Activity 5: Managing Forests for Change
Suggested Solution Diagrams: Teacher Notes

Slide	Notes
1	This slide presentation provides teachers with some graphic illustrations of the solutions that student groups should draw to represent the climate scenarios in Part B of Activity 5. Note: The management actions illustrated on these diagrams are not the only measures that can be taken. We provide these solution maps as a guide to several important cause/effect relationships that often play a significant role in the behavior of a forest. If your students find different ways of viewing the relationship between the variables, ask them to explain and justify their ideas and alter the diagram accordingly.
2	In Scenario 1, the level of atmospheric carbon dioxide has increased. Since this is a resource for trees and photosynthesis, increased carbon dioxide will result in increased **Tree growth**. However, if precipitation and levels of nutrients have not increased, then the increased tree growth could be limited by available water and available nutrients.
3	Fertilizing can replenish the nutrients taken up by the trees as a result of the extra growth. Increased genetic diversity would mean that some trees might still do well even with less water available. If the forest experiences less rain, however, water is likely to be the limiting factor and the additional tree growth will not be sustained.
4	While the forest would initially show increased growth from the added carbon dioxide, other limiting factors, such as water and nutrients, would eventually limit growth. This diagram shows those limits with red arrows for emphasis.
5	In Scenario 2, a decrease in rainfall has caused a decrease in groundwater. Since **Precipitation** and **Groundwater** are moving in the same direction, we connect them with an S-arrow. The decrease in groundwater will cause a decrease in the amount of available water. We show this relationship with an S-arrow to **Available water**, since the two variables move in the same direction.
6	We can address this problem by thinning the forest. With a lower density of trees, the remaining trees will have more water available to them.
7	In Scenario 3, we again have dry conditions. The lack of rain will cause a decrease in groundwater, which will decrease available water. In addition, some plants in the understory have continued to grow. A thick, dry understory significantly increases the probability of a high-intensity (and quite damaging) wildfire.

8	As with Scenario 2, thinning the forest will help decrease the competition for water. A prescribed fire also can be used to reduce the amount of fuel load in the forest understory, if done with care. In dry conditions, even prescribed fires can burn out of control and cause damage to the remaining trees. Therefore, the prescribed burn would best be performed before the fuel load becomes too big or too dry. The green arrow from **Prescribed fire** to **Tree growth** represents the potential for some tree loss caused by the prescribed fire under these conditions.
9	In Scenario 4, we have two factors that will increase growth directly and indirectly. First increased precipitation will cause an increase in groundwater, which will cause an increase in available water. The decrease in competition will reduce tree stress from lack of nutrients/water and increase the rate of tree growth. In addition, a longer growing season will directly increase tree growth by providing more favorable temperature conditions for a longer period of time. With these conditions that promote high growth, soil nutrients will become a limiting factor.
10	By applying improved fertilizer to the forest, a manager can take advantage of adequate water and longer growing season to get more growth from the trees.
11	In Scenario 5, there has been an increase in severe storms. These storms damage trees, creating conditions that promote disease. We can show how **Severe storms** increases the risk of disease by using an S-arrow. More storms may also increase available water, or the torrent of rain may run off the forest and into streams and lakes.
12	Thinning is a good way to halt the spread of disease. Also, if we have been managing our forest for genetic diversity, then this would help to reduce the risk of disease, as some trees are likely resistant to the disease in question.
13	In Scenario 6, the temperature has increased, which triggers an increase in fungi that cause disease. We can show this on the map by adding cards for temperature and fungi. Since an increase in **Temperature** causes an increase in **Fungi**, we can connect those to cards with an S-arrow. And since fungi increase the risk of disease, we can connect **Fungi** to **Risk of tree disease** with another S-arrow.
14	To deal with this problem, we could try two approaches. First, prescribed fire can be used to decrease the amount of fungi. In wet conditions, the fire is unlikely to damage the trees, but will clear out the understory. Second, if we have been managing our forest for genetic diversity, then this would help to reduce the risk of disease, as some trees are likely resistant to the disease from the fungus in question.
15	One of the most challenging aspects of climate change is the increased uncertainty regarding what weather conditions a particular locale will see from year to year. In Scenario 7, we can add the **Precipitation** and **Groundwater** cards as we did earlier. However, this time, we do not know whether the precipitation from year to year will be higher or lower than usual.

16	To deal with this level of uncertainty, a forest manager must develop a genetically diverse forest in which trees can vary in tolerance for unusually wet or unusually dry conditions and in resistance to disease. Creating this diversity will help keep the loss of trees relatively small regardless of what type of weather conditions materialize. Careful thinning and the use of improved fertilizer also may help keep the forest resilient for whatever climate occurs.
17	Students may ask about the impacts of long-term increases in precipitation. Here we can use a new variable, **Flooding**, to account for these changes. If **Precipitation** remained high, then **Flooding** would increase. This would cause a decrease in **Tree Growth**, as it would decrease the amount of oxygen available to the trees.