14. Who Lives Here and Why? Modeling Forest Communities

Lesson overview: In this activity, students create a graphical model of forest communities in the northwestern Sierra Nevada. They create the model using a table that describes the current distribution of tree species on a fictitious mountainside called Sasquatch Peak. Students then use the model to describe the species composition of current forest communities and to predict the potential effects of changing climate conditions on the distribution of species.

Subjects: Science, Mathematics, Reading, Speaking and Listening
Duration: one half-hour class session, possibly followed by a station activity
Group size: Whole class
Setting: Classroom
FireWorks vocabulary: *aspect, climate, climate change, distribution (of a species), elevation, environmental conditions, gradient, migration/species migration*

Goals: To increase students' understanding that

- forest communities develop under specific environmental conditions
- species with similar needs are likely to occur together
- species distributions and community composition may change as climate conditions change
- models can be used to describe what we understand and predict what may happen in the future

Objectives:

- Students can list tree species that are likely to occur together in montane forests of the Sierra Nevada
- Students can use a graphical model to predict some changes that could occur as climate conditions change.

Standards:		6th	7th	8th
CCSS	Writing	4,10	4.1	4,10
	Reading: Informational Text	4,10	4,10	4,10
	Speaking and Listening	1,2,4,6	1,2,4,6	1,2,4,6
	Reading: Science and Technology	3,4,7,10	3,4,7,10	3,4,7,10
	Writing: Science and Technology	2	2	2
NGSS	Interdependent Relationships in Ecosystems	LS2.A		
	Weather and Climate	ESS2.D, ESS3.D		
	Natural Selection and Adaptation	LS4.B, LS4.C		
	Growth, Development, Reproduction of Organisms	LS1.B, LS4.B		
EEEGL	Strand 1	A,C,E,F,G		

Teacher background:
Every species needs certain *environmental conditions* in order to survive and reproduce. Trees, for example, need a certain amount of sunlight and moisture and certain temperature conditions. They may also need a specific day length to begin growing and specific soils to provide nutrients and moisture. Environmental conditions are a very important aspect of a species' habitat.

In this activity, students use a simplified description of the environmental conditions required by 12 tree species to describe forest communities and how the species in these communities might respond to climate change. The species studied here occur in montane forests of the northwestern Sierra Nevada; students learned about their ecology in Activity 11 and how to identify them in Activity 13.

The description of environmental conditions in this activity is limited to species' moisture requirements and elevational ranges. These two characteristics are represented as *gradients* from "dry" to "very moist" and "hot" at low elevations to "cool" at high elevations on a fictitious mountain called Sasquatch Peak. These conditions are oversimplified, since a site can be hot or cool, dry or moist not only due to its elevation and location relative to ridges and creek beds but also due to its *aspect*, slope steepness, soil properties, and many other factors. The sketch of the mountainside, then, is a graphical model of the combinations of moisture and elevation available to trees. Students will use it to do what models do best: describe what we know and predict what could happen if conditions changed.

Handout M14-1: Where Can Trees Grow on Sasquatch Peak? describes the most common conditions in which each tree species occurs. (Note that these conditions are the MOST COMMON ones, not the OUTER LIMITS of what the species can tolerate.) Given the descriptions in the table, students can show where each species is likely to occur on the mountainside model. They can also predict which species are likely to occur together, thus forming a forest community. And they can predict how the best locations for a species might change if climate conditions change. If individual trees in the current locations can spread their seeds or otherwise reproduce in a "new" location for them – and then thrive and reproduce there - we say the species has *migrated* to the new location. If they cannot, the species may gradually die out.

This activity provides a very simplified model of what may happen to tree distributions as climate conditions change. The only variables considered here are temperature and moisture. In reality, tree distributions are much more complex, and predicted changes in distribution must address variables including seed dispersal, species interactions, insects and diseases, connectivity of habitat, and changes in fire frequency, severity, and size.

Here is some further background on climate change and species migration:

Assisted migration: https://earlycareerecologists.wordpress.com/2013/01/16/trees-on-the-move-debating-assisted-migration-in-climate-change-mitigation/

Global species migration: https://www.washingtonpost.com/national/health-science/up-and-up-plants-and-animals-migrating-as-climate-changes/2011/08/18/gIQAzlTxNJ_story.html

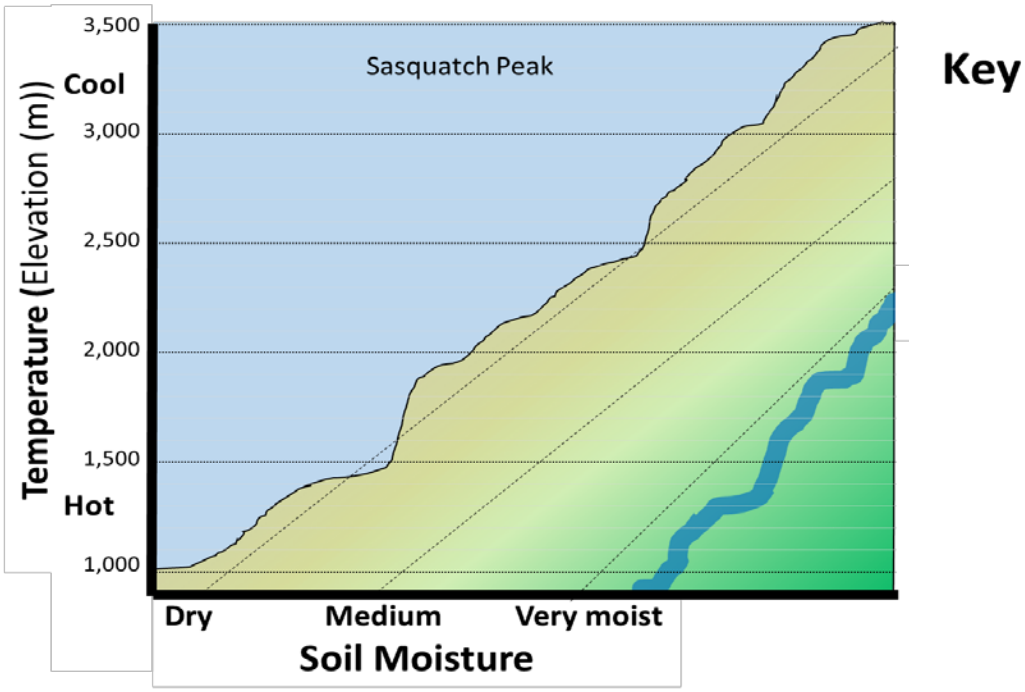
Tree migration, eastern U.S. examples:
http://news.nationalgeographic.com/news/2009/02/090209-trees-migrating-north.html

"How Global Warming is Changing the Wild Kingdom" (http://www.livescience.com/3864-global-warming-changing-wild-kingdom.html)

"Animals and Plants Adapting to Climate Change" (http://www.livescience.com/3863-animals-plants-adapting-climate-change.html)

Materials/Preparation:

- Make 1 copy/student:
  Handout M14-1: Where Can Trees Grow on Sasquatch Peak
  Handout M14-2: Trees in a Changing Environment
- Download the template for the Sasquatch Peak Forest Model (***GradientModelTreeDistributions.pptx*,** Slide 1, shown below) so it can be projected on a whiteboard -- or -- project and copy it onto butcher paper. If you have a smartboard with memory, trace the axes and labels from the projection with black marker.
- Markers - 12 colors other than black



Procedure

1. Display the Sasquatch Peak Forest Model (***GradientModelTreeDistributions.pptx*,** Slide 1).
2. Give each student a copy **Handout M14-1: Where Can Trees Grow on Sasquatch Peak?**
3. Have students form 12 teams. You may want to use the same teams used in Activity 13 (Mystery Trees). You will work with the "California black oak" team to demonstrate how the model works. Give each team a colored marker.
4. Explain: Each tree species grows best in certain *environmental conditions* and cannot grow at all in other conditions. The places where a species currently occurs is its *distribution.* (This is a little like the home range of an animal.) We're going to assemble a model that shows the environmental conditions in which the trees we've been studying (in Activities 12 and 13) MOST COMMONLY grow – in other words, a model of typical forest communities in our area. What are some important environmental conditions and why do they matter? Draw out the following concepts and list them on the board:
   - Elevation matters because it influences the temperature, length of summer vs. winter, amount of snow vs rain, exposure to wind, etc.
   - Slope, *aspect,* and steepness matter because they control how much direct sunlight the plants receive (and thus temperature), how much wind they are exposed to, and how rain and snow are deposited and melted/absorbed/evaporated.
   - Soil matters because it influences the nutrients available to the plant, the air available to roots, and how well water is retained.
   - Amount of moisture matters because it influences how much water is available to plants.
5. We've talked about <u>environmental</u> conditions, but plants also need certain <u>biological</u> conditions to thrive. Can you think of any? Here are a few: abundant pollinators, fungi that help roots absorb moisture ("mycorrhizae"), sparseness of competing vegetation, limited numbers of animals feeding on plant parts, limited parasites and decay fungi.
6. Explain how to interpret the graph. Spend time looking at the axes and how they are labeled: We'll use a sketch of a mountainside on the board to show where our 12 tree species are likely to live in a fictitious place called Sasquatch Peak. The data we need are in **Handout M14-1**, which shows the most common *environmental conditions* in which each species' occurs – the heart of its *distribution* - in terms of elevation and moisture. (To put it a different way, the table shows where the species COMMONLY occur, not the LIMITS of where it can POSSIBLY occur.) Thus model of the mountainside illustrates two *gradients* in environmental conditions – temperature (represented by elevation) and soil moisture.
7. Explain: This model is useful, but it is somewhat simplistic. Sites generally <u>do</u> get hotter as you go down in elevation, but that's not the only influence. What other things contribute to making a location hot? Aspect, presence of shade from other vegetation or mountains, presence of lakes or streams, wind patterns, topography – such as narrow canyons vs open slopes …. Sites generally <u>do</u> get more moist as you get close to a creek or lake, but that's not

the only influence. What other things can make the soil more or less moist? Aspect, steepness, drainage patterns, soil properties, presence of other vegetation…

Work with a couple of students to show how to illustrate a tree species' distribution on the model. Use California black oak as the example.

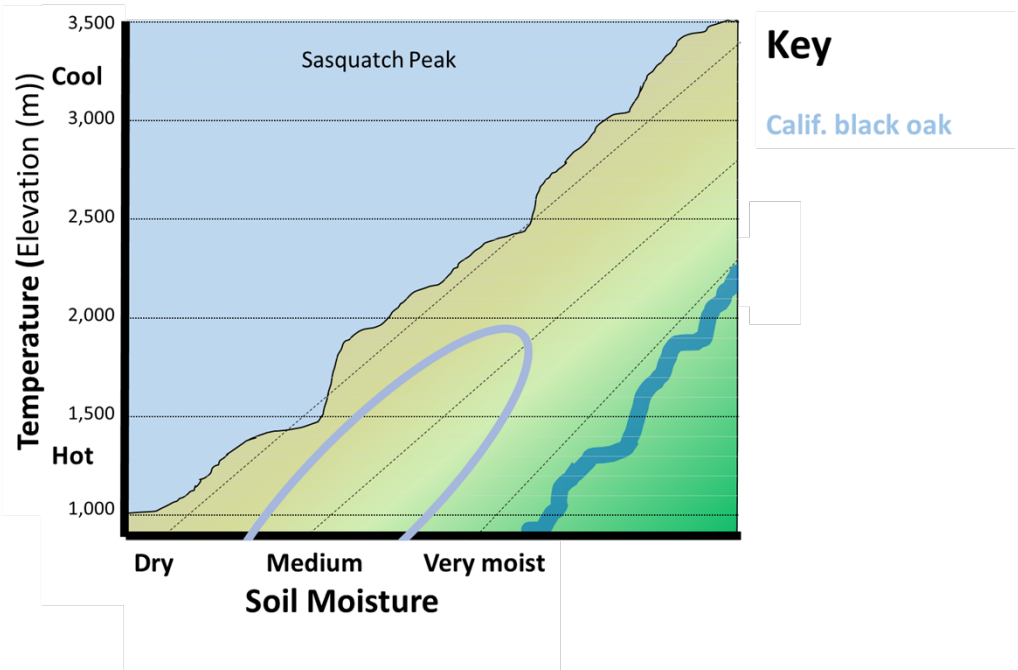
- Use this information from **Handout 14-1:**

Tree Species	Elevation (m)	Need for Moisture
California black oak	500-1800	Medium

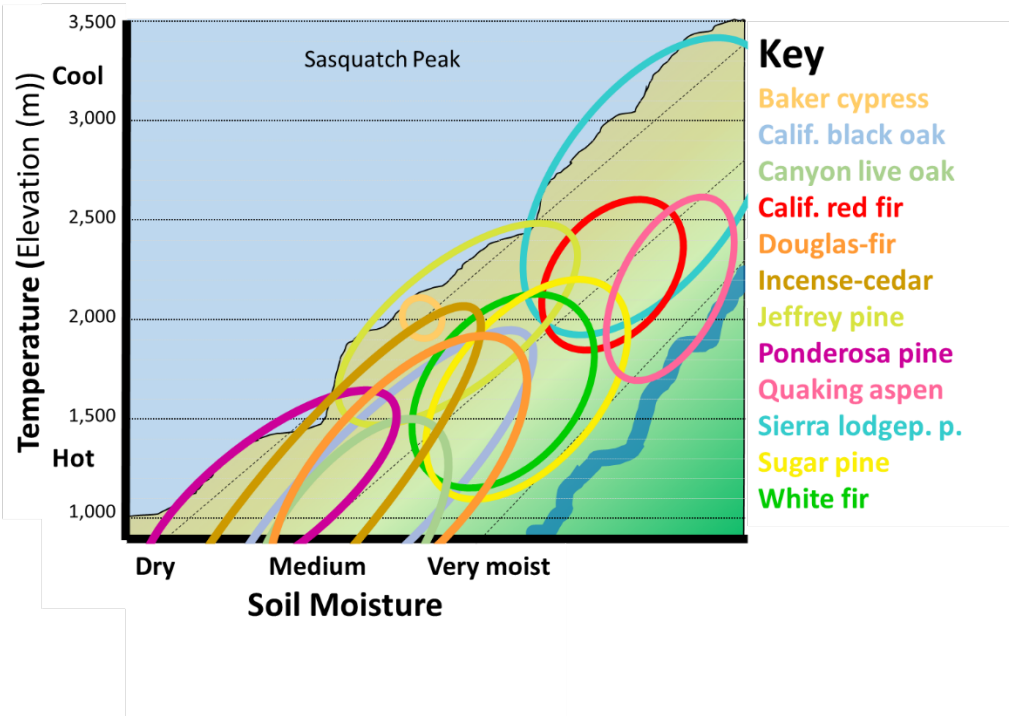
- On the graph, under "Key," use a colored marker to write "California black oak."
- Ask: What is California black oak's general elevation range? 500-1800 meters.
- Explain: The moisture gradient (shown by black dashed lines) follows the contour of the mountain. Dry sites (low moisture requirement) are near the ridge along the left edge, and moist sites (high moisture requirement) are near the creek.
- Ask: What is California black oak's need for moisture? Medium. Look at where the dashed line for "medium" soil moisture occurs on the model.
- On the model, have students mark the lowest and highest elevations (500 m and 1800 m) with a dot, placing the dots along the "medium" moisture line. (If the table lists an elevation below the range of Sasquatch Peak for any species, mark the approximate lowest elevation somewhere below the model.)
- About midway between these two dots, have students move to the left and right to mark approximate driest and wettest conditions where California black oak is likely to be common. (The table doesn't give you much information on this. Talk with the students about how wide the species' tolerance for dry and wet conditions should be.)

- Draw an oval connecting the four dots to show the approximate distribution of the species (see the example below). You can also write the species name, in small letters, inside the oval. But look out – it's going to get complicated!

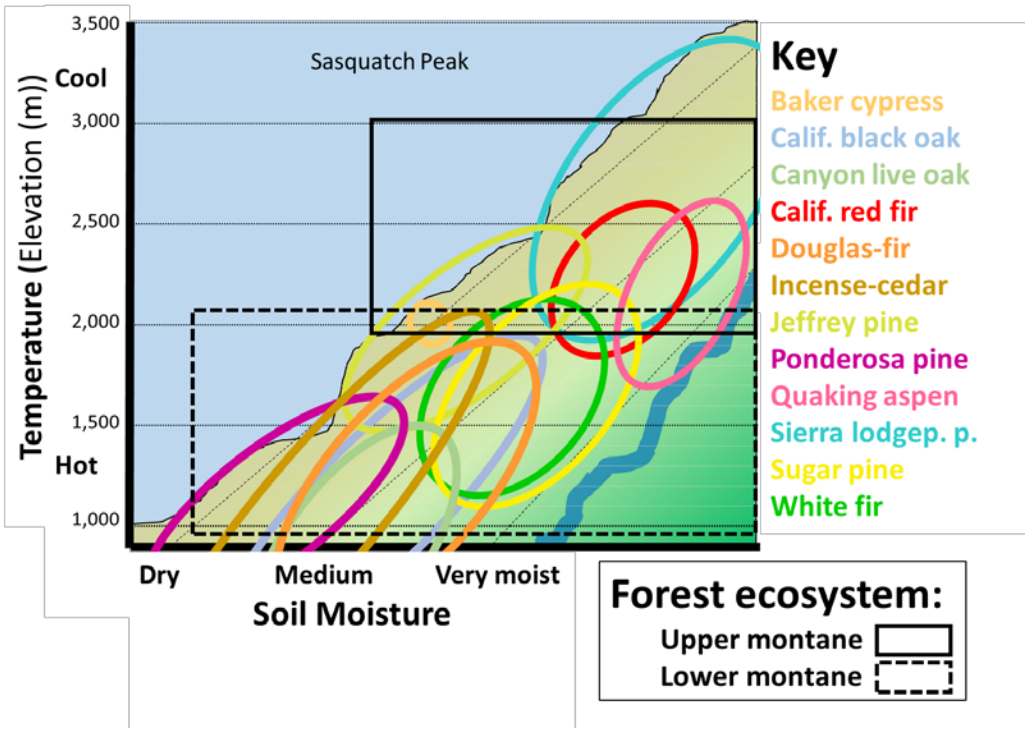
Note that the specific distributions for tree species vary throughout the Sierra Nevada, so the distributions listed in this table are just one example.



9. Ask each team to use the steps above to sketch their tree's distribution on the model.



If you have a smartboard with memory, save the model after each addition!
Explain: The model shows how complicated forest communities are – and we've included only a few species! As we learn more about fire, we're going to focus mainly on the ecology of two forest communities within this big area: lower montane and upper montane forests. Draw a rectangle around each of these regions of the model (example below).



10. Explain: The distribution of lower and upper montane forests overlap. Species common in high elevations of lower montane forests are also common in the lower parts of upper montane forests and vice versa.

11. Ask: What species are most common in lower montane forests? Ponderosa pine, incense-cedar, Douglas-fir, California black oak, sugar pine, white fir, canyon live oak. What species are most common in upper montane forests? Jeffrey pine, California red fir, Sierra lodgepole pine, and quaking aspen.

12. Discuss: This graphical *model* is useful because we can easily see which species may occur together at similar elevations within lower and upper montane forests. But remember that the boundaries shown in our model are not strict LIMITS for those tree species. Many individuals occur outside the conditions listed. For example, the model shows little or no overlap between the distributions of ponderosa pine and sugar pine. That suggests that these two species do not occur together, where in fact, they often do. LIKE ALL MODELS, THIS ONE IS HELPFUL, BUT IT IS NOT A PERFECT REFLECTION OF REALITY.

13. Explain: Over the past 100 years, the *climate* in our area has gotten warmer. In some places, it has gotten drier too. Ask: How would you describe climate, as opposed to day-to-day weather? Climate is the average patterns of weather over a long time, such as decades or centuries.

Some people say, “What you’re wearing today shows the weather. What’s in our closet shows the climate.”

14. Ask: Since our 12 species depend on the moisture and weather conditions that we have just graphed, what would you expect them to do if those conditions change? The places where the trees can grow will also change.

15. Discuss: We can use the model to predict how *climate change* might make a location more or less favorable for our tree species. If you were in a moist area around 1,100 m with a lot of sugar pine and then, over the next 20 years, the climate got a lot hotter and drier, what species might become more common? Ponderosa pine, Douglas-fir, incense-cedar, California black oak, canyon live oak. Suppose some sugar pine seeds landed in a medium-moist area at 2,500 m elevation. Would they have much of a chance to grow up? Why or why not? Their chances would probably be better than they are now because it will probably be warmer.

16. Explain: There is a term for what happens when species move to new areas because conditions in their old homes have changed. It is called *species migration*. We’re going to use our graphical model of upper and lower montane forests to make some predictions about species migration in response to climate change.

Assessment:
Give each student a copy of **Handout M14-2: Trees in a Changing Environment.** Go through the directions at the top. Tell students whether to use the graphic on the handout or on the board. Consider doing the first question together.

Evaluation: Use **Answer Key for Handout M14-2: Trees in a Changing Environment**

Handout M14-1: Where Can Trees Grow on Sasquatch Peak?

This table lists the environmental conditions where some tree species are most common on Sasquatch Peak**,** a fictitious mountain somewhere in the northwestern Sierra Nevada. The valley bottom is at 900 m elevation, but some species are able to live at lower elevations than this. The summit of the peak is at 3,500 m. The species distributions given here are generalized from data reported in the *Fire Effects Information System* (https://feis-crs.org/feis/) and *Silvics of North America**

We are studying lower and upper montane communities in the northern Sierra Nevada. We are not studying subalpine communities, which occur at higher elevations, but you may be interested to know a little about these forests: Trees that occur in subalpine communities in the Sierra Nevada include Sierra lodgepole pine, whitebark pine, western white pine, and mountain hemlock.

Tree Species	Elevations where this species is most common in the northwestern Sierra Nevada (m above sea level)	Need for moisture
Baker cypress	1900-2100	Low
California black oak	500-1800	Medium
Canyon live oak	500-1300	Medium
California red fir	1900-2600	Medium
Douglas-fir	700-1700	Medium
Incense-cedar	700-2000	Low to medium
Jeffrey pine	1500-2500	Low to medium
Ponderosa pine	500-1700	Low to medium
Quaking aspen	1600-2600	High
Sierra lodgepole pine	1900-3400	Low to high
Sugar pine	1000-2100	Medium to high
White fir	1200-2100	Medium

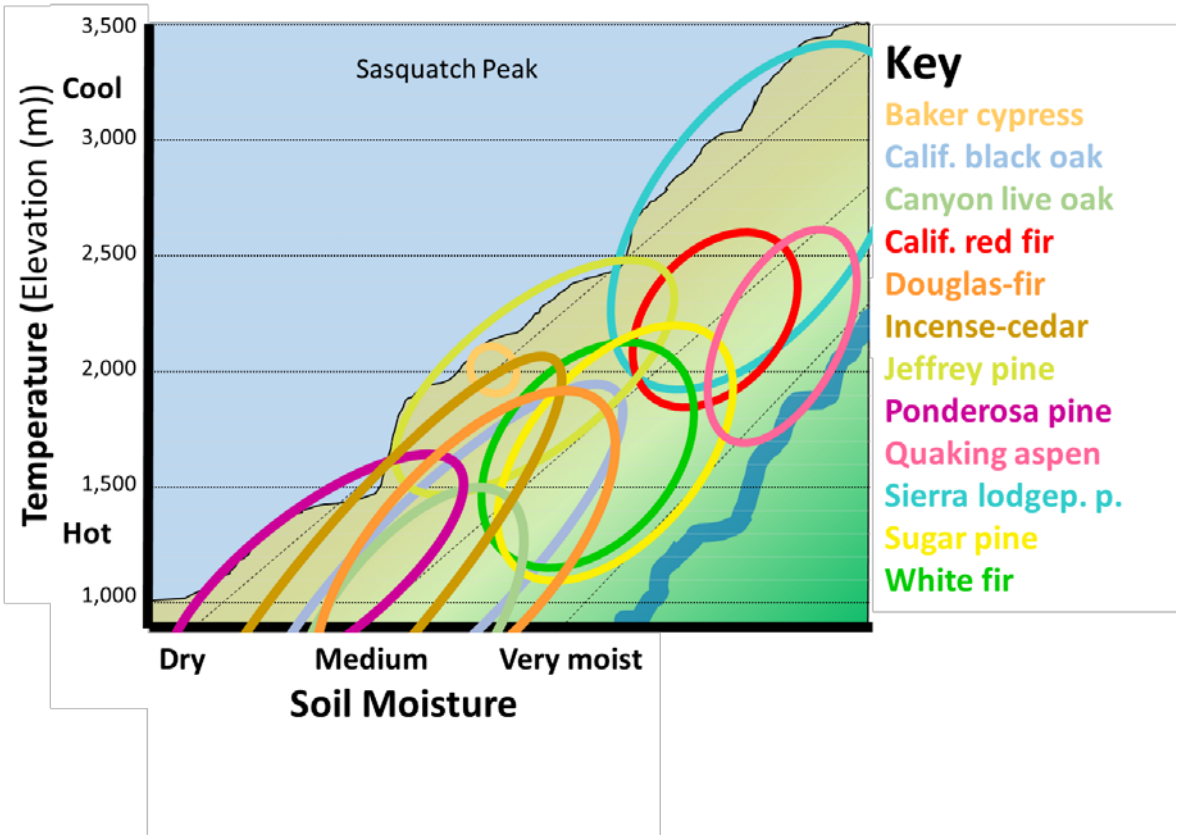
* Burns, Russell M.; Honkala, Barbara H., tech. coords. 1990. Silvics of North America. Volume 1. Conifers. Agric. Handb. 654. Washington, DC: U.S. Department of Agriculture, Forest Service. 675 p.

Burns, Russell M.; Honkala, Barbara H., tech. coords. 1990. Silvics of North America. Vol. 2. Hardwoods. Agric. Handb. 654. Washington, DC: U.S. Department of Agriculture, Forest Service. 877 p.

Handout M14-2: Trees in a Changing Environment

Name: _____

Directions: Use this graph or the Sasquatch Peak model on the board to answer the questions.



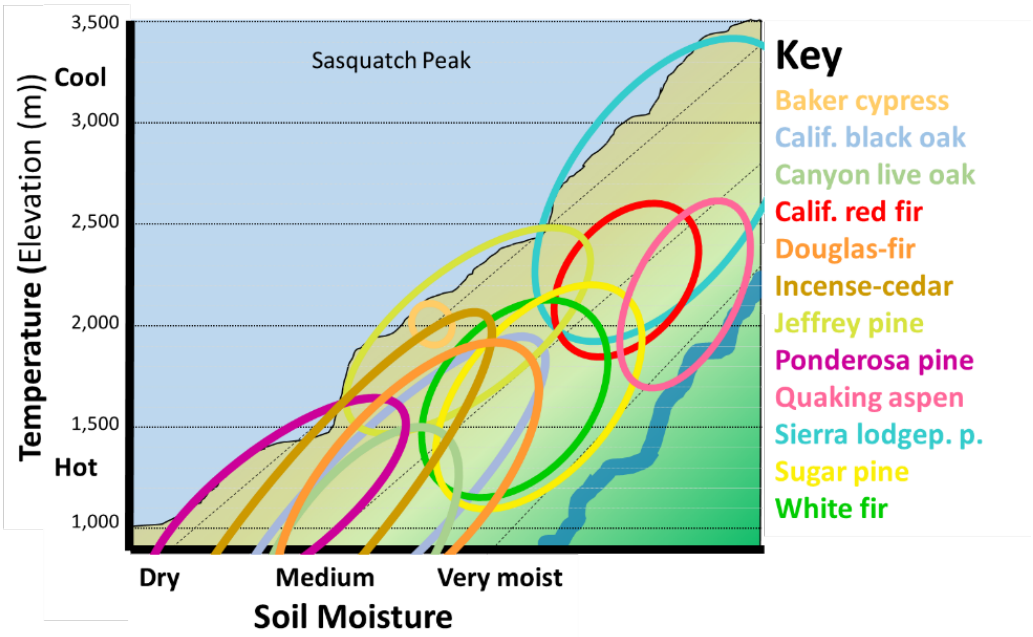
1. Suppose you are a sugar pine living at a moist area at 1,800 m elevation and your home gets a lot drier. Name two tree species that are not in your community now but might grow well there over the next 100 years: _____ _____

2. Suppose you are a California red fir living at 1,900 m elevation and your home gets a lot warmer and drier. Are your seedlings likely to survive? _____

3. Suppose you are a white fir living at 2,100 m elevation and your home gets a little warmer and wetter. A squirrel carries some of your seeds to 2,400 m elevation and drops them under an aspen tree. Are they likely to grow into mature trees? Why or why not?
   _____
   _____

4. Suppose you are an incense-cedar growing at 1,600 m elevation and your home gets drier. Are your seedlings likely to start growing under sugar pines? Why or why not?
   _____
   _____

Answer Key:
Handout M14-2: Trees in a Changing Environment



1. Suppose you are a sugar pine living at a moist area at 1,800 m and your home gets a lot drier. Name two tree species that are not in your community now but might grow well there over the next 100 years: Any of these: Incense-cedar, Jeffrey pine, Baker cypress

2. Suppose you are a California red fir living at 1,900 m elevation and your home gets a lot warmer and drier. Are your seedlings likely to survive? No

3. Suppose you are a white fir living at 2,100 m elevation and your home gets a little warmer and wetter. A squirrel carries some of your seeds to 2,400 m elevation and drops them under an aspen tree. Are they likely to grow into mature trees? Why or why not? Their chances are mixed. Temperatures up at 2,400 m will probably be warm enough in the future, but aspen sites are already wetter than white fir likes. If the site gets even wetter, it might be hard for white fir seedlings to thrive. In addition, the odds that ANY seed will grow into a mature tree are very low.

4. Suppose you are an incense-cedar growing at 1,600 m elevation and your home gets drier. Are your seedlings likely to start growing under sugar pines? Why or why not? Incense-cedar seedlings might indeed start growing under sugar pines because the sites where sugar pines currently grow are likely to get drier. In addition, incense-cedar seedlings are pretty good at growing under the shade of mature trees, so the sugar pines should not inhibit growth.