North American Plant Distributions: Yesterday, Today, and Tomorrow

High school students practice skills interpreting graphs and drawing conclusions while learning about North American plant diversity and distribution. First, they investigate current patterns of plant diversity and distribution across North America, exploring broad latitudinal gradients of species richness and climate influences on vegetation type. Second, they build on this knowledge to predict changes based on current projections on global warming.

Several enrichment activities focus on regional and local patterns of plant diversity and distribution. This shift allows students to grasp the importance of scale in ecology. Students have opportunities to explore the roles of biotic and abiotic factors, the natural changes during ecological succession, and the impact of introduced species on diversity and distribution.

Learning goals: to define the elements of a biome and compare land biomes, to understand the abiotic factors that influence biomes, to identify patterns of diversity and distribution, and their changes over time

Key words: ecosystem, biome, temperate zone, tropical zone, climate, abiotic factors, biotic factors, diversity, distribution, communities, ecological succession, global warming

Background

The North American continent treated in the *Flora of North America* covers 21.5 million km^2 of land, north of Mexico to the limits of plant life in the artic. It stretches between latitudes 26º and 85ºN, between longitudes 15ºW and 173ºE, and from sea level to high mountains. This great and varied landscape is home to about 20,100 plant species (about 21% of those are endemic). North America has most of the major land biomes found around the world: tundra, taiga, temperate forest, chaparral, grasslands, and deserts. Tropical forests and savannas are absent because the continent is centered in the temperate, not the tropical, zone.

Over Earth's long history the climate has shifted. The distribution of plants in North America has shifted too. Biomes map of ice-age periods and current conditions are strikingly different. Mean annual temperature during the last full-glacial period was about 6ºC lower. An ice sheet covered the northern half of North America. When warming began 18,000 years ago, this ice sheet retreated to the Arctic Circle and plants (such as spruces, pines, and oaks) advanced northward. Ice-age communities also included combinations of plants not seen today. Soil cores and fossils provide evidence of past conditions.

We rely on scientific predictions for an outlook on the future. Earth's climate has warmed by 0.6ºC in the last 100 years. The global climate is predicted to be 1.4 to 5.8ºC warmer by the end of this century. Plants are already responding to global change in some ways that meet predictions.

At high latitudes and alpine areas, where climate change is expected to be most severe, plant communities are shifting distribution. Shrubs are shifting northward and expanding into the Arctic. The treeline in North America, Europe, and New Zealand is advancing to higher elevations up mountain slopes. Plants in the Alps are shifting up slope by 1–4 meters in elevation per decade. Regional shifts in the distribution of particular plants species are expected. Responses in plant physiology and reproduction are also occurring. The length of the growing season in some areas has increased by about 3.6 days per decade over the last 50 years. What kinds of changes are expected (or already reported) in your region?

Minds-on Activities (Student Worksheets)

- *A Plant Number Game* **–** Interpret patterns of plant diversity across North America
- *Mapping North American Biomes* **–** Analyze climate graphs and vegetation maps
- *Charting Climate Change Effects* **–** Predict future changes in plant distributions

Enrichment Activities

- Why are some plant groups found in eastern North America and eastern Asia? Research how and why the distribution of plants such as *Liriodendron* or *Cornus* have changed over time.
- What patterns of diversity and distribution can you see in your schoolyard, backyard, or local park? As a class project, survey local diversity and distribution by sampling at least two vegetation plots. Identify differences in the plots and suggest explanations for patterns; then collect data to test the hypotheses (see the Lesson Exploring Local Biodiversity for details).
- Grasslands once covered 25% of North America, and the large bison herds that once ranged across the region are all but gone. Create a map of past distribution patterns for prairies and bison (or prairie dogs). What role do animals play on a prairie? What about fire?
- Do human activities help or hinder the natural cycle of ecological succession after a volcanic eruption, a major hurricane, or forest fire? Research a case study of ecological succession, such as Mount St. Helen's or Yellowstone National Park. Illustrate the natural stages from pioneer community to climax community, indicating how human actions can alter the process.
- Which introduced plants are problems in your region? Design a study on an invasive plant pest. Here are some starting questions: How quickly has the plant spread? Does it negatively affect native plants or animals; if so, how? What is the most effective way to control or permanently remove the plant?
- If land biomes cover only about 25% of the Earth's surface, what biomes cover the rest? What characteristics are important in describing these biomes? Map the global distribution of estuaries. Why do estuaries support so many organisms?
- Is the evidence for global warming convincing? Evaluate the evidence. Write a letter to the President of the United States, a senator, or a representative supporting or opposing the official position based on your evaluation of the evidence.

Explore more!

MBGNet – Missouri Botanical Garden's Education Department has biome photos and facts.
http://mbgnet.mobot.org/

Regional Centers of Plant Diversity – The National Museum of Natural History, Department of Botany has maps and data on centers of plant diversity within North America and other areas.
http://www.nmnh.si.edu/botany/projects/cpd/namap.htm

Canyons, Cultures and Environmental Change – Learn about past and present environments and human activity in the four corners region of Colorado, Utah, Arizona, and New Mexico.
http://www.cpluhna.nau.edu

Nearctica – All things North American are the focus of this site, with biomes links.
http://www.neararctic.com/ecology/habitats/biomes.htm

United States Global Change Research Program, US Climate Change Science Program – These linked sites provide an overview of US climate change research and access to reports.
http://www.usgcrp.gov/ and http://www.climatescience.gov/

Intergovernmental Panel on Climate Change (IPCC) – Publications including the Third Assessment Report–Climate Change 2001–are available at this site.
http://www.ipcc.ch/

World Wildlife Fund – Discover current research findings of WWF's Climate Change Program.
http://www.panda.org/climate

What can you do?

Get involved! Discover new ways to understand, improve, and protect our world.

Globe – A worldwide program to involve primary and secondary students and teacher in collecting scientific data.
http://www.globe.gov/fsl/html/

Mapping the Environment – Missouri Botanical Garden's Department of Education provides easy to use GIS modules to analyze data on climate, ecoregions, and more.
http:/mobot.org/education/mapping/index.html/

Global Warming – The Environmental Defense Fund provides 20 simple ways citizens can reduce global warming.
http://www.edf.org/Want2Help/b_gw20steps.html/

Community-Based Environmental Protection – The U.S. Environmental Protection Agency integrates environmental management and protection issues of local communities.
http://www.epa.gov/ecocommunity/

Suggested Readings and Resources

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NRC Content Standards: Unifying Concepts & Processes 1.1, 1.3, 1.4; Science as Inquiry 2.1; Physical Science 3.6; Life Science 4.3, 4.4, 4.5, 4.6; Energy and Space Science 5.1; Science and Technology 6.1; Science in Personal and Social Perspective 7.3, 7.5, 7.6

Grades and Levels: high school, with modification for middle school

Adapting activities on plant distributions for middle school level

Introduce younger students to the biome in your region, ask them to suggest common native plants. Have students use a map of North America to shade in the distribution of several species that form the dominant vegetation type of your area. Also, have them chart the major climate variables for your region. Divide the class into groups covering North American land biomes (tundra, taiga, temperate forest, chaparral, desert, grassland). Ask each team to produce a poster illustrating the location of a biome in North America and its characteristic climate, plants, and animals. Or have students address similar questions at a local scale.

Download the *Flora of North America* base map at http://www.fna.org/FNA/Guide/basemap.shtml. Or prepare and print maps of North America using the United States Geological Survey's site: http://nationalatlas.gov/natlas/natlasstart.asp.

A Plant Number Game

Is plant diversity uniform across North America?

The map below shows the number of plant families represented in each state or province of North America (Figure from *Flora of North America* volume 1, page 134).

1. Compare the number of number of plant families across regions of North America. Do you see a trend in the data?

2. Draw latitudinal lines for 30°N and 60°N on this map. Does this new information change how you interpret the data? How?

3. Extend your interpretation the data to predict global patterns of diversity. Describe and explain your prediction.

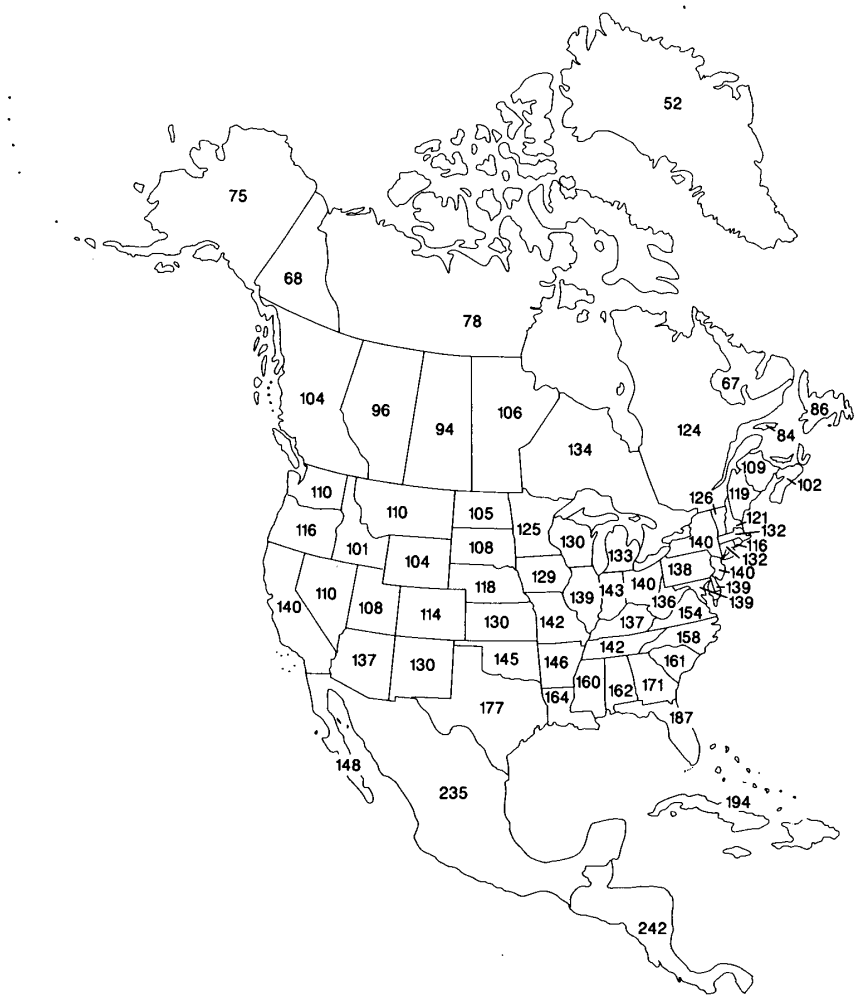


FIGURE 6.1. Numbers of plant families by state and province.

Mapping North American Biomes

Can you recognize a North America biome by its climate?

All plants need certain resources for survival. And plants differ in their ability to tolerate various environmental factors. The distribution of plants is largely determined by their response to environmental conditions.

In the previous activity you discovered that patterns of diversity are associated with latitude. Some broad patterns of plant distribution are also associated with latitude, because on a global scale climate varies with latitude. Tropical climates form a warm wide belt around the equator. Climates become increasingly frigid toward the poles. At the same latitude, however, climate conditions are variable due to regional factors.

Below are climate data for two cities in Oregon, Portland and Bend. Notice the average temperature is given in degrees Celsius, rainfall in millimeters. Why?

Portland, Oregon 45ºN 122ºW, 6 meters above sea level		
Month	**Temperature (ºC)**	**Precipitation (mm)**
January	4.2	133
February	6.4	105
March	8.5	92
April	10.5	61
May	13.9	53
June	17.5	38
July	20.1	15
August	20.3	23
September	17.3	41
October	12.5	76
November	7.8	135
December	4.5	149

Bend, Oregon 44ºN 121ºW, 1115 meters above sea level		
Month	**Temperature (ºC)**	**Precipitation (mm)**
January	0.0	43
February	2.0	28
March	3.7	21
April	6.3	16
May	10.0	25
June	14.4	24
July	17.4	11
August	17.1	11
September	13.0	11
October	8.5	20
November	3.2	38
December	0.0	46

Plot these data in the climate diagrams provided. Then predict biomes for these regions.

Climate diagram for Portland, Oregon													
ºC	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**mm**
23													150
21.5													140
19													130
17.5													120
16													110
14.5													100
13													90
11.5													80
9													70
7.5													60
6													50
4.5													40
3													30
1.5													20
0													10

Climate diagram for Bend, Oregon													
ºC	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**mm**
23													150
21.5													140
19													130
17.5													120
16													110
14.5													100
13													90
11.5													80
9													70
7.5													60
6													50
4.5													40
3													30
1.5													20
0													10

Biome: _____ Biome: _____

Check your predictions against a biome map. How did you do?

It takes about 3.5 hours to drive from Portland to Bend, located in central Oregon. What regional factors make the climates of these relatively nearby cities different?

List at least 2 plant species that are characteristic of the biome in each region and adaptations of these plants to their environment.

Think about biomes a bit more…

Arctic tundra covers about 19% of North America. How do plants survive at such low temperatures and with such short growing seasons? Plants in alpine regions also face environmentally harsh conditions. How are conditions at high latitudes and high elevations similar?

There are three major desert formations in North America: the Mojave Desert, the Sonoran Desert, and the Chihuahuan Desert. Desert scrub also extends through the Great Basin region. Map the 3 major deserts and identify some plants common to each desert. Do the plants show similar adaptations to desert conditions? How do the deserts differ? Compare, for example, their rainfall patterns.

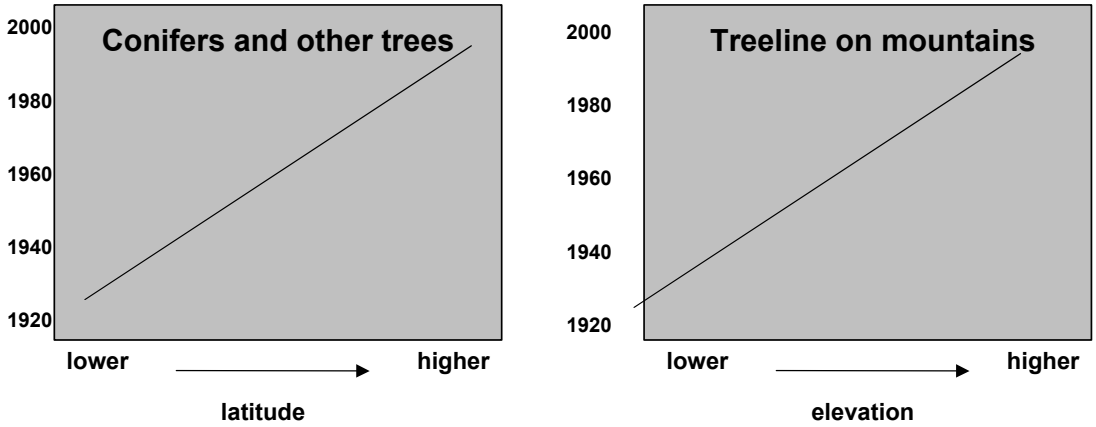
Grasslands of central North America are often called prairies. Do tallgrass and shortgrass prairies differ in ways other than height?

How does the temperate rainforest in the Pacific Northwest differ from a tropical rainforest? In what other parts of the world are temperate rainforests found?

Charting Climate Change Effects

How will plants respond to climate change? Will they migrate to suitable habitat and form new communities? Will their behavior, physiology, and reproduction adapt? Or will they become extinct? Climate change is expected to affect individual plants, plant communities, interactions between plants and animals, and entire ecosystems.

Plant communities across the globe are responding as predicted. Describe the general shifts in distribution shown in the charts below.



Will future climate change be too rapid for plants to adapt to existing locations or migrate to new habitats, meeting new competitors and pests? Plants are rooted in place. Being stationary organisms makes plants susceptible to rapid climate change because they can migrate only when dispersing seeds for the next generation. Barriers to migration may prevent some plants and animals from moving to new habitats. List three man-made obstacles and three natural barriers.

The average temperature across the world will increase with global warming, but the effects of climate change will vary from region to region. Consider each situation below and predict how plants will respond to climate changes in each area.

Florida Keys, Florida	**Arctic National Wildlife Refuge, Alaska**
The conditions: Along with global warming, sea level is predicted to rise and major storms become more frequent. **The plant community:** coastal pine forests **Predicted plant response:**	**The conditions:** Ground temperatures are higher and seasonal thawing is more extensive, melting the permafrost. **The plant community:** forbs and lichens of the tundra and conifers of the boreal forests **Predicted plant response:**
Rocky Mountain National Park, Colorado	**A natural area in your region**
The conditions: Warmer temperatures at higher elevations. **The plant community:** alpine flower meadows, shrubs, and trees at lower elevations **Predicted plant response:**	**The conditions:** What are predicted climate changes in your region? **The plant community:** What plants are typical of this region? **Predicted plant response:** Will particular habitats or plants be threatened?

Why are some plant species more vulnerable to change than others?
How will changing conditions affect our food crops?