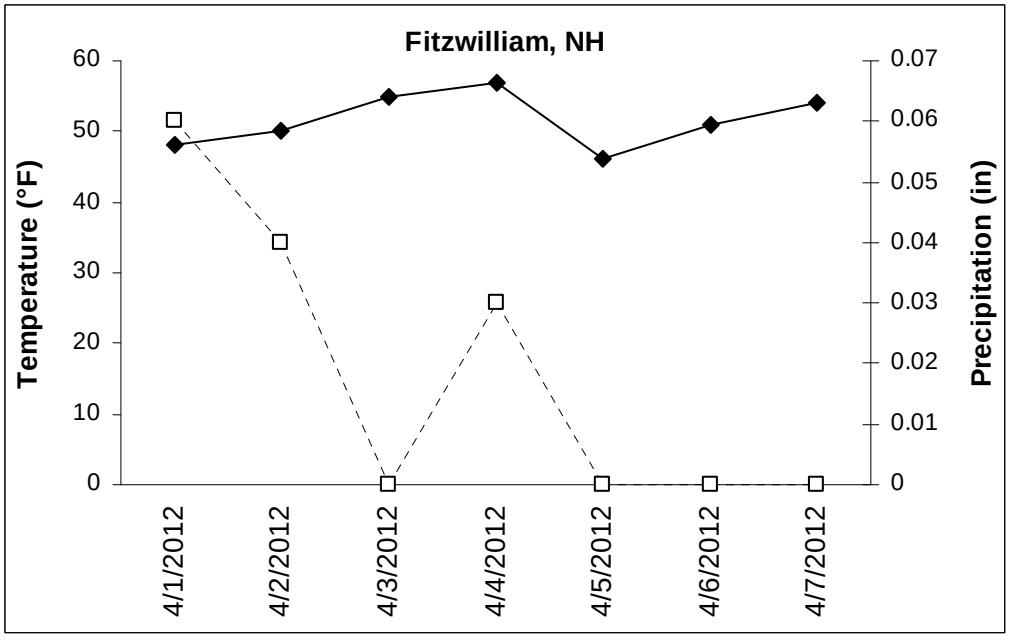


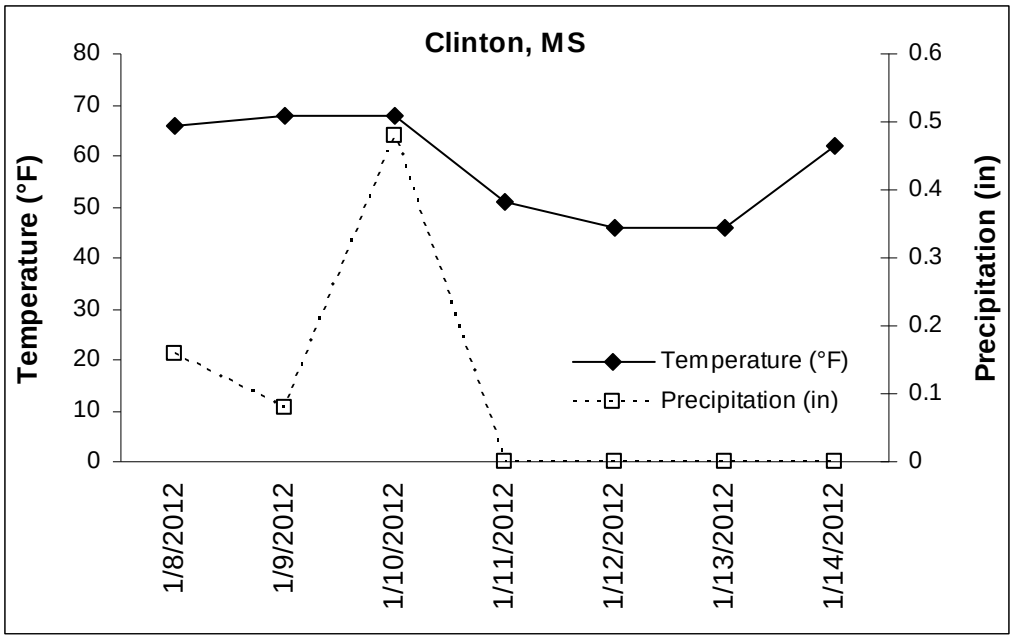
Warren County, NJ

Date	Temperature (°F)	Precipitation (in)
3/4/2012	41	0
3/5/2012	41	0
3/6/2012	42	0
3/7/2012	61	0
3/8/2012	69	0
3/9/2012	48	0.17
3/10/2012	36	0

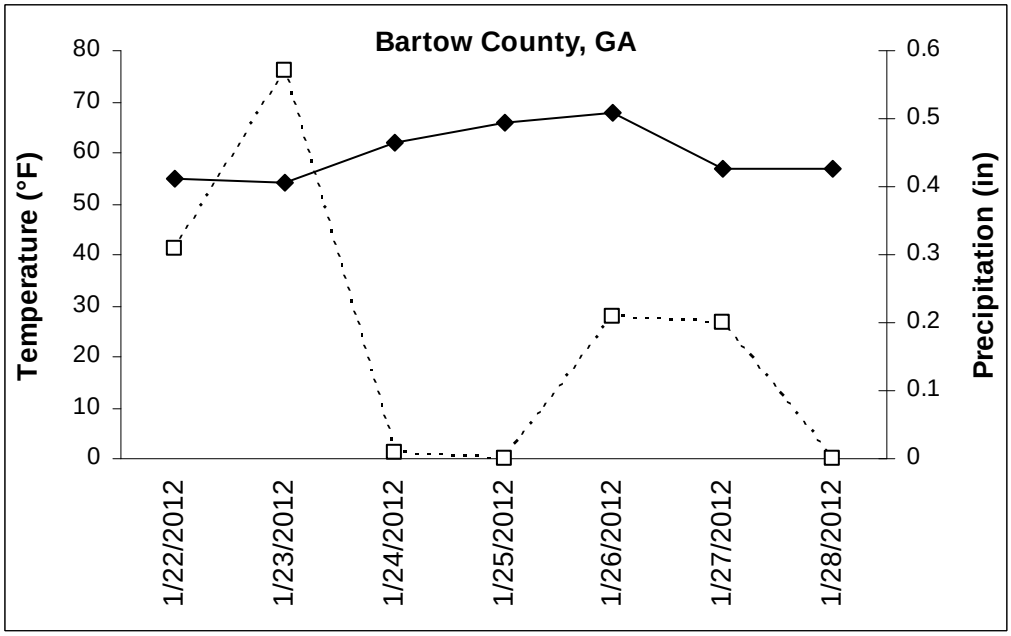


Arlington, VA			Fitzwilliam, NH		
Date	Temperature (°F)	Precipitation (in)	Date	Temperature (°F)	Precipitation (in)
2/27/2012	64	0	4/1/2012	48	0.06
2/28/2012	56	0	4/2/2012	50	0.04
2/29/2012	56	1.44	4/3/2012	55	0
3/1/2012	70	0.05	4/4/2012	57	0.03
3/2/2012	55	0.34	4/5/2012	46	0
3/3/2012	63	0.16	4/6/2012	51	0
3/4/2012	51	0	4/7/2012	54	0





Clinton, MS			Bartow County, GA		
Date	Temperature (°F)	Precipitation (in)	Date	Temperature (°F)	Precipitation (in)
1/8/2012	66	0.16	1/22/2012	55	0.31
1/9/2012	68	0.08	1/23/2012	54	0.57
1/10/2012	68	0.48	1/24/2012	62	0.01
1/11/2012	51	0	1/25/2012	66	0
1/12/2012	46	0	1/26/2012	68	0.21
1/13/2012	46	0	1/27/2012	57	0.2
1/14/2012	62	0	1/28/2012	57	0



Directions and Data Collection

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3) Using the Amphibian Tracker Map[8], look up the **actual** amphibian Sighting Date for each location and record in the table below and in the appropriate box on the Data worksheet in Excel. For some locations, there may be multiple amphibian sightings listed. Be sure to *look through all of the results for each location* and choose the sighting that occurred within the week of provided climate data.

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[8] http://goo.gl/maps/ubix6

4) Using the climate data provided in the Data worksheet, look up the Temperature on the actual sighting date for each location and record in the table below in the appropriate box on the Data worksheet in Excel.

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5) For each location, was your prediction correct? Why or why not?
Warren County, NJ:

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6) Examine the climate data for each site. On the sighting date, was the temperature and precipitation the highest value for that seven day period? In the table below, write yes if so; no if not.

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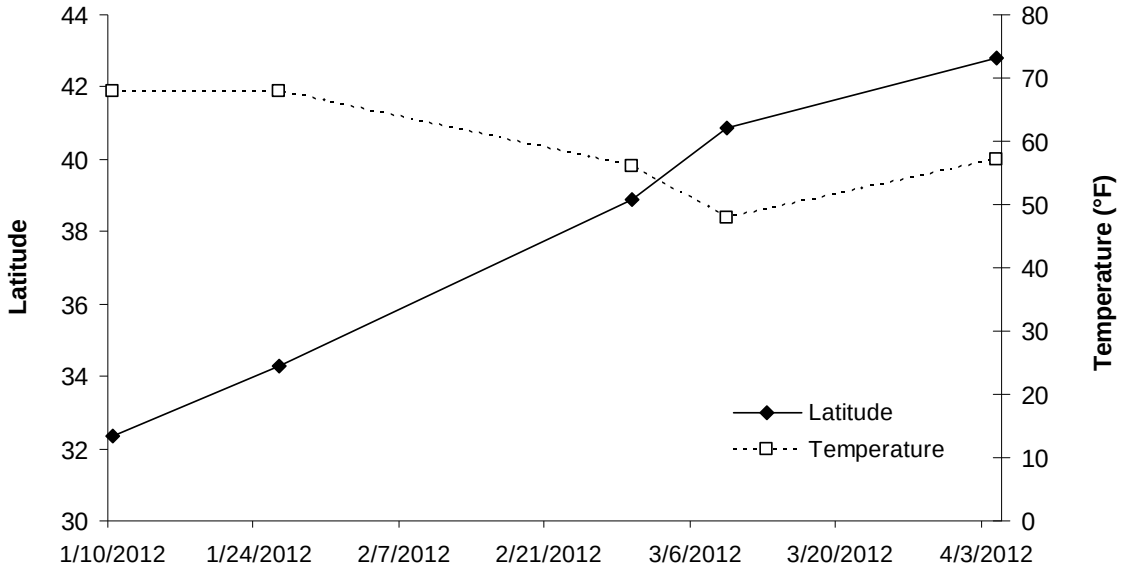
Clinton, MS	
Bartow County, GA	

a. Does it appear that one variable is more important than the other for predicting amphibian migration, or are both equally important?

7) The graph below shows Latitude and Temperature in relation to amphibian Sighting Date.



a. What is the relationship between latitude and migration date? Why do you think this is?

b. Based on your latitude, when would you predict amphibians to migrate?

c. What is the relationship between temperature and migration date?

d. If a week of unusually warm weather occurred early in the year at a high latitude location, how might this affect amphibian migration?

e. What might be more important to amphibian migration: maximum or minimum temperature?

8) What do you think are the most important environmental variables that cue migration events in amphibians?

9) It is projected by the United States Global Change Research Group[9] that the average U.S. temperature will increase by 4–11˚C by the year 2100. How might this change affect the timing of amphibian migration in the eastern United States?

10) How might data collected about amphibian migrations be used by scientists studying climate change?

[9] http://globalchange.gov/what-we-do/assessment/previous-assessments/global-climate-change-impacts-in-the-us-2009

Student Instructions – Formal Lab Report

Introduction:

In this section, you should introduce the topic that is being investigated. To do so, you will need to cite important information that you have learned from the provided background information.

Generally, scientific papers do not contain quotations of another author's writing – not even just a few words or phrases. You should aim to present all of the information in your own words, without using the words of the original author. Whenever you communicate information that is not general knowledge and that you obtained from another source, it is important to credit the author of the original work. You may do so in parentheses at the end of the sentence, or within the sentence itself.

Example:

Some vernal pools fill with water when trees lose their leaves and are no longer pulling water from the pool with their roots (Richardson 2012).

OR

As described by Richardson (2012), some vernal pools fill with water in autumn, when trees lose their leaves and are no longer pulling water from the pool with their roots.

All sources that you have cited should also appear in a "References Cited" list at the end of your report.

Your introduction should begin with a broad idea, and then increase gradually in level of detail. You might begin by stating a basic idea about migration or amphibians that is important to the rest of your investigation.

By the end of your introduction, the reader should understand precisely what your questions were when you began your investigation and why these questions are important or interesting. Your questions should be specific to the particular organisms and environment that you are studying.

Be sure to clearly state your hypothesis and your predictions. Refer back to the section of the student instructions entitled "Your Task" for more information.

Methods:

Scientific papers generally contain a methods section explaining how the investigation was conducted in detail. This is important because other scientists may wish to repeat the study, utilize the method in a similar study, or offer criticism of the way the study was conducted. This enables the scientific community to ensure the quality of research and share ideas with one another.

Scientists may use a wide variety of methods to answer a research question, such as experimentation, simulation, mathematical modeling, or synthesizing other existing research. Think carefully about the method that you used to answer your question in this investigation. Which data did you use? Where did the data come from? How were the data analyzed? Provide as much information as you are able to.

Results:

In this section, the results of the investigation are presented, both in words and through figures. Describe in words whether or not your predictions came true and the weather conditions on days of amphibian migration sightings. You should also include the graph of latitude, temperature and amphibian sightings that was generated in Microsoft Excel. You can do this by simply copying the graph on your clipboard and pasting into your report.

Discussion:

In the discussion section, discuss the significance of your results and whether or not your predictions were fulfilled. Was your hypothesis met? Discuss the importance of environmental cues and latitude to amphibian migration and the potential implications of climate change.

Also, discuss suggestions for further study. Sometimes new research questions emerge from the results of an investigation.

References Cited:

For each source cited in your writing, a corresponding full citation should be listed here. Citations should appear in alphabetical order.

Field Trip to a Vernal Pool

After completing this lesson plan, students can put their knowledge about amphibian migrations to use as they help plan a class field trip to a local vernal pool. The class can work together to use local weather predictions and records of local amphibian migrations to select a date for their field trip. It would be advisable for the classroom teacher to contact local conservation groups, who can help you determine the best date and time to visit.

You may wish to create a field data sheet for students to bring on the trip. Students can use their data sheets to record data about adult amphibians, tadpoles, or egg masses that they observe at the vernal pool. They can also make observations and collect data about the habitat at the field site, such as weather conditions, vegetation, and water quality.

A monitoring program may exist in your state where your class can submit the data that you have collected to a conservation group or wildlife association that is interested in the condition of local vernal pools. Such programs may have their own data sheets and a special method for submitting data.

Monitoring program websites are excellent resources for planning a field trip to a vernal pool. Handbooks for visiting vernal pool sites, field data sheets, or identification reference sheets may be provided, and can be used as examples when planning your trip.

Monitoring, Mapping and Certification Programs by State:

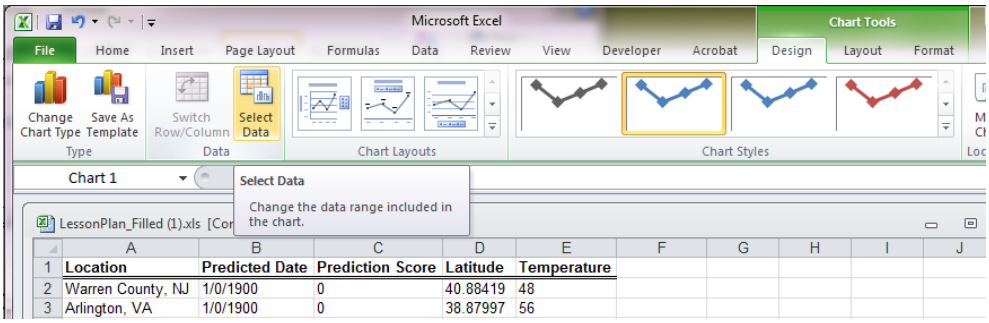
Connecticut Vernal Pool Monitoring Program: http://www.ctwetlands.org/vpmonitoring.html
Massachusetts Vernal Pool Certification: http://www.vernalpool.org/macert_1.htm
Ashuelot Valley Environmental Observatory: http://www.aveo.org/citizen-science/vernal-pools/
Vermont Vernal Pool Mapping Project: http://www.vtecostudies.org/VPMP/index.html
New York Department of Environmental Conservation: http://www.dec.ny.gov/lands/51925.html

What to Bring on the Field Trip:

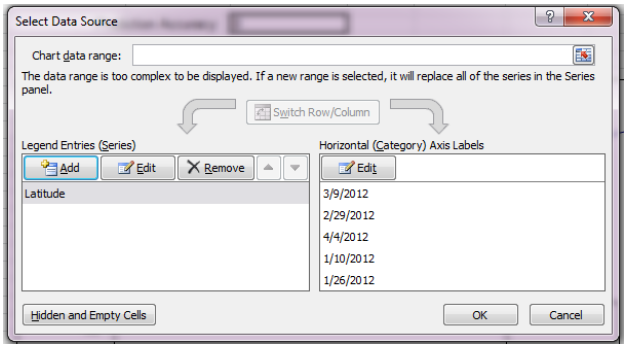
- Footwear that is appropriate for the field (rain boots, old sneakers, or waders if available)
- Weather-appropriate clothing and raincoat (if needed)
- Clipboards, pencils and field data sheets
- Polarized sunglasses (optional)
- Camera
- Small plastic bins for capturing and examining organisms
- Dip nets
- Map of the field site
- First aid kit

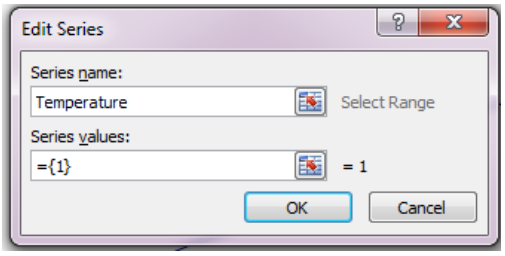
Instructions for Using Microsoft Excel – Professional Edition 2010

Click once on the graph to select it.
Under Chart Tools menu, select **Design,** and then **Select Data**.

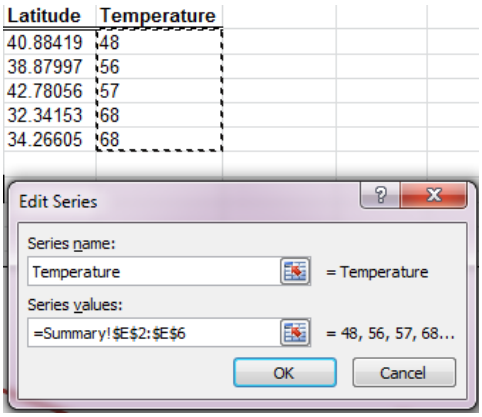


Under the Series tab, click the **Add** button. Type *Temperature* in the **Series Name** box. Then clear the text in the **Series Values** box.

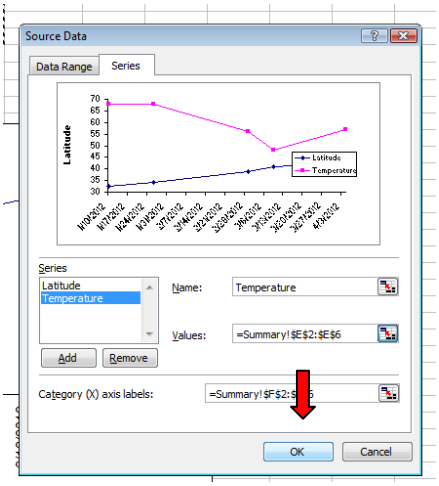




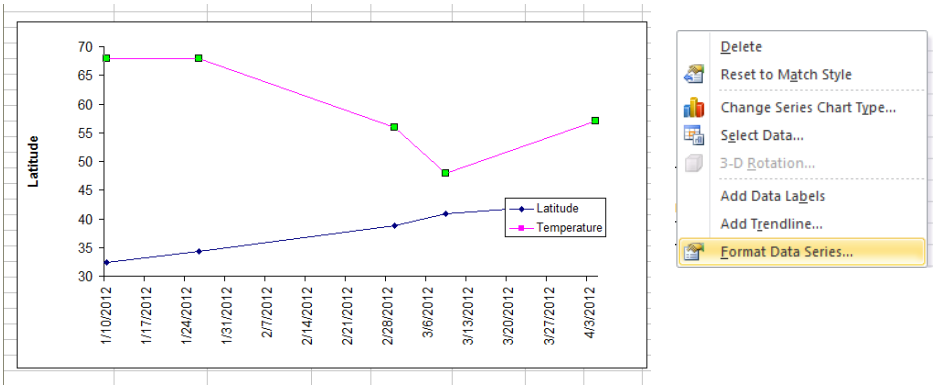
With your cursor in the Series Values box, select the data from the Temperature column using your mouse/touchpad. The data will now be in the Series values box. Click OK.



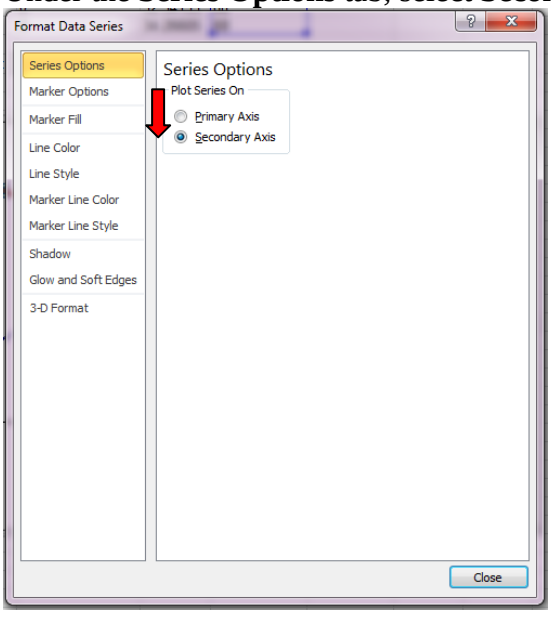
Then click **OK** in the Source Data window.



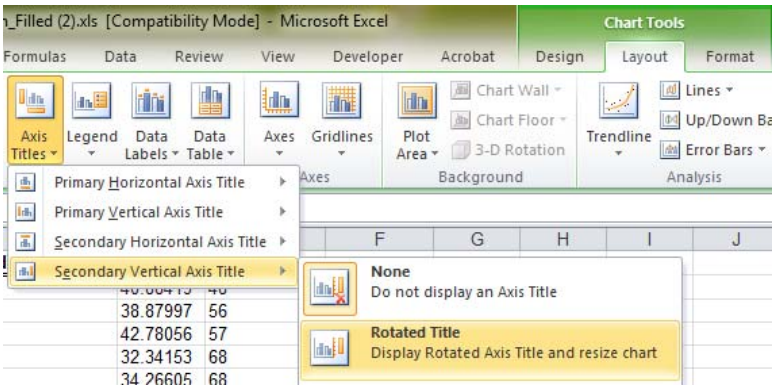
Right click on any point of the Temperature line within the graph and select **Format Data Series**.



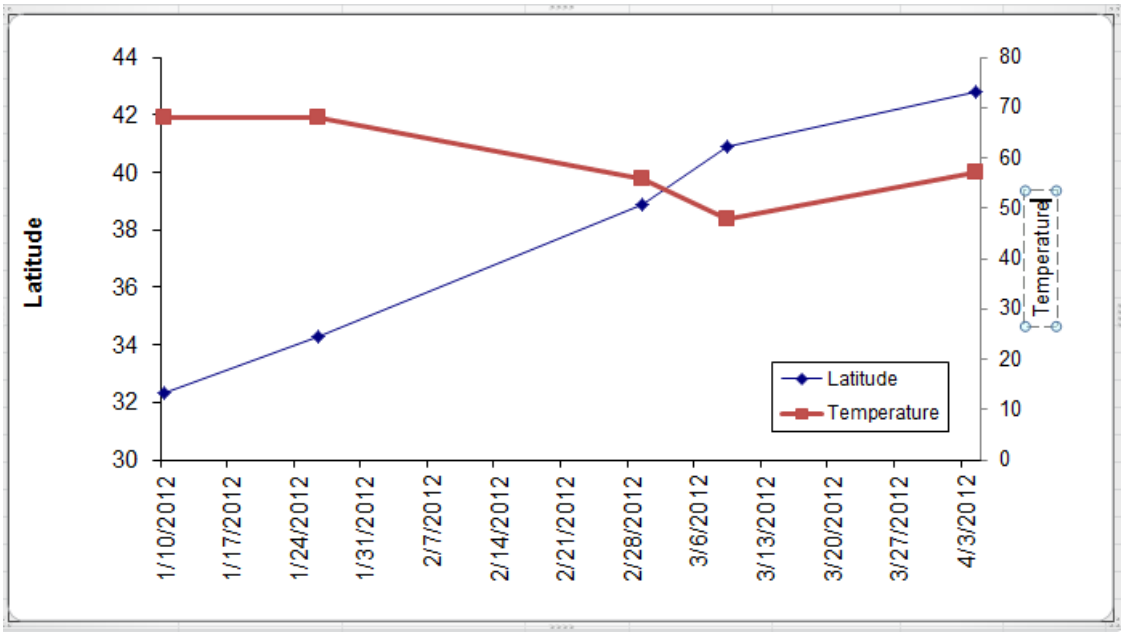
Under the **Series Options** tab, select **Secondary axis**. Then click **OK**.



Click once on the chart to select it again.
Under the Chart Tools menu, select **Layout**, then **Axis Titles**, **Secondary Vertical Axis Title,** and **Rotated Title.**

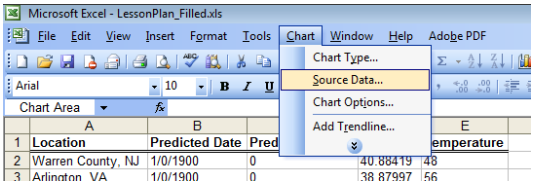


Type *Temperature* in the text box that appears near the secondary axis.

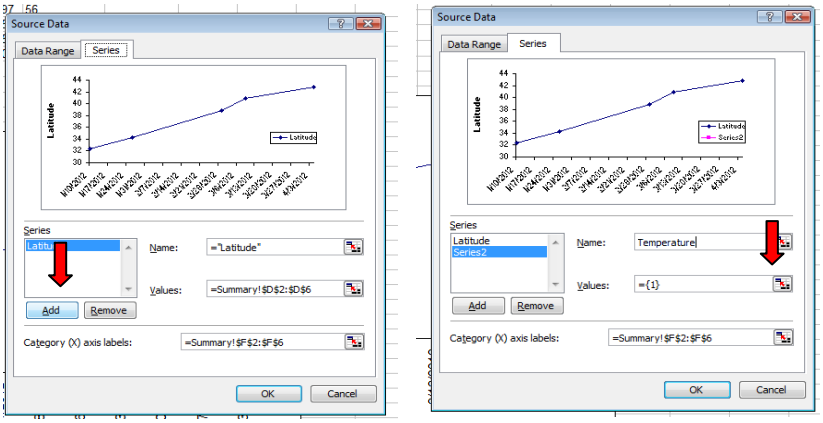


Instructions for Using Microsoft Excel – Professional Edition 2003

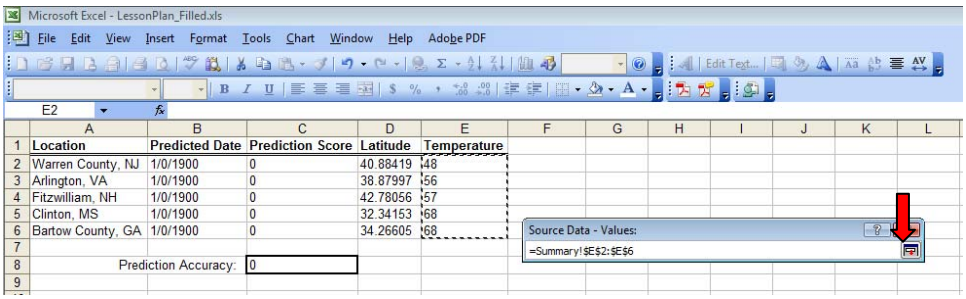
Click once on the graph to select it.
From the **Chart** menu, select **Source Data**.



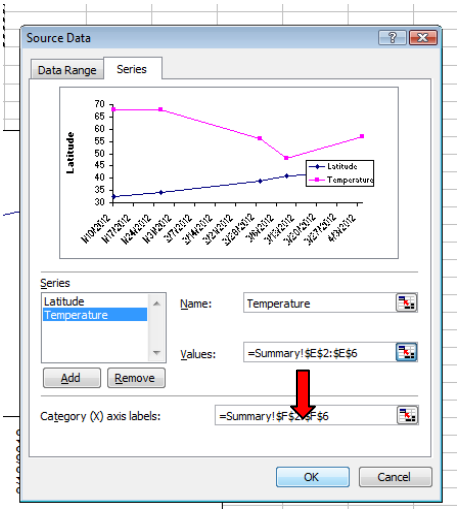
Under the Series tab, click the **Add** button. Type *Temperature* in the **Name** box.
Then click the box in the **Values** cell.



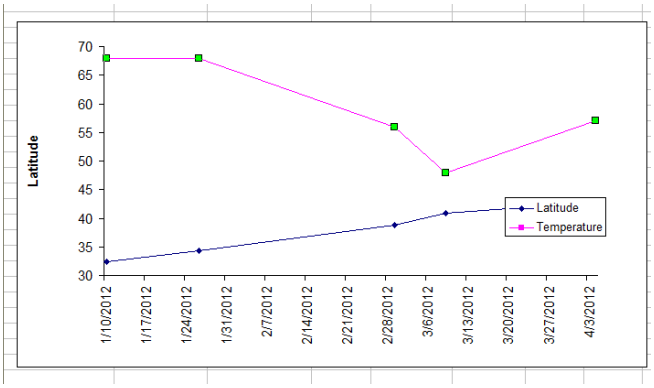
Select the data from the Temperature column using your mouse/touchpad, and then click the box in the Values window. The data will now be in the Values cell.



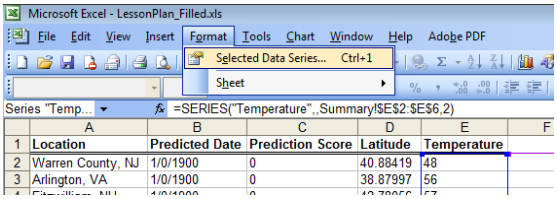
Then click **OK**.



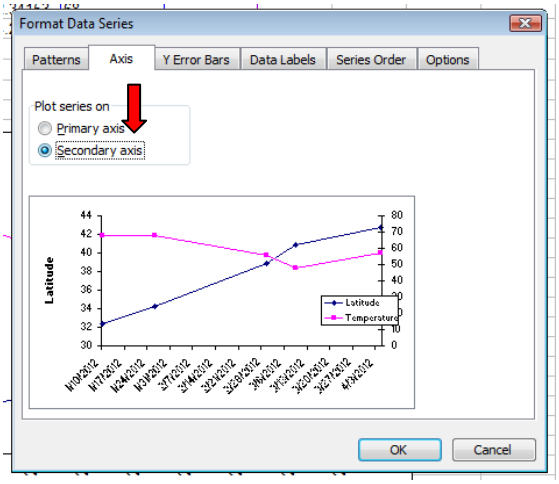
Click on any point of the Temperature line within the graph to select the Temperature data series.



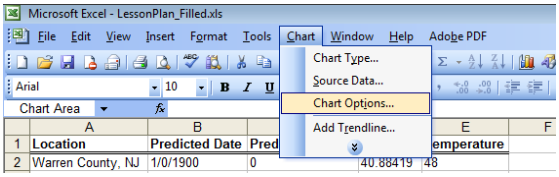
From the **Format** menu, select **Selected Data Series**.



Under the **Axis** tab, select **Secondary axis**. Then click **OK**.



From the **Chart** menu, select **Chart Options**.



Type *Temperature* in the box under **Second value (Y) axis**. Then click **OK**.