

FACTS II: The Aspen FACE Experiment

By Jenn Carlson

Grade: 10

Subject: Biology

Time Required: 2 class periods

Overview

This activity is designed to relate the process of photosynthesis to human induced changes in the atmosphere's composition. Students should begin this activity with a solid knowledge of photosynthesis. Students will have the opportunity to analyze data from a current real-world scientific experiment examining the ecosystems effects of increased CO₂ and/or O₃.

Objectives

Upon completion of this activity, students should be able to:

- Explain how increased CO₂ influences photosynthesis and therefore plant growth
- Explain how increased O₃ influences photosynthesis and therefore plant growth
- Explain how increased CO₂ + O₃ influences photosynthesis and therefore plant growth
- Identify controlled and manipulated variables
- Identify ozone damaged plant leaves

Content Standards:

LEC16 III.5.HS.4 Describe the responses of an ecosystem to events that cause it to change.

LEC17 III.5.HS.5 Describe how carbon and soil nutrients cycle through selected ecosystems.

LEC18 III.5.HS.6 Explain the effects of agriculture and urban development on selected ecosystems.

C15 I.1.HS.2 Design and conduct scientific investigations.

C18 I.1.HS.3 Recognize and explain the limitations of measuring devices.

C 19 I.1.HS.4 Gather and synthesize information from books and other sources of information.

R13 II.1.HS.3 Show how common themes of science, mathematics, and technology apply in real-world contexts.

R16 II.1.HS.6 Develop an awareness of and sensitivity to the natural world.

Activities

Procedure

Briefly review the photosynthesis equation. Students should also be familiar with ground level ozone. If they are not, you may use the EPA publication *Ozone: good up high bad nearby* to allow students to read about and then discuss “bad ozone” and its causes and effects. Explain to students that they will be receiving data from a current real-world scientific experiment (The Aspen FACE Experiment) examining the ecosystems effects of increased CO₂ and/or O₃. You may pass out copies of the handout from The Aspen FACE Experiment website, use a projector to navigate through the site and discuss the experiment with the students, or create your own PowerPoint with personal photographs. Be sure to discuss what the manipulated variables are and what variables are being controlled.

Students should then make three hypotheses regarding aspen tree growth:

- 1) If CO₂ is elevated, then...
- 2) If O₃ is elevated, then...
- 3) If CO₂ + O₃ are elevated then....

Students will receive the volume growth index data for aspen in the years 1998, 1999, and 2000. If you have access to a computer lab, the data can be made available on the public directory and the students can follow the directions below to create a single graph that will compare the different variables. If you do not have access to a computer lab (or need to practice their graphing skills!) you can have them graph the data by hand.

Upon completing their graphs, students should then label the worksheet with the three photographs as CO₂, O₃, or CO₂ + O₃, based on the trends they see on their graphs.

Next, students will explain why a control is needed in a scientific experiment. Based on this knowledge, they should describe what they would expect the photo for the control plot to look like.

Lastly, and most importantly, the students should use their graph and the photographs to draw three conclusions based on their hypotheses. Each conclusion should restate the hypothesis, tell whether it was correct, and explain why. Explanations should relate the results to photosynthesis and what is known about “bad ozone.”

Their final product should include three hypotheses, a SINGLE graph showing all data (labeled correctly), three correctly labeled photographs, an explanation an description of the control, and three conclusion statements with explanation based on what they know about photosynthesis and “bad ozone.”

Extension: Have students find leaves both with and without and O₃ damage and include them in their final product. A typical ozone damaged aspen leaf would have purple stippling (spots).

Sources

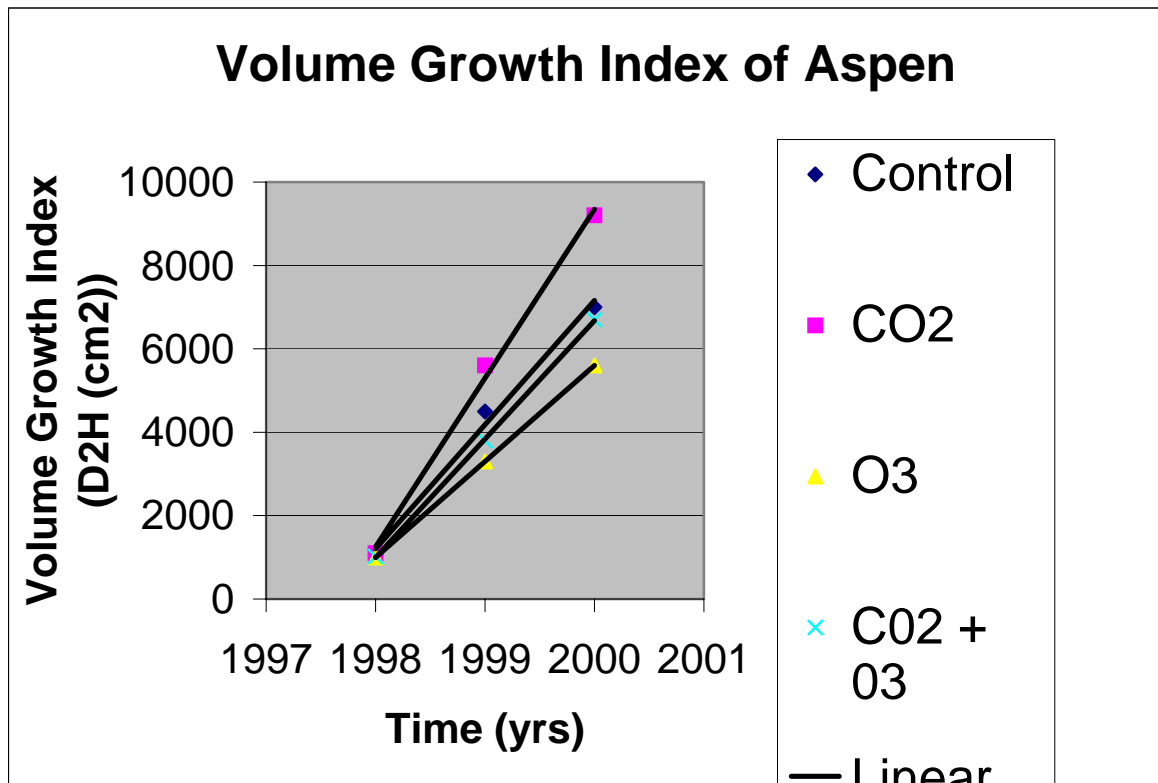
EPA Office of Air and Radiation. (2003) *Ozone: good up high bad nearby*. Retrieved July 14, 2005 from <http://www.epa.gov/oar/oaqps/gooduphigh/>.

Facts II: The Aspen FACE Experiment. Retrieved July 15, 2005 from <http://aspenface.mtu.edu/>

Karnosksy, et al. (2003) Tropospheric O₃ moderates responses of temperate hardwood forests to elevated CO₂: a synthesis of molecular to ecosystem results from the Aspen FACE project. *Functional Ecology* 17, 289 – 304.

Ozone Biomonitoring. *Ozone sensitive species: trembling aspen*. Retrieved July 15th, 2005 from <http://www.fiaozone.net/species/aspen/index.htm>.

Example Graph



Data

Year	Control	CO ₂	O ₃	CO ₂ + O ₃
1998	1050	1100	1000	1020
1999	4500	5600	3300	3800
2000	7000	9200	5600	6700

FACTS II: The Aspen FACE Experiment

Rubric

	Points Possible	Points Earned
CO ₂ Hypothesis	1 pt	
O ₃ Hypothesis	1 pt	
CO ₂ + O ₃ Hypothesis	1 pt	
Graph	4 pts	
Correctly labeled photographs	2 pts	
Correct explanation & description of control	2 pts	
Conclusions (Restate hypothesis, was it correct, and WHY)		
- CO ₂ Hypothesis	3 pts	
- O ₃ Hypothesis	3 pts	
- CO ₂ + O ₃ Hypothesis	3 pts	
TOTAL	20 pts	

Name: _____ Date: _____ Hour: _____

FACTS II: The Aspen FACE Experiment

Directions

- I. HYPOTHESES.** Using what you know about photosynthesis and “bad ozone,” hypothesize about what the Aspen FACE data will show in each of the treatments (elevated CO₂, O₃, or CO₂ + O₃). Record them on your worksheet.

- II. GRAPH.** Follow the directions below to create a single graph that will show the growth of aspen in all four treatments. Print your graph when finished.
 1. In Excel, open the Aspen FACE file
 2. Click on the graph button
 3. Choose XY (Scatter), Click Next
 4. Choose the Series Tab
 5. Select Add
 6. In the Name field type “Control”
 7. Click on the red arrow to the right of X Values to return to sheet one. Highlight A2 – A4. Click on the red arrow to return to the series tab
 8. Click on the red arrow to the right of Y Values to return to sheet one. Highlight B2 – B4. Click on the red arrow to return to the series tab
 9. Select Add
 10. In the Name field type “CO₂”
 11. Click on the red arrow to the right of X Values to return to sheet one. Highlight A2 – A4. Click on the red arrow to return to the series tab
 12. Click on the red arrow to the right of Y Values to return to sheet one. Highlight C2 – C4. Click on the red arrow to return to the series tab
 13. Select Add
 14. In the Name field type “O₃”
 15. Click on the red arrow to the right of X Values to return to sheet one. Highlight A2 – A4. Click on the red arrow to return to the series tab
 16. Click on the red arrow to the right of Y Values to return to sheet one. Highlight D2 – D4. Click on the red arrow to return to the series tab
 17. Select Add
 18. In the Name field type “CO₂ + O₃”
 19. Click on the red arrow to the right of X Values to return to sheet one. Highlight A2 – A4. Click on the red arrow to return to the series tab

20. Click on the red arrow to the right of Y Values to return to sheet one. Highlight E2 – E4. Click on the red arrow to return to the series tab
21. Click Next
22. Choose the Title Tab
23. In the Chart title field type “Volume Growth Index of Aspen over Time”
24. In the Value (X) axis field type “Time (years)”
25. In the Value (Y) axis field type “Volume Growth Index (D₂H (cm²))”
26. Select the Axes tab
27. Check both Value (X) axis and Value (Y) axis boxes (this shows the units)
28. Select the Series tab
29. Check the Show legend box
30. Click Next
31. Click Finish
32. Right click on a data point. Choose add Trendline. Click ok. Repeat for all four sets of data.
33. Select your graph and print

III. PHOTOGRAPHS. Label the three pictures on the worksheet as elevated CO₂, elevated O₃, or elevated CO₂ + O₃, based on the trends you see on your graphs. The photos were not taken systematically. Look closely at the pictures to find a way to compare the three plots.

IV. CONTROL. In a short paragraph, explain why a control is needed in a scientific experiment. What would you have expected the photo for the control ring to look like compared to the others?

V. CONCLUSIONS. For each hypothesis:

- 1) Restate the hypothesis
- 2) Tell whether or not it was correct, and
- 3) Explain *why* based on what you know about photosynthesis and “bad ozone”

Record your conclusions, in complete sentences, on your worksheet.

FACTS II: The Aspen FACE Experiment

Name: _____ Date: _____ Hour: _____

Worksheet

ASPEN GROWTH HYPOTHESES

- 1. If CO₂ is elevated, then _____

- 2. If O₃ is elevated, then _____

- 3. If CO₂ + O₃ are elevated, then _____

GRAPH – please attach
PHOTOGRPAHS





CONTROL

CONCLUSIONS

1.

2.

3.

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<http://aspenface.mtu.edu/>

The Aspen FACE (Free-Air Carbon Dioxide Enrichment) Experiment is a multidisciplinary study to assess the effects of increasing tropospheric ozone and carbon dioxide levels on the structure and function of northern forest ecosystems



Located at the Harshaw Experimental Forest near Rhinelander, Wisconsin, the Aspen FACE Experiment operates as a DOE User Facility, and is a collaborative effort among the following organizations:

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|--|---|
| Michigan Technological University | Estonian Academy of Science |
| US Forest Service North Central Research Station | Canadian Forest Service |
| Brookhaven National Laboratory (FACTS I) | Slovak Forest Resources Institute |
| Natural Resources Research Institute | Academy of Finland |
| University of Michigan | University of Wisconsin, Madison |

The Aspen FACE experiment consists of twelve 30m rings in which the concentrations of carbon dioxide and tropospheric ozone can be controlled. The design provides the ability to assess the effects of these gasses alone, and

in combination, on many ecosystem attributes, including growth, leaf development, root characteristics, and soil carbon.

Each ring consists of a series of vertical ventpipes which disperse carbon dioxide, ozone or normal air into the center of the ring. This computer controlled system uses signal feedback technology to adjust gas release each second in order to maintain a stable, elevated concentration of carbon dioxide and/or ozone throughout the experimental plot. Because there is no confinement, there is no significant change in the natural, ambient environment other than elevating these trace gas concentrations.

Distribution of species within ring.

