

# North of the Border:

Are Nonnative Species Moving Northward As the Climate Changes?

## *What Kinds of Scientists Did This Research?*

**botanist:** This scientist studies plants.

**ecologist:** This scientist studies organisms and their relationship with their living and nonliving environment.

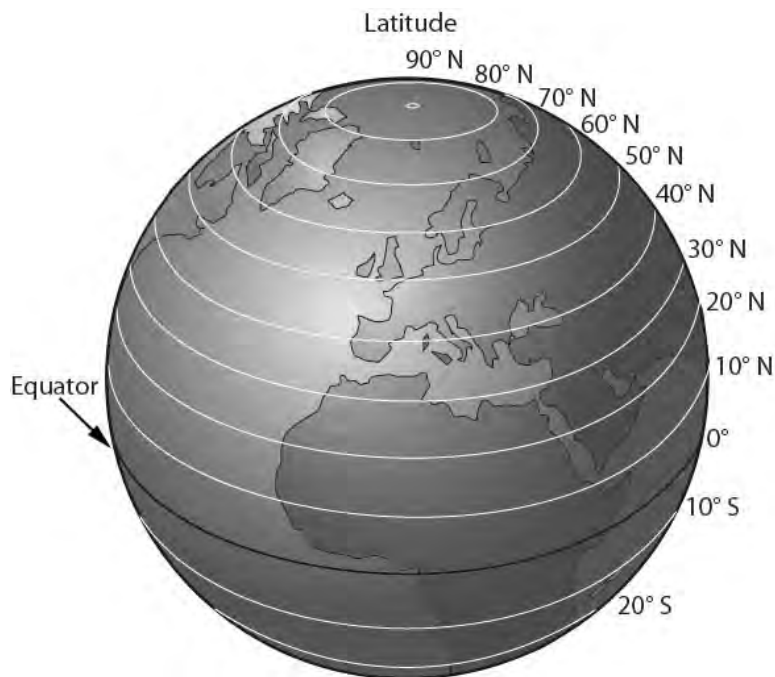
# Thinking About Science

As science advances over time, new scientific questions are continually discovered. Many of the scientific questions asked today would have been unthinkable even ten years ago. Every time a team of scientists learns something new, the new finding creates new questions. New technology, in addition, enables scientists to explore questions that could not have been explored in the past. The world of science, therefore, keeps expanding. Now is an exciting time to be a scientist. The future will bring even more opportunities for scientific exploration.



# Thinking About the Environment

Plants and nonhuman animals live in a particular range, or area. Range is determined by many factors. Some of these factors include temperature, amount of rainfall, soil type, and **elevation**. The scientists in this research identified plant and animal species' ranges by latitude (FIG. 1).



**FIGURE 1. LATITUDE MEASUREMENTS ARE TAKEN BY OBSERVING IMAGINARY LINES ON EARTH'S SURFACE FROM THE EQUATOR TO THE POLES. EACH IMAGINARY LINE OF LATITUDE IS NUMBERED. THESE MEASUREMENTS ENABLE SCIENTISTS TO EXACTLY IDENTIFY AREAS ON EARTH BETWEEN THE EQUATOR AND THE POLES. AREAS CLOSE TO THE EQUATOR ARE WARMER THAN AREAS CLOSE TO THE POLES. ILLUSTRATION BY SAMANTHA BOND.**

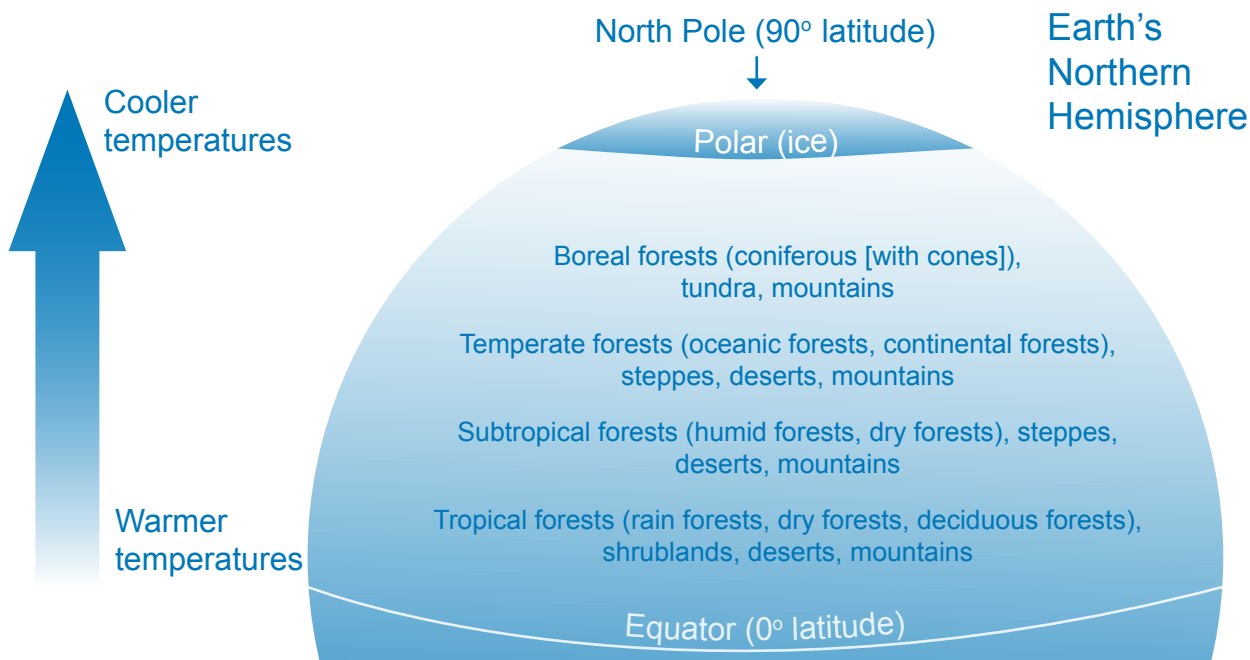
## Meet the Scientist



**Qinfeng Guo,**  
ECOLOGIST:

My favorite science experience is exploring plants and their **habitats** in the field, especially in the **tropics**. I want to know why certain habitats have more **native** or nonnative species than others and how native species interact with those introduced from elsewhere. I am also always **intrigued** by the specific functions performed by each species in an ecosystem.

Photo by Stephanie Worley Firley.



**FIGURE 2.** TROPICAL PLANTS GROW IN AREAS CLOSE TO THE EQUATOR. LAND LYING FARTHER FROM THE EQUATOR HAS DIFFERENT TYPES OF PLANTS. AREAS WITH DIFFERENT TYPES OF PLANTS ARE BROADLY CLASSIFIED AS TROPICAL, SUBTROPICAL, TEMPERATE, AND BOREAL.

Scientists can determine the highest and lowest latitude in which a species lives in a particular area. Areas close to the equator are warm, and areas close to the poles are cold. The average weather, or climate, affects the type of vegetation growing in an area (FIG. 2). Although many factors affect the range of plants and animals, latitude is one way to define a species' range.

## Introduction

Nonnative plant and animal species live in areas where they are not naturally found. These species were brought to new areas on purpose or by mistake. Nonnative plants, for example, may have been brought to a new area on purpose to help beautify an area. Harmful insects, on the other hand, might have moved to a new area by riding on a wooden packing crate. These insects were brought to the new area by mistake. Some nonnative species live and survive in a new area without human help. Scientists call these nonnative species naturalized (**na chə rə līzd**).

## Number Crunch

A circle has 360 degrees. How many degrees of latitude are found between the North Pole and the South Pole? (Hint: The area between the North Pole and the South Pole is one half of a circle.)





A nonnative species becomes naturalized by successfully competing with native species. Naturalized species compete with native species for food, water, sunlight, space, and other resources. This competition can harm native species and can change the native ecosystem. Scientists want to understand and predict the impact of nonnative species. To do this, scientists need to know where these species become naturalized.

A naturalized species has two ranges. The first range is the one where the species lives in its native habitat. The second range is the one where the species is naturalized, surviving in a nonnative area without the help of humans. A species' range is limited by its ability to survive in different climates. Species, therefore, are more able to survive east to west across the globe, but are limited by latitude. The scientists in this study wanted to answer this question: Are naturalized species' latitudinal ranges the same, larger, or smaller than their native ranges?

## Reflection Section



- ➡ Describe the problem caused by naturalized species.
- ➡ Should humans care about what happens to native species? Why or why not?

## Methods

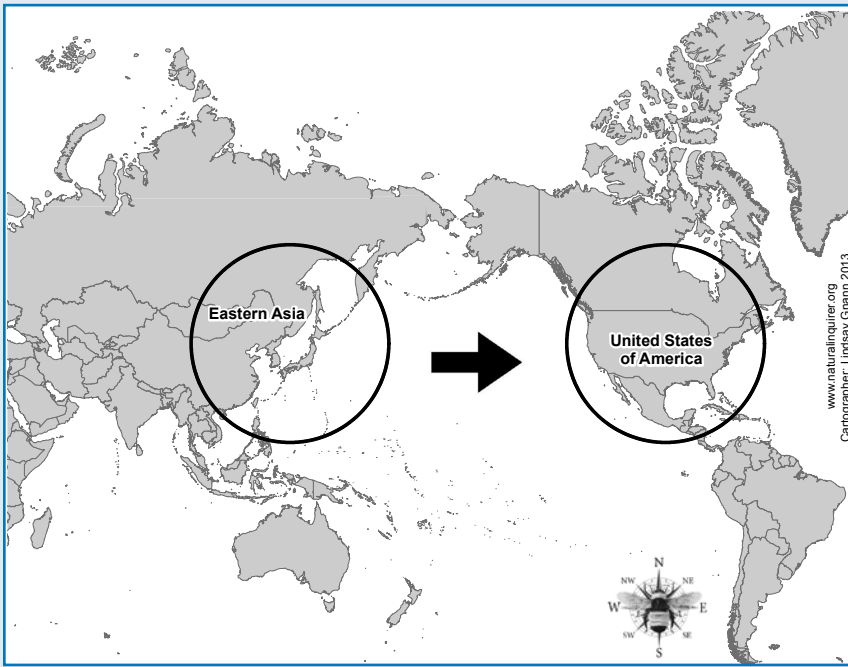
The scientists used **databases** that identify the ranges of 744 plant, bird, and **mammal** species. Bird and mammal species were introduced globally across different continents. Some plant species were brought from eastern Asia to the United States (FIG. 3). The naturalized United States species included 147 bird species, 85 mammal species, and 512 plant species (FIGS. 4-9).

## Meet the Scientist



**Hong Qian,**  
BOTANIST AND ECOLOGIST:

My favorite science experience is finding out what causes different species to live in different areas worldwide. One of the most interesting questions is what causes the "latitudinal diversity gradient." Over 200 years ago, scientists noticed that many different species live in and near tropical regions. In habitats closer to the poles, however, fewer different species are found. Causes of the latitudinal diversity gradient are not well known. In my research, I explore how **evolutionary** processes and **ecological** factors interact to influence global patterns of species diversity.



**FIGURE 3.** THE SCIENTISTS STUDIED THE NATIVE AND NATURALIZED LATITUDINAL RANGES OF PLANTS BROUGHT FROM EASTERN ASIA TO THE UNITED STATES. MAP BY LINDSAY GNANN.



**FIGURE 4.** CATTLE EGRET. PHOTO COURTESY OF JOY VIOLA, NORTHEASTERN UNIVERSITY, AND [HTTP://WWW.BUGWOOD.ORG](http://www.bugwood.org)



**FIGURE 5.** EUROPEAN STARLING. PHOTO COURTESY OF LEE KARNEY, U.S. FISH AND WILDLIFE SERVICE, AND [HTTP://WWW.BUGWOOD.ORG](http://www.bugwood.org).



**FIGURE 6.** BLACK-TAILED JACKRABBIT. PHOTO COURTESY OF THE U.S. FISH AND WILDLIFE SERVICE ARCHIVE, AND [HTTP://WWW.BUGWOOD.ORG](http://www.bugwood.org).



**FIGURE 7. COMMON BRUSH-TAIL POSSUM.** PHOTO COURTESY OF ALFRED VIOLA, NORTHEASTERN UNIVERSITY, AND [HTTP://WWW.BUGWOOD.ORG](http://www.bugwood.org).



**FIGURE 8. GARLIC MUSTARD.** PHOTO COURTESY OF CHRIS EVANS, ILLINOIS WILDLIFE ACTION PLAN, AND [HTTP://WWW.BUGWOOD.ORG](http://www.bugwood.org).



**FIGURE 9. KUDZU.** PHOTO COURTESY OF JAMES H. MILLER AND TED BODNER, SOUTHERN WEED SCIENCE SOCIETY, AND [HTTP://WWW.BUGWOOD.ORG](http://www.bugwood.org).

**For each plant and animal species, the scientists recorded:**

- The northernmost latitude of the species' native range.
- The southernmost latitude of the species' native range.
- The northernmost latitude of the species' naturalized range.
- The southernmost latitude of the species' naturalized range.



## What Makes an Observed Change Significant?

When scientists do experiments or make observations, they realize that they usually will not be able to make a conclusion for sure. In most instances, the best they can do is conclude that an observed change is not due to a chance occurrence. Depending on the number of observations and the strength of the observed change, scientists might call an observed change significant.

When scientists are fairly certain that the observed change was not caused by a chance occurrence, the change is considered significant. Scientists do not just decide for themselves whether a change is significant. Scientists use mathematical equations to determine whether a change is significant.

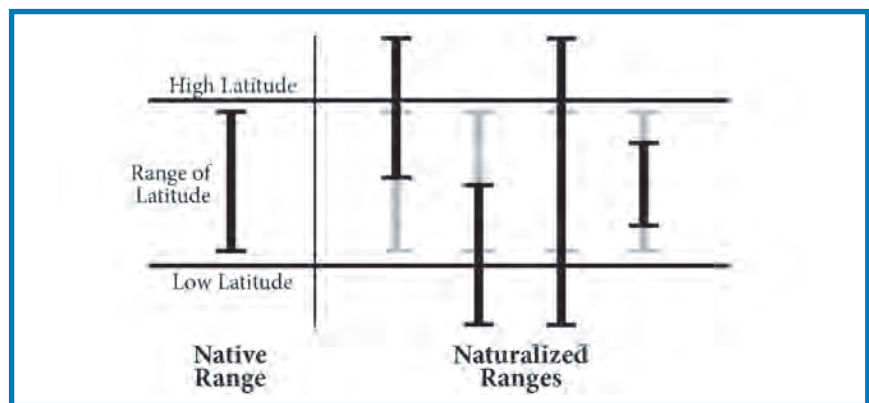
When most people say that something is significant, they mean that the event or object has a great amount of importance. When scientists say that an observed change is significant, they mean that it is very likely the change was not caused by chance.

Because latitude is expressed in numbers, the scientists were able to calculate certain things. From the northernmost and southernmost latitudes, the scientists calculated the midpoint of the range. The scientists also calculated the extent of each species' range. The extent is the total distance between the northernmost and southernmost latitudes.

### The scientists wanted to know three things:

1. Are naturalized species found in latitudes higher, lower, or the same as their native latitudes?
2. What percentage of species' naturalized ranges shifted toward the poles, toward the equator, or in both directions as compared with their native ranges (FIG. 10)?
3. Does a significant difference exist in the extent of naturalized ranges as compared with native ranges?

FIGURE 10. FOUR WAYS A NATURALIZED RANGE COULD SHIFT AS COMPARED WITH A NATIVE RANGE. ILLUSTRATION BY STEPHANIE PFEIFFER.



## Reflection Section



- ➔ How did the scientists calculate the midpoint of the ranges?
- ➔ Look at figure 10. This figure shows four ways the range of naturalized species could shift as compared with their native range. Do you think it is possible that the naturalized range might not shift at all? Why?

# Findings

The scientists found that the range midpoint for all species was similar for native and naturalized ranges. Of the species studied, individual plants showed the greatest similarity between their midpoints, followed by mammals and then birds. While the **average** midpoint might have been similar, individual bird species showed more variety in their midpoints overall.

In every case, however, the midpoint of the naturalized range was a bit higher than the native range midpoint (FIG. 11).





THE MUTE SWAN IS A NONNATIVE SPECIES.  
PHOTO BY JIM OCCI, BUGPICS, AND COURTESY OF HTTP://WWW.BUGWOOD.



Species	Degrees Latitude
Birds	0.23 degrees higher
Mammals	3.83 degrees higher
Plants introduced from Asia to North America	2.47 degrees higher

FIGURE 11. THE AVERAGE MIDPOINT OF THE NATURALIZED RANGE, COMPARED WITH THE NATIVE RANGE, IN DEGREES OF LATITUDE.

Legend for Figure 12

-  Shift toward the equator
-  Shift toward the North Pole
-  Shift toward the North Pole and the equator
-  No shift

Most species either shifted their naturalized range toward the North Pole or did not shift their range (FIG. 12).

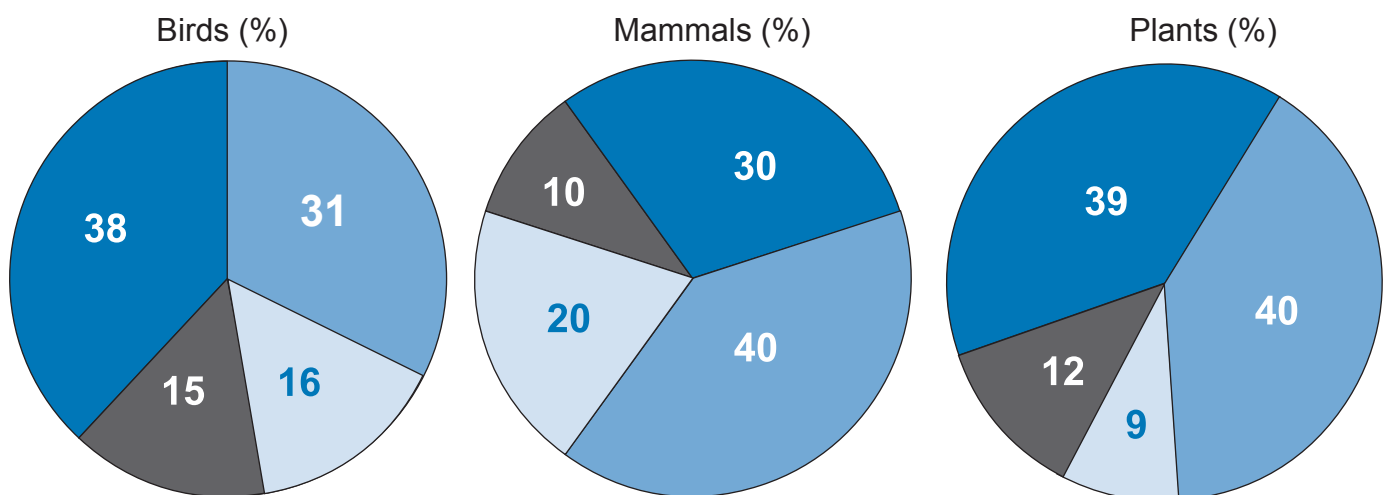


FIGURE 12. PERCENTAGE OF SHIFTING IN NATURALIZED RANGES COMPARED WITH NATIVE RANGES.

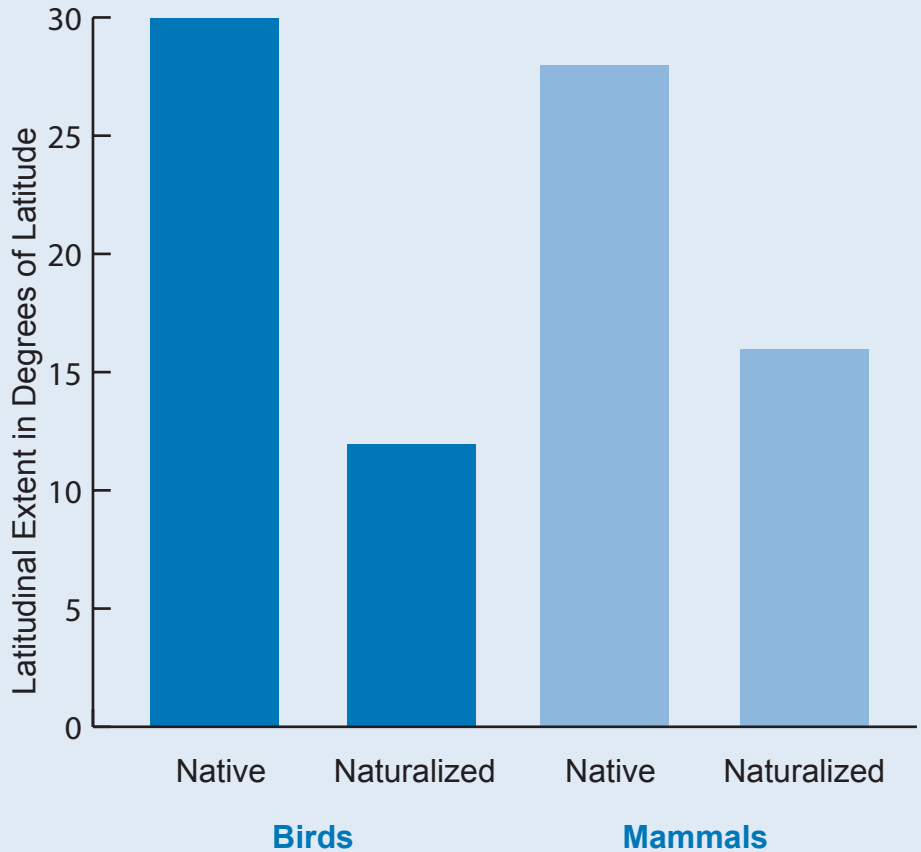




CHINESE VIOLET IS A NONNATIVE SPECIES. PHOTO BY FOREST AND KIM STARR, STARR ENVIRONMENTAL, AND COURTESY OF [HTTP://WWW.BUGWOOD.ORG](http://www.bugwood.org)

**FIGURE 13.** THE RANGE EXTENT WAS GREATER FOR SPECIES IN THEIR NATIVE RANGES.

The native range extent for most species was greater than their naturalized range extent. In other words, most native species lived across more degrees of latitude than the same species living in a naturalized range (FIG. 13).



## Reflection Section



- ➔ For the most part, the range of naturalized species either did not shift or shifted toward the North Pole as compared with native ranges. Why might some of the ranges shift toward the North Pole?
- ➔ The midpoint of naturalized ranges was similar to the midpoint of native ranges for all species. What is one possible explanation?

# Discussion

The scientists were particularly **intrigued** by one of their findings. They noted that bird, mammal, and plant species showed a slight shift in the North Pole's direction in their naturalized range. The scientists do not know why this is happening, but they have some ideas.

Humans might have introduced more nonnative species to higher latitudes across the United States than in lower latitudes. This introduction of more nonnative species would mean more naturalized species live in higher latitudes.

Another possible explanation involves climate change. Climate change has meant warmer temperatures across the United States.

Mammals and birds, which can easily move from place to place, may be moving north as the climate warms. Naturalized species, furthermore, may be more responsive to climate change than native species. This responsiveness may be true because naturalized species are not **constrained** by **predators** and competitors. In their native habitat, species evolve together to create a balance between predators and **prey**.

The nature of scientific study may also play a role. Newer studies of naturalized species include climate change effects. Older studies of native species' ranges may not include climate change. It may be that newer studies of native species' ranges would reflect a northern shift as well.

The findings show that when a species' native range is large, its naturalized range is also large. If no other information is available, this finding can help scientists predict the future range of naturalizing nonnative species. In addition, the findings show that naturalized ranges are, in general, smaller than native ranges. This finding could mean that naturalized species will continue to expand their range over time.

The scientists believe that species' range shift in the North Pole's direction is important. This shift may mean that the mix of species in higher latitudes will change in the future. More naturalized species at higher latitudes will cause northern ecosystems to change. These changes will place more stress on native species, which are already under stress from climate change.

## Reflection Section



- ➡ How do the scientists think climate change may be affecting species' naturalized ranges?
- ➡ What might happen to northern native species and ecosystems as naturalized species move northward?

Adapted from Guo, Q.; Sax, D.; Qian, H.; Early, R. 2012. Latitudinal shifts of introduced species: possible causes and implications. *Biological Invasions*. 14: 547–556. [http://www.srs.fs.usda.gov/pubs/ja/2012/ja\\_2012\\_guo\\_002.pdf](http://www.srs.fs.usda.gov/pubs/ja/2012/ja_2012_guo_002.pdf).



# Glossary

**average** (ə v(ə-)rij): The number determined by dividing the sum of two or more quantities by the number of quantities added.

**constrain** (kən **strān**): To hold in or keep back by force.

**database** (dā tə **bās**): A comprehensive collection of related data organized for convenient access, generally in a computer.

**ecological** (e kā **lä** ji kəl): Having to do with ecology. Ecology is the study of the relationship of living things with each other and their environment.

**elevation** (e lə **vā** shən): The height above sea level.

**evolutionary** (e və **lū** shən er ē): Of, relating to, or produced by evolution. Evolution is the process of continuous change from a lower, simpler, or worse state to a higher, more complex, or better state.

**habitat** (hə bə **tat**): The place or environment where a plant or animal naturally or normally lives and grows.

**intrigue** (in **trēg**): To arouse the interest, desire, or curiosity of.

**mammal** (mə **məl**): Any warm-blooded animal with a backbone and glands to produce milk for feeding their young.

**native** (nā **tiv**): Living or growing naturally in a particular region.

**predator** (pre də **tər**): An animal that preys on other animals for food.

**prey** (prā): An animal, including insects, taken by a predator for food.

**tropics** (trā **piks**): The region that surrounds the equator and goes from 23.5 degrees north latitude to 23.5 degrees south latitude.

**vertical** (vər **ti** kəl): Going straight up or down from a surface.

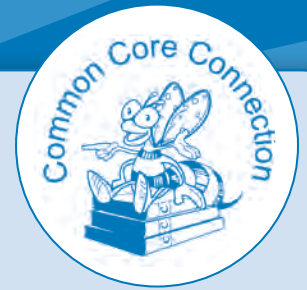
Accented syllables are in **bold**.  
Marks and definitions are from <http://www.merriam-webster.com>.



JACK-IN-THE-PULPIT IS A NATIVE SPECIES. PHOTO BY BABS McDONALD.



# FACTivity



## Time Needed

30-40 minutes

## Materials

- The data table provided in this FACTivity
- The two blank graphs provided in this FACTivity
- Pencil and thin black felt marker
- Piece of blank paper or science notebook
- Ruler (optional)

The question you will answer in this FACTivity is: What are general patterns, if any, between the native and naturalized ranges of 25 plant species?

## Methods

You will plot the native range and naturalized range of 25 plants on a graph. Note that these data are actual data provided to you by the scientists in this study. For each plant, place a dot on the graph at the southern and northern limits of its range. The degrees in latitude are given on the Y axis. (The y axis is on the left). Draw a dark vertical line with the felt marker to connect the two dots for each plant. See the example graph on page 85 before beginning.

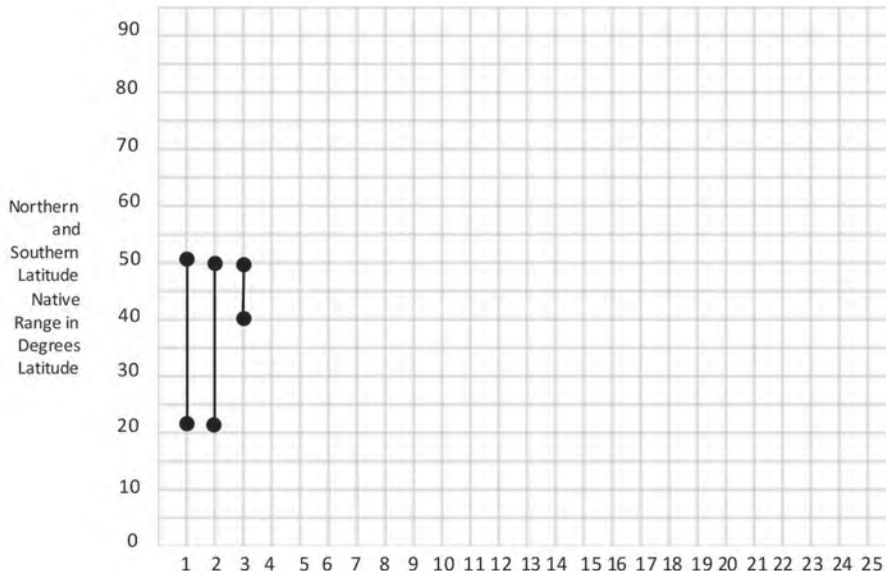
After you have finished completing both graphs, compare the two. Identify and write three observations about the overall patterns you see, using complete sentences, correct punctuation, and proper grammar.

THE MIMOSA TREE IS A NONNATIVE SPECIES. PHOTO BY JAMES H. MILLER, U.S. FOREST SERVICE, AND COURTESY OF [HTTP://WWW.BUGWOOD.ORG](http://www.bugwood.org).



Plant Number	Native Range in Degrees Latitude		Naturalized Range in Degrees Latitude	
	Southern Limit	Northern Limit	Southern Limit	Northern Limit
1	23.0	52.0	28.0	54.5
2	27.5	47.0	37.5	40.3
3	23.0	50.0	43.0	45.2
4	44.0	48.2	34.1	65.0
5	55.0	55.0	31.2	54.2
6	23.0	47.0	28.0	54.2
7	23.0	25.5	28.0	28.0
8	25.2	63.0	63.3	63.3
9	23.0	47.0	31.3	54.5
10	42.0	42.0	40.0	63.3
11	37.5	47.5	41.5	44.7
12	36.0	63.0	43.0	43.0
13	42.0	63.0	33.5	54.0
14	38.1	55.5	28.0	63.3
15	30.0	47.0	37.5	49.0
16	23.0	25.2	28.0	28.0
17	42.0	47.0	34.1	54.5
18	37.7	48.2	31.2	54.5
19	23.0	38.1	28.0	38.8
20	23.0	26.9	31.2	47.2
21	32.0	63.0	37.5	43.0
22	23.0	66.5	28.0	65.0
23	23.0	29.1	28.0	33.5
24	35.5	63.0	37.5	65.0
25	42.0	58.0	31.2	65.0

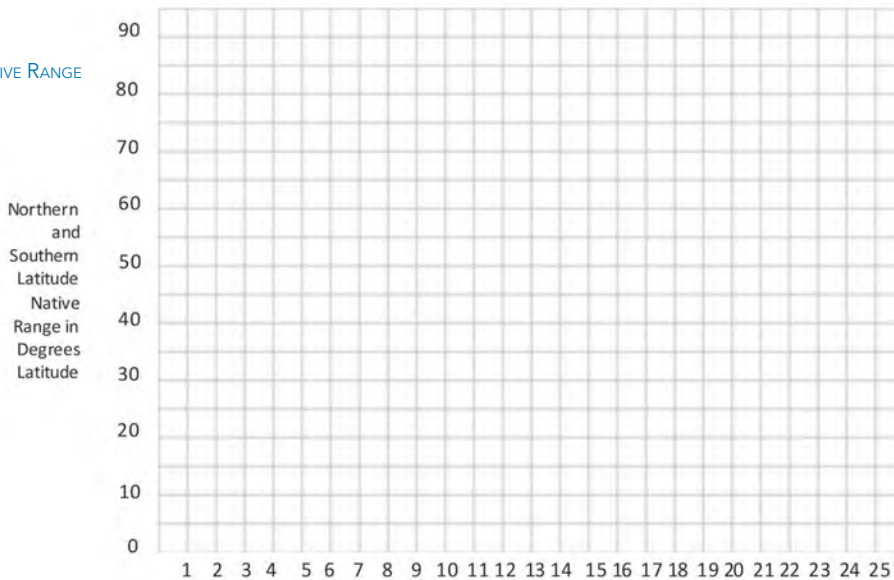
## Example Graph



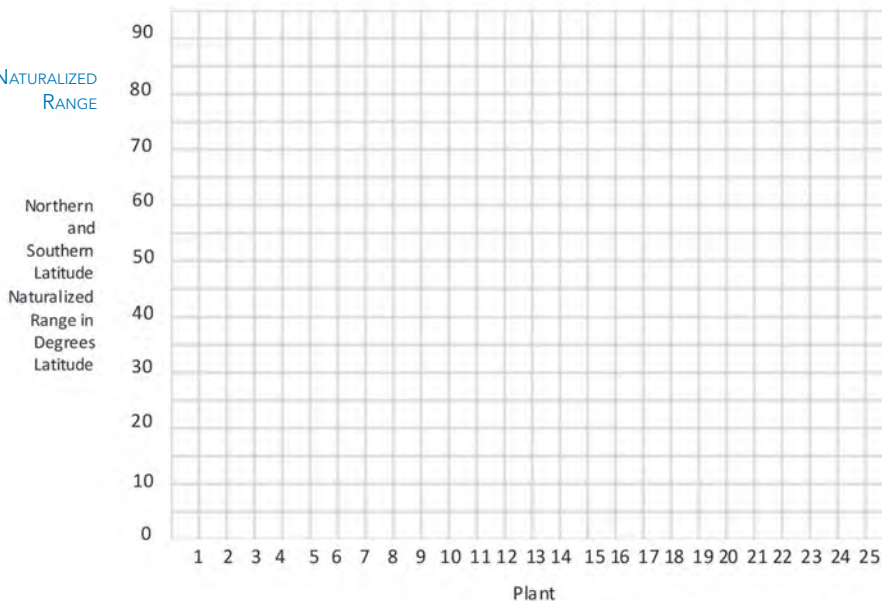
Your teacher will lead a class discussion with the following question:

*How do your observations compare with the scientists' observations for native and naturalized plant ranges and why?*

NATIVE RANGE



NATURALIZED RANGE



If you are a Project Learning Tree-trained educator, you may use *Invasive Species*, as an additional resource.



## FACTivity Extension



Calculate the range extent (in both ranges) for each of the 25 plants by adding the southern latitudinal limit to the northern latitudinal limit. Calculate the average latitudinal extent. Calculate the average for both the native and naturalized ranges. What pattern do you see between the two averages?

### Web Resources

Eastern Forest Threat Assessment Center Bookmarks  
<http://www.forestthreats.org/products/bookmarks>

Eastern Forest Threat Assessment Center Fact Sheets  
<http://www.forestthreats.org/products/fact-sheets>



THE GYPSY MOTH CATERPILLAR IS A NONNATIVE SPECIES. PHOTO BY U.S. FISH AND WILDLIFE SERVICE JAMES APPLEBY, UNIVERSITY OF ILLINOIS.