Lab 20: Biogeography

Learning Objectives

- Explain how ecosystems are defined and mapped.
- Identify and describe global ecoregions.
- Understand the factors that impact fire behavior and fire mitigation methods.
- Explain why there is a designated biodiversity hotspot in California.
- Conduct a field study in a local ecosystem.

Introduction

Throughout this course, you have reviewed many different aspects of the physical environment. You have studied many different aspects of the atmosphere and climate. You have investigated the distribution of water and its impact on the shape of our planet. You have studied many different processes that create, modify, and destroy the surface of the Earth.

While each of the topics that you have previously covered is fascinating in their own right, (especially, perhaps to your professor) each of these aspects of the physical environment contributes to the likelihood of survival and success of the plants and animals dependent on the conditions in different areas. The plants and animals that depend upon them are influenced strongly by the non-living conditions where they survive and strive. These conditions include the winds, temperature, precipitation, humidity, soils, slope, and slope orientation (aspect). These varying conditions impact the distribution of natural vegetation and the ability of animals to glean from that vegetation.

Biogeography is the study of the distribution of plants and animals. Closely related to biogeography is the study of **ecology**. An ecologist studies the relationship between plants and animals and their relationship with the non-living things around them, such as water, soil, air, and sunlight. Interrelated plants and animals and their non-living, physical environment are referred to as an **ecosystem**.

Part A: The Geography of Ecosystems—Making Sense of Where Things Live

One common way of categorizing and mapping ecosystems is to organize them based on biomes (Figure 20.1). **Biomes** are regions defined by the predominant plant characteristics found in that area. For over a century, biologists, ecological scientists, and geographers have worked to classify and organize distinct biomes. Even today there are several different methods of categorizing these biomes. Several current geographers have adopted the following generalized terrestrial (excluding aquatic) biomes. These include:

- ➢ Ice Sheet and Polar Desert
- ➢ Tundra
- ➢ Taiga
- ➢ Temperate Broadleaf Forest

- Temperate Steppe
- Subtropical Rainforest
- Mediterranean Vegetation
- Monsoon Forest
- Arid Desert
- Xeric Shrubland
- Dry Steppe
- Semiarid Desert
- Grass Savanna
- Tree Savanna
- Subtropical and Tropical Forest
- Tropical Rainforest
- Alpine Tundra
- Montane Forest

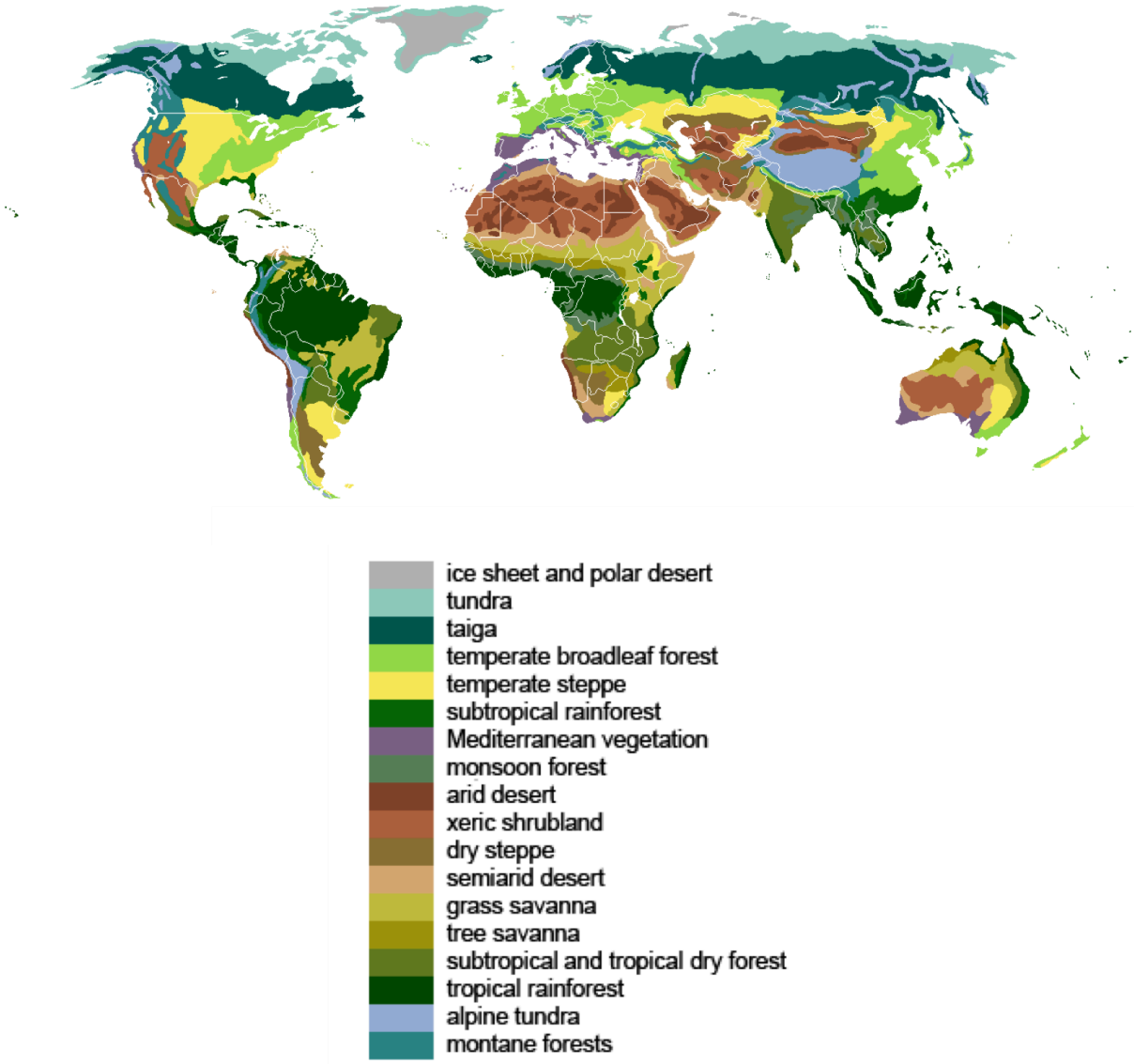

Figure 20.1: Terrestrial Biomes of the World.[1]

One drawback of the generalization involved with defining biomes is that it tends to overlook many other aspects of an ecosystem that impact the distribution of plants and animals. Biomes primarily focus on the predominant plant species found in a region. This places the emphasis on correlations between regions but does not consider the causation for potentially similar plant

[1] Figure by Ville Koistinen is licensed under CC BY-SA 3.0

communities. Some of these other ecological factors worth considering include soil type, atmospheric conditions, topography, and proximity to a water source. Also, the biomes are very general. In our global efforts for ecological preservation, there is a need for finer granularity. Greater details on specific ecosystem characteristics can help us better understand the minor differences that are important to preserve. In recent times, there have been several other approaches to categorizing and mapping ecosystems that have attempted to account for some of these other ecological factors. The Environmental Protection Agency (EPA) has developed a tiered approach of organizing ecosystems in a framework defined as **ecoregions**. In their system, there are four tiered levels of ecological regions. Level one provides a very broad overview of the ecosystems found in the region. Each of the subsequent ecoregional levels provides more and more detail. As of 2020, the EPA, working in partnership with Canada and Mexico, have only developed their ecoregion classification for North America. Other organizations have developed similar ecoregion boundaries and classifications beyond North America.

Check It Out! Environmental Protection Agency Ecoregions

The Environmental Protection Agency (EPA) has developed the ecoregions schema for organizing ecosystems. They provide a detailed description and a series of maps. One defining characteristic that they use is a nested approach, where you can see the nation divided into a few general ecological areas, with other tiers more and more detailed. So, check it out!

The United States Geological Survey (USGS,) in partnership with several other commercial and non-profit organizations, developed the **Ecological Land Unit** classification schema. This global project has defined multiple ecological characteristics based on a 250-meter grid. These ecological characteristics include:

- Bioclimate: A description of the temperature and precipitation
- Land Cover: The type of vegetation and how the land is being used
- Land Form: The physiographic features (the physical landscape)
- Lithography: the soil type or characteristic

For several continents, more specific details have been provided for each of these ecological characteristics. In the following section, you will explore the global ecological land units.

1. What are the three different ways of classifying the biosphere? Hint: each method was discussed in the paragraphs above.

2. What are the similarities among the three schemas?

3. What are the main differences among the three schemas?

Exploring Ecological Land Units

The USGS and Esri (formally the Earth Systems Research Institute) have developed an online tool to explore the global Ecological Land Units. Using their online map viewer and Google Maps, you will explore several locations around the world in order to complete Tables 20.1 and 20.2 (provided below the following instructions).

Step 1

Go to the USGS Global Ecosystems Viewer. This website works best with the Chrome or Edge web browsers.

Step 2

Zoom out to a full extent of the world.

4. What are your overall observations of the map? Do you notice any patterns? Explain your response in one to two sentences.

Step 3

Using the "Find address or place" search tool, search for the locations in Tables 20.1 and 20.2 based on the coordinates.

5. Follow the steps below and complete Tables 20.1 and 20.2 for each location.

Step 4

Zoom in or out to discover the location description.

Step 5

Click on the map on or near the coordinate location. A small dialog box will provide Ecological Land Unit data. (For some locations, additional information may be provided. Complete Tables 20.1 and 20.2 with the basic information provided).

Step 6

Using Google Maps (Satellite or Street View) or Google Earth, navigate to the same location. Use the satellite imagery to determine the general appearance of the setting.

Table 20.1: Selected California Locations

Coordinates		36.42, -116.88	41.78, -124.11	37.72, -122.11
Location	Your Home or Your Campus			
Bioclimate				
Land Cover				
Land Form				
Lithology				
Topographic Position				
Appearance (from imagery)				

Table 20.2: World Locations

Coordinates	-3.00, -61.00	-0.35, 29.90	27.57 N, 85.42 E
Location			
Bioclimate			
Land Cover			
Land Form			
Lithology			
Appearance (from imagery)			

6. List three ideas that you learned previously in the semester that help you to understand the information that you added to Tables 20.1 and 20.2.

7. List three observations that you can make based on Table 20.1. Tip: did you notice anything interesting about the ecological land units found in California?

8. List three observations that you can make based on Table 20.2. Tip: did you notice anything interesting about the ecological land units found in the world locations?

Part B: Limiting Factors

Some plant and animal species can live virtually anywhere. For example, the mallard duck will avoid the bitter tundra in the winter, avoid the scorching heat of central Mexico in the summer, and will survive and thrive throughout most of North America for most of the year. Other species, such as the Coastal Redwood, have very specific needs in terms of soil type, slope,

temperature, and moisture. Any factor, or characteristic, that limits the distribution of a plant or animal is referred to as a **limiting factor**.

Several common factors can limit the distribution of plants and animals. These include temperature highs, lows, or annual ranges in temperature. It can include the amount and type of precipitation. Slope and aspect are two additional limiting factors. In the following exercise, you will decipher the impacts of limiting factors on the distribution of several tree species found across North America.

Below, you will find several maps of North America. These include an array of environmental variables that may have an impact on the distribution of tree species. The variables include January Temperature (Figure 20.2), July Temperature (Figure 20.3), Annual Precipitation (Figure 20.4), Climate (Figure 20.5), and a Shaded Relief map (Figure 20.6), which provides a general perspective of slope and elevation.

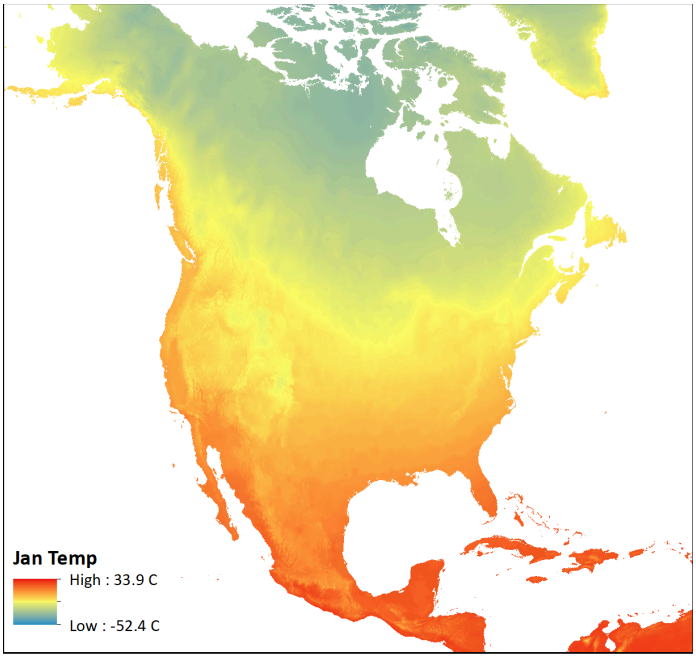

Figure 20.2: North America January Temperature Map.[2]

[2] Figure by Scott Crosier is licensed under CC BY-NC-SA 4.0

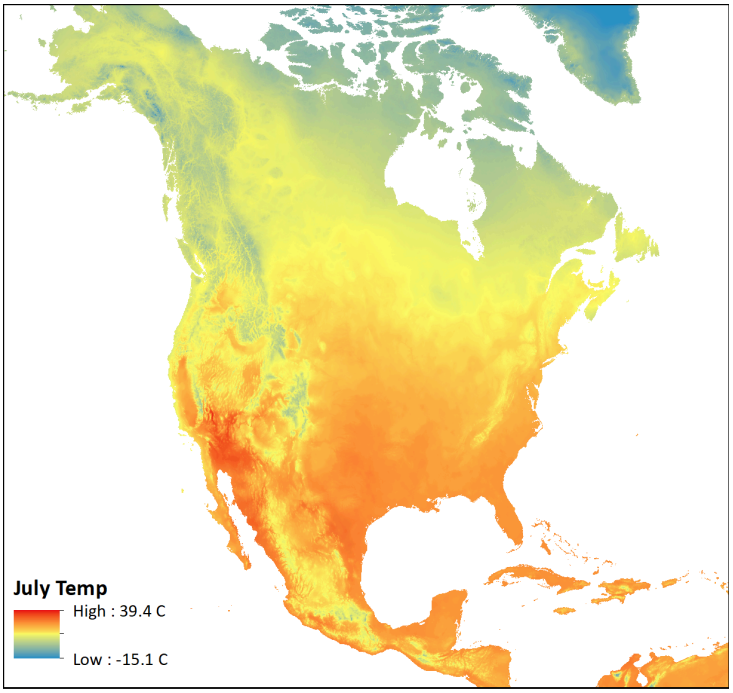

Figure 20.3: North America July Temperature Map.[3]

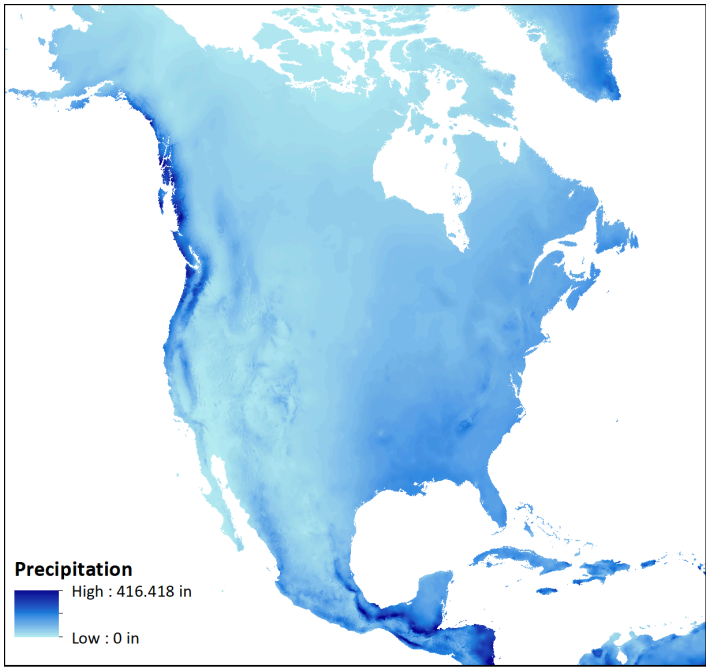

Figure 20.4: North America Annual Precipitation Map.[3]

[3] Figures by Scott Crosier are licensed under CC BY-NC-SA 4.0

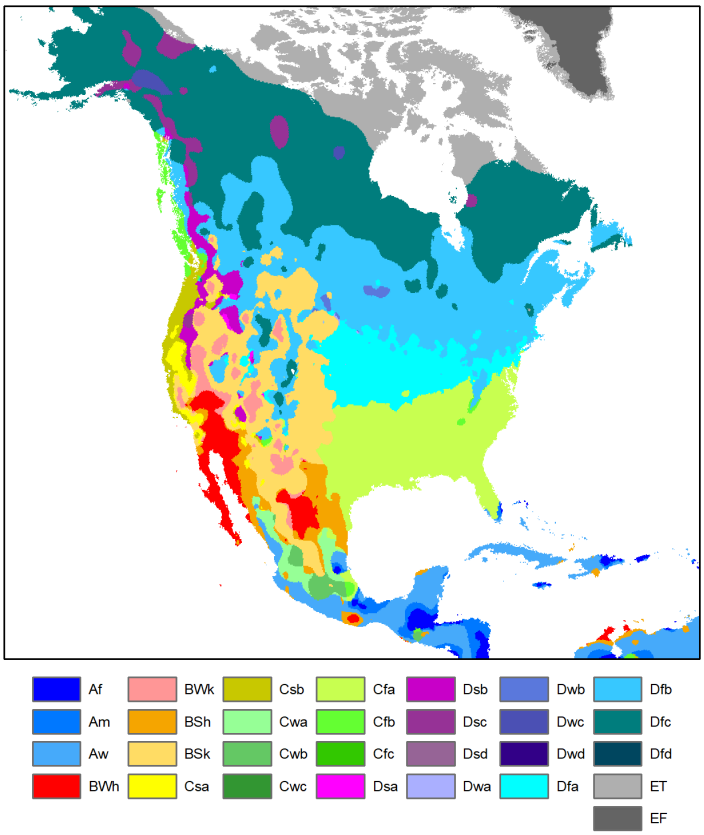

Figure 20.5: North America Climate Map.[4]

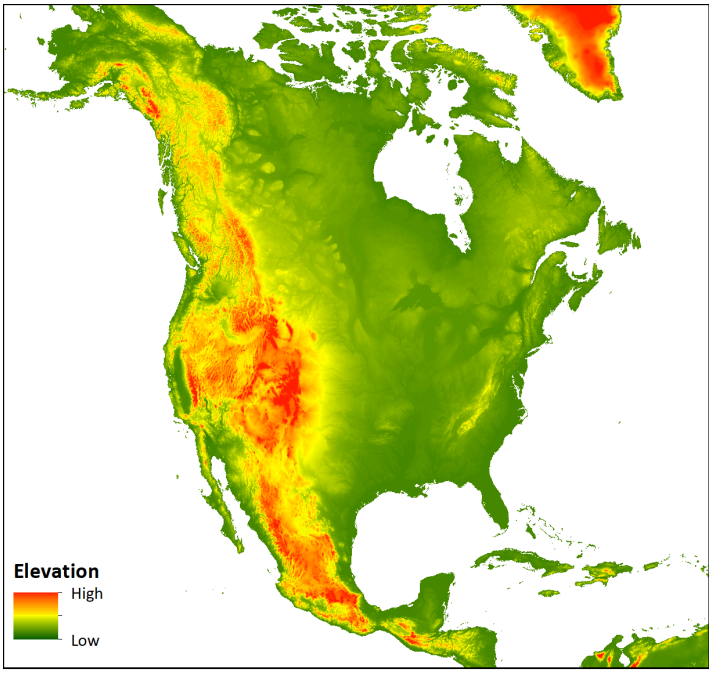

Figure 20.6: North America Elevation Map.[4]

[4] Figures by Scott Crosier are licensed under CC BY-NC-SA 4.0; GIS data for Figure 20.5 obtained from https://people.eng.unimelb.edu.au/mpeel/koppen.html

Now, consider the following species distribution (range) maps for several tree species that are found in North America (Figures 20.7 through 20.11).

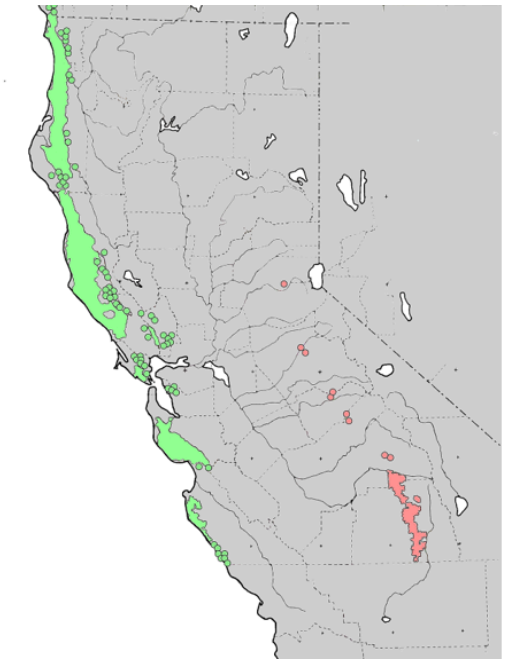

Figure 20.7: On left, distribution map of *Sequoia sempervirens* (Coastal Redwood; shown in green). Photograph on right.[5]

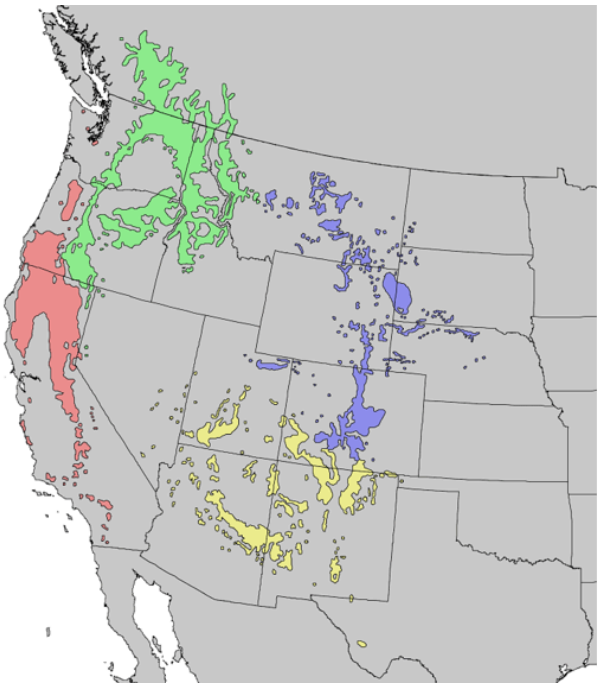

Figure 20.8: On left, distribution map of *Pinus ponderosa* (Ponderosa Pine; several subspecies presented) Photograph on right.[6]

[5] Figure by U.S. Forest Service is in the public domain; Photo by Gabriel Tovar on Unsplash
[6] Figure by USDA is in the public domain; Photo by Walter Siegmund is licensed under CC BY-SA 3.0

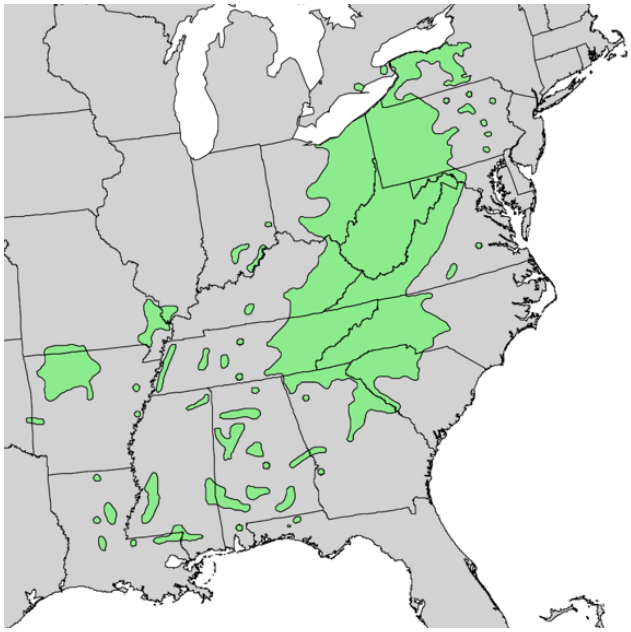

Figure 20.9: On left, distribution map of *Magnolia acuminata* (Cucumber Tree or Blue Magnolia) Range Map. Photograph on right.[7]

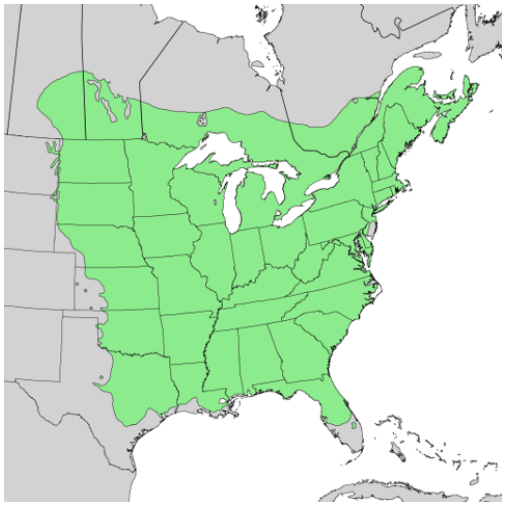

Figure 20.10: *Ulmus americana* (American Elm) Range Map. Photograph on right.[8]

[7] Figure by USGS is in the public domain; Photo by Bruce Marlin is licensed under CC BY 3.0
[8] Figure by USGS is in the public domain; Photo by Msact is licensed under CC BY-SA 4.0

On left, distribution map of *Pinus pseudostrobus* (Chamite or Pacingo) Range Map. Photograph on right.[9]

Compare each distribution map (Figures 20.7 through 20.11) with the environmental variables mapped above (Figures 20.2 through 20.6). Look for corresponding trends. To help with your analysis, you may access this google slides document that shows the tree distribution maps with the environmental variable maps.

9. On Table 20.3, indicate with a checkmark if you think that the corresponding variable influences the distribution of the tree species.

10. Once you have considered all 5 variables, in the final column of Table 20.3, indicate whether you consider the variables to have a strong or weak impact on the range of the species overall.

[9] Figure by USGS is in the public domain; Photo by Stan Shebs is licensed under CC BY-SA 3.0

Table 20.3: Limiting Factor Analysis

Tree Species	Jan. Temp	July Temp	Annual Precip.	Climate	Elevation	Impact on Range (strong or weak)
Sequoia sempervirens						
Pinus ponderosa						
Magnolia acuminata						
Ulmus americana						
Pinus pseudostrobus						

11. Which environmental variable impacts the largest number of tree species? Use Your Critical Thinking Skills: In one to two sentences, explain why this environmental variable has the greatest impact.

12. Use Your Critical Thinking Skills: Some species have a very limited range. Why do you think that is? Explain your response in one to two sentences.

13. Use Your Critical Thinking Skills: If a tree species has a limited range, how might that impact the ability of the tree to withstand changes to the environment, such as climate change? Explain your response in one to two sentences.

Part C: Fire Ecology

Fire is the release of heat and light as a result of the combustion of fuel. Fire requires three elements: fuel, oxygen, and a heat source. These are commonly organized as the fire triangle (Figure 20.12).

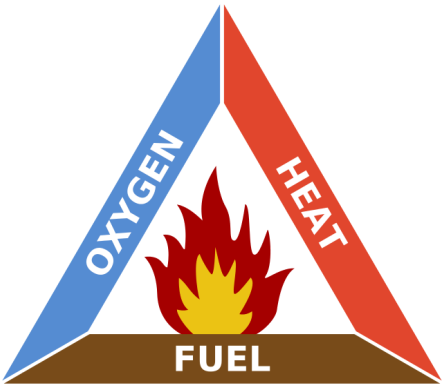

Figure 20.12: The Fire Triangle.[10]

When studying (and suppressing) fire, the fire triangle assists in understanding the process of fire. Because each component is essential for the process of combustion to take place, any disruption in any of the three components will slow or stop the process. This is true for the fire in your fireplace, the campfire you enjoy when in the woods, or a structural or forest fire.
In larger forest fires, there are other factors that impact fire behavior. **Fire behavior** is the way in which the fire will interact with the landscape. It includes the temperature of the fire, rate of spread, the development of convectional uplifts, and ember production. Fire behavior is influenced by the available fuel, local weather conditions, and the topography of the landscape.

Fuel

In natural settings, there are a wide variety of fuels that can be found. These range from forests and trees, to grasses and desert shrubs. Beyond just the type of fuel, it is important to consider the condition of the fuel. If you were to compare a very humid, moist, forested area with a similarly forested region in a dryer area, the fire would behave quite differently. So, the ease with which the fuel will burn can vary based on the type of vegetation as well as on the annual cycle.

Weather

The vitality of vegetation is closely tied with the soil moisture available, the humidity, and other conditions. Beyond this, the weather itself can have an impact on fire behavior. Many natural fires are caused by lightning strikes. If these strikes are accompanied by precipitation, they tend to have lower impacts. However, when dry lightning (an electrical storm without precipitation) strikes, the results can be devastating. Humidity will impact the speed at which the fuel is consumed. Wind can also drive flames and increase the oxygen available to the flames.

Topography

Topography or the shape and surface of the landscape also impacts the likelihood of fire. In previous labs, you have explored mountain and valley breezes. These are caused by the surface temperature of a slope heating up, causing the air to rise up the slope. The same process is even

[10] Figure by Gustavb is licensed under CC BY-SA 3.0

stronger when a hillside is covered in flames. Topography not only impacts weather and the fuels that can grow on different surfaces but also has a direct impact on the migration of fire.

14. In the Table 20.4, specify a low, medium, or high risk for each element of fire behavior for each setting. To familiarize yourself with each of the settings, go to the following websites or search the Google maps with their coordinates and select the satellite view option.
    - ➢ Humboldt Redwoods State Park
    - ➢ Running Springs, San Bernardino Mountains
    - ➢ Joshua Tree National Park

Table 20.4: Fire Risk Analysis

Setting (Coordinates)	**Fuel** low, medium, or high?	**Weather** low, medium, or high?	**Topography** low, medium, or high?
Redwood coast on a foggy day (41.21, -124.0)			
San Bernardino Mountains during Santa Ana wind conditions (34.20, -117.13)			
Joshua Tree National Park on an autumn afternoon (34.01, -116.10)			

15. Use Your Critical Thinking Skills: Assume that you are a Forest Manager in the Sierra Nevada mountain range. Your concern is the health and safety of the forest as well as

providing a place for people to recreate. Relate your answers to the questions below to the three elements of fire behavior. Your response to each question should be two to three sentences in length.

a. What could you do to mitigate the impacts of these elements of fire behavior?

b. Would it be best to suppress all fires or allow some to burn? How might this decision impact fire behavior?

c. If you were issuing campfire permits to people visiting your forest, what considerations would you use to decide if it were safe to issue a permit?

d. A developer wants to convert some private land near your forest to residential vacation homes. Knowing that your forest periodically burns, what concerns would you have? What practices would you want the property owners to implement? Why?

e. What impacts would a changing climate (namely, higher temperatures) have on your forest and periodic forest fires?

Part D: California's Biodiversity

California's varied topography and climate have given rise to a remarkable diversity of habitats and a correspondingly varied array of both plant and animal species. California has more native species than any other state in the nation and also has the greatest number of **endemic species**; these are species that occur nowhere else in the world (CDFG 2003). California has a designated hotspot because of the remarkable biodiversity and significant threat of losing habitats and

wildlife species unique to California (Myers et al. 2000).[11] Called the California Floristic Province (Figure 20.13), this biodiversity hotspot is one of only 36 in the world. **Biodiversity** refers to biological variety and variability of living organisms, which can be measured by the number of species in an area, by the number of individuals of each species in an area, or in terms of genetic diversity.

Figure 20.13: California Floristic Province Locator Map.[12]

California's biodiversity stems from exceptional variation in landscape features, latitudinal range, geological substrates and soils, and climatic conditions, resulting in a wide range of ecosystems to support plant and animal species. Alpine meadows; desert scrub; oak woodlands; diverse grasslands; vernal pool complexes; moist redwood forests; spring-fed lakes; freshwater streams, rivers, and marshes; coastal wetlands, beaches, dunes and bluffs; and giant marine kelp beds provide a wide variety of habitats that support a correspondingly diverse array of both plant and animal species.[13]

The frequency, intensity, and seasonal timing of fire in the landscape have been major factors determining the composition of flora throughout the state. Fire-dependent vegetation types cover over half the surface area of California (Sugihara et al. 2006). Alteration of the natural fire regime is an important ecosystem stress, particularly in forest- and shrub-dominated habitats (Ainsworth and Doss 1995). Widespread forest management practices, including fire suppression without active forest management, as well as increases in human-caused wildfires, have altered fire regimes. The effects of wildfires differ among ecological communities. In sage scrub, chaparral, and grassland systems, lightning-induced fires are relatively frequent and plants have evolved to germinate post-fire. Human-caused fires, however, have resulted in unnaturally high fire frequencies, especially along roads and near the urban-wildland interface, interrupting the natural successional dynamics of these habitats. These more frequent fires can decrease the quality of aquatic habitats by reducing shading and woody debris, as well as directly damaging terrestrial habitats. Areas where fire was relatively rare, such as the high desert, have experienced an increase in fire frequency because of changes in vegetation.

[11] Text by California Department of Fish and Wildlife is in the public domain
[12] Figure by NoahElhardt is licensed under CC BY-SA 3.0
[13] Text by California Department of Fish and Wildlife is in the public domain

Increased fuel loads associated with invasive species have resulted in an increased number of fires (Brooks 1999). An **invasive species** is an organism that is brought to a new location by human activities. It causes ecological or economic harm by outcompeting native species, reducing biodiversity, or altering habitats. The increased fire frequencies then favor the Mediterranean grasses that were introduced to California with the arrival of European settlers and livestock. Once established, the non-native grasses grow in a dense-thatch pattern that chokes out native vegetation, lowers habitat quality for wildlife, and provides additional fuel for the cycle of frequent burning (Keeley 2009).[14]

16. List the ways humans have impacted California's biodiversity.

Conserving the state's outstanding biodiversity creates many values. Wildlife provides significant economic and quality-of-life benefits to the state through recreation, tourism, sport and commercial harvest, and ecological services, such as pollination. Many of the places where wildlife thrives are often the same as those valued for recreation and other human activities. By learning the causes of impacts to the state's wildlife and the steps that can be taken to reduce those impacts, California's residents have the opportunity to become more active stewards of this precious natural treasure, ensuring that the Golden State remains an important place for viable wildlife populations for generations to come.[14]

Let's learn more about the California Floristic Province by reviewing the information provided by the Critical Ecosystem Partnership Fund.

Step 1

Go to the California Floristic Province webpage.

17. Do you live within the California Floristic Province? Zoom in and out of the map, if needed.

Step 2

Read the "About this Hotspot" section.

18. What percentage of the original vegetation in the California Floristic Province remains in more or less pristine condition?

[14] Text adapted from the California Department of Fish and Wildlife is in the public domain

19. Apply What You Learned: How would recent wildfires impact the condition of the original vegetation in the California Floristic Province? List the possible impacts.

Step 3

Click the + sign next to Species and read about plants, birds, mammals, reptiles, amphibians, freshwater fishes, and invertebrates.

20. What are five important ideas that you learned about species?

Step 4

Click on the "Threats" heading to read how human activities threaten the California Floristic Province.

21. List the major threats to the California Floristic Province.

22. Apply What You Learned: How do you benefit from California's biodiversity?

23. Use Your Critical Thinking Skills: How do your day-to-day activities influence the California Floristic Province?

Part E: Field Studies of an Ecosystem

24. For this portion of the lab, you will be making one or more observations of an ecosystem. This could be a location in your backyard or neighborhood, on your campus, or even further afield. Plan on observing your location for at least 30 minutes each visit.

Step 1

Choose a location to observe. Your professor may have a specific location where you should go. You may also want to discuss a location with your professor. Choose a safe location.

Step 2

Prepare yourself for your field experience. You should have the appropriate clothing for varying weather conditions, water, sunscreen, and snacks. You should also have a field journal, paper, several pencils and/or pens, and any other devices that you may use to collect data in the field. Lastly, you may want to have a hand lens (to see small things), a set of binoculars or a spotting scope (to see things farther away), and field guides.

Step 3

Head to your location! Find a comfortable spot to sit and observe.

Step 4

Record your findings on the worksheet available on the following pages. If your professor asks for multiple observations, duplicate the worksheet. You may need to use your phone to find some of the data for the worksheet.

Step 5

Prepare a report of your findings. Your professor will provide details on what you should include.

Field Worksheet

Where and When

Date:

Arrival Time:

Departure Time:

Location (address, name, or coordinates):

Elevation:

Setting (Description of area):

Atmosphere

Temperature:

Wind Direction and Speed:

Cloud Cover:

Humidity:

Air Pressure:

Hydrosphere

Current or recent precipitation:

Nearby surface water (ocean, lake, river, stream):

Lithosphere

Soil Color:

Soil Texture:

Soil Moisture:

Topography:

Biosphere

Choose a specific perimeter that you can see and assess. For your list, consult with your professor on the use of descriptions, scientific names and/or common names.

Flora (Plants)

On this page, or on a separate sheet of paper, list each plant species present. Include the following:

A. The name and/or description
B. Total number of individuals
C. Size (or range in size) of the individuals

Fauna (animals)

On this page, or a separate sheet of paper, list each animal species present. Be sure to consider mammals, reptiles, insects, and so forth. Include the following:

1. The name and/or description
2. Total number of individuals you saw
3. Their actions or behaviors
4. Their interactions with one another, the plants, or with the environment

Part F. Wrap-Up

Consult with your geography lab instructor to find out which of the following wrap-up questions you should complete. Attach additional pages to answer the questions as needed.

25. What is the most important idea that you learned in this lab? In two to three sentences, explain the concept and why it is important to know.
26. What was the most challenging part of this lab? In two to three sentences, explain why it was challenging. If nothing challenged you in the lab, write about what you think challenged your classmates.
27. What is one question that you have about what you learned in this lab? Write your question along with one to two sentences explaining why you think your question is important to ask.
28. Review the learning objectives on page 1 of this lab. How would you rate your understanding or ability for each learning objective? Write one sentence that addresses each learning objective.
29. Sketch a concept map that includes the key ideas from this lab. Include at least five of the terms shown in bold-faced type.
30. Create an advertisement to educate your peers on the important information that you learned in this lab. Include at least three key terms in your advertisement. The advertisement should be about half a page in size (about 4 inches by 6 inches).
31. One way to think of physical geography is that it is the study of the relationships among variables that impact the Earth's surface. Select two variables discussed in this lab and describe how they are related.
32. How does what you learned in this lab relate to your everyday life? In two to three sentences, explain a concept that you learned in this lab and how it relates to your day-to-day actions.
33. How does what you learned in this lab relate to current events?
    a. Write the title, source, and date of a news item that relates to this lab.
    b. In two to three sentences, discuss how the news item relates to what you have learned in this lab.
    c. In one to two sentences, discuss whether or not the news item accurately represents the science that you learned. Tip: consider whether or not the news item includes the complexity of the topic.
34. Search O*NET OnLine to find an occupation that is relevant to the topics presented in today's lab. Your lab instructor may provide you with possible keywords to type in the Occupation Quick Search field on the O*NET website.
    a. What is the name of occupation that you found?
    b. Write two to three sentences that summarize the most important information that you learned about this occupation.
    c. What is one question that you would want to ask a person with this occupation?