

# Lesson: Ozone Damage Data Collection

**Grade Level:**  
5th grade and up

**Subject Areas:**  
Earth Science

**Activity time:** 30 minutes

**Setting:** Indoors

**Skills:** Gathering information through observing; Analyzing information; Drawing conclusions.

**Vocabulary:**

- **Biomonitoring:** Over time, looking at a plant or animal that lives in a natural environment to check the quality of the ecosystem.
- **Chlorophyll:** Green pigment found in most plants that absorbs light plants use to make food.
- **Chlorosis:** a condition where plants produce insufficient chlorophyll and become discolored. Leaves often become pale yellow.
- **Ecosystem:** combined physical and biological components of an environment.
- **Ground level Ozone:** an air pollutant created by the interaction of nitrogen and VOC's in the presence of sunlight.
- **VOC's:** Volatile Organic Compounds. Highly reactive compounds in the air that can be either natural or man-made.

**Objectives: Students will:**

- 1) explain how ground level ozone can injure plants;
- 2) describe a biomonitoring project.

**National Standards:**

- Content Standard A: Science as Inquiry;
- Content Standard C: Life Science;
- Content Standard F: Science in Personal and Social Perspectives;

**Materials:**

- Color copies or projected images of leaves
- Data Sheet

**Background:**  
**Ozone Bio-monitoring Garden Project**

An Ozone Bio-monitoring Garden is a way schools can take part in an important study to determine the effects of ozone on plant populations. The study will help to understand the relationship between foliar ozone injury and the growth of plants. The results of the study may be used to inform decision makers so adequate protective measures can be developed to improve the quality of the air we breathe. Results can be compared by tracking one leaf over the growing season and comparing a plant's growth over several years.

Ozone is formed when nitrogen oxides (NOx) combine with volatile organic carbons (VOCs) in the presence of sunlight to form an unstable gas that harms humans, plants and animals. Humans suf-

fer through lung ailments leading to permanent lung damage and reduced immune system function. Plants show foliar damage and slowed growth. This adversely impacts the agriculture and forestry industries as well as plants in nature. Impacts to animals and aquatic systems have not yet been adequately studied.

Much can be done to reduce tropospheric (ground level) ozone by reducing energy use. Switching to more energy efficient appliances, using alternative, cleaner fuels when available, riding a bike or walking instead of driving, driving the most fuel efficient vehicle possible, and using mass transportation are all ways to reduce energy consumption. Working with local, regional and national decision-makers to develop the best possible standards to protect air quality for the benefit of public health and the environment is another important way to reduce ozone and improve air quality.

**Monitoring**  
Ozone produces a type of injury on plant leaves that is unique and easy to diagnose. Typical symptoms:

- Appear after late June (except in high elevations areas which have shown symptoms in late May)
- Are found on most mature leaves first (so if you see what appears to be symptoms only on the newest leaves near the top of the plant, what you are seeing isn't ozone related).
- Are seen on the upper leaf surface, if you turn it over and it goes through, it is probably insect or



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other damage.

- Appear as purplish-black spots (called stippling or purpling) that DOES NOT cross leaf veins. If spots do cross veins, it is damage likely caused by insects.

### Introduction:

Explain to the students that they will collect data on photographs of leaves from one plant growing in Great Smoky Mountains National Park. In the field, data is only collected on the 8 lowest leaves and is done weekly.

### Procedure:

- 1: Have students practice their estimation skills by visiting the website <https://www.handsontheland.org/environmental-monitoring/ozone-bio-monitoring/ozone-injury-training.html>. Select the “display #” and click “Go”. Select species Common Milkweed. Ozone damage appears on the leaf as brownish-red stippling (dots). Use the dropdown list to select the % category of damage on the leaf displayed, then click “check”.
- 2: Hand each student or groups of students one of the data sheets.
- 3: Either project images of each leaf, starting with the lowest leaf, or make color copies of the plant page for each student.
- 4: Have students estimate the percentage of ozone damage on each leaf. The plant they are collecting data on is Cut-leaf Coneflower (*Rudbeckia laciniata*).

### Wrap Up:

Have each group compare their answers. Did they all estimate the same percentages of ozone damage? Probably not. When data is collected in Great Smoky Mountains National Park throughout the summer, we are left with a trend for the entire growing season. Even if one set of data collectors make mistakes, we will still get an overall trend that shows the plants health. You can track a real plant through the growing season by going to the Hands on the Land website <https://www.handsontheland.org/environmental-monitoring/ozone-bio-monitoring/ozone-plant-visualization.html>

Select “Purchase Knob” as the garden. Select any plant ID number. The last two numbers are the year. Next click the “Graph” button. CB0209 is the Crownbeard plant 02 from the year 2009. You will need Flashplayer to be able to see this graphic.

Drag the scroll bar under the drawing of the plant to see it change over the growing season. A red color indicates that a leaf is missing. Black indicates that the leaf is still there but is completely dead. Purple indicates ozone damage, yellow indicates chlorosis and green indicates a healthy leaf.

You will notice errors in the data since a plant can't recover from ozone damage, chlorosis or dead tissue. You will also notice that even with errors, you can still see the trend of ozone damage through the season.

Ask students why they think it is important to monitor plants for ozone damage?

*The damage impacts the plants ability to photosynthesize as chlorophyll is lost. This also impacts the nutritional value of the plant if it is eaten by animals. Research has shown that plants with ozone damage are not as able to protect themselves against insect infestations or diseases.*

### Assessment:

Students can be graded on both the practice described in procedure 1 and the accuracy of their final data.

### Answer Key:

Leaf 1: 76 - 100%  
Leaf 2: 51 - 76% (high end)  
Leaf 3: 51- 76% (low end)  
Leaf 4: 26 - 50% (high end)  
Leaf 5: 7-25%  
Leaf 6: 1 - 6%  
Leaf 7: 1 - 6%  
Leaf 8: 0%

### Extensions:

Monitor sensitive plants in your area either by planting them in your schoolyard or out in the wild. Go to <https://www.handsontheland.org/monitoring/projects/ozone/O3SensitiveSpp-on-NPS-FWS-Lands.pdf> for a list of sensitive species.

### Resources:

**Ozone Biomonitoring Study on Hands on the Land**  
<https://www.handsontheland.org/environmental-monitoring/ozone-bio-monitoring.html>



# Monitoring Life in Great Smoky Mountains National Park

## Ozone Damage Data Sheet



### Ozone Bio-monitoring Garden Data Sheet - Alternate Leaves

Group Name: \_\_\_\_\_ Date: \_\_\_\_\_

Garden Location: \_\_\_\_\_ Plant ID #: \_\_\_\_\_

Plant species: \_\_\_\_\_ Plant height (cm): \_\_\_\_\_

Total # of leaves on the entire plant: \_\_\_\_\_

Observations (in flower, in bud...) \_\_\_\_\_

**TOP OF PLANT**

leaf present <input type="checkbox"/>		missing <input type="checkbox"/>	
0%   1-6%   7-25%   26-50%   51-75%   76-100			
P			
Observations			

leaf present <input type="checkbox"/>		missing <input type="checkbox"/>	
0%   1-6%   7-25%   26-50%   51-75%   76-100			
P			
Observations			

8

7

leaf present <input type="checkbox"/>		missing <input type="checkbox"/>	
0%   1-6%   7-25%   26-50%   51-75%   76-100			
P			
Observations			

6

leaf present <input type="checkbox"/>		missing <input type="checkbox"/>	
0%   1-6%   7-25%   26-50%   51-75%   76-100			
P			
Observations			

4

5

leaf present <input type="checkbox"/>		missing <input type="checkbox"/>	
0%   1-6%   7-25%   26-50%   51-75%   76-100			
P			
Observations			

3

leaf present <input type="checkbox"/>		missing <input type="checkbox"/>	
0%   1-6%   7-25%   26-50%   51-75%   76-100			
P			
Observations			

2

1

leaf present <input type="checkbox"/>		missing <input type="checkbox"/>	
0%   1-6%   7-25%   26-50%   51-75%   76-100			
P			
Observations			

1

leaf present <input type="checkbox"/>		missing <input type="checkbox"/>	
0%   1-6%   7-25%   26-50%   51-75%   76-100			
P			
Observations			

**BOTTOM OF PLANT**

Rate the % of ozone symptoms covering the entire leaf  
 P= purpling (reddish-purple injury spots caused by ozone)



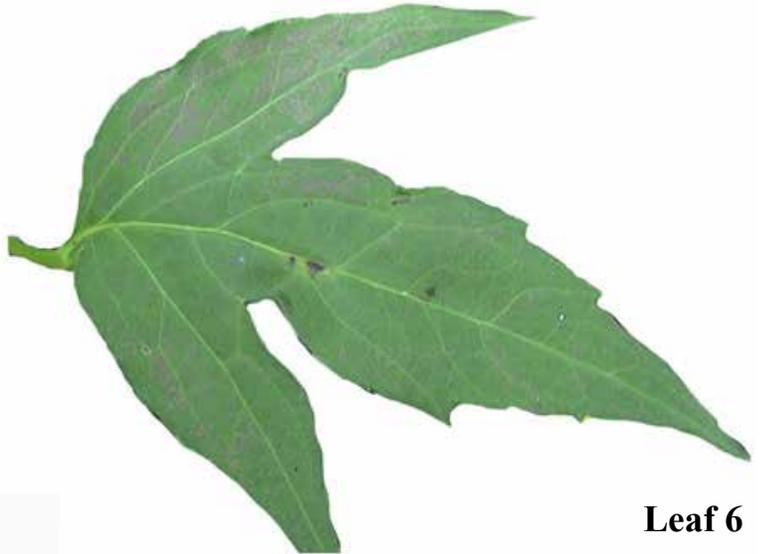
Note: Leaf 1 is the lowest leaf on the plant



Note: Leaf 8 is the highest leaf on the plant



**Leaf 5**



**Leaf 6**



**Leaf 7**



**Leaf 8**