

Ozone Indicator Garden

What is an Ozone Indicator Garden?

Gardens with indicator plants react to air pollution and as **bioindicators** show the health of our ecosystem. Scientists use bioindicators to understand how our actions affect the natural world. Your school garden will show the level of air pollution caused by bad ozone.

What is Good or Bad Ozone?

Ozone is a gas that naturally occurs in the air all around us. The ozone in the upper atmosphere is good because it protects us from the sun's harmful ultraviolet (UV) rays. However, ozone closer to the ground may combine with other gasses to create unhealthy air for people, plants, and wildlife. It may also seep into the earth's soil or our water. Pollutants from cars, power plants, and chemical refineries combine with the ozone and sunlight to create smog. Over time, this **Bad Ozone** may cause health problems, so it is important to monitor these levels.

How Do Plants Show Bad Ozone Levels?

Plants absorb carbon dioxide and release oxygen through tiny pores in their leaves called **stomata**. However, when these stomata open to take in air, they can also take in pollutants such as bad ozone, which oxidizes (burns) plant tissue during respiration. Some plants, like **Evening Primrose**, are highly sensitive to bad ozone, which leads to the formation of tiny dark brown, black, or purple spots on their leaves. These spots, known as purpling or stippling, do not cross the veins of the leaf and typically appear on older leaves first. If you notice these marks, it indicates that your plants have suffered ozone damage. If the spots cross the leaf veins the damage may be caused by insects rather than bad ozone.

Bad Ozone Damage



Bad Ozone Leaf Damage



Insect Leaf Damage



Vocabulary List:

Air: Gas mixture, including nitrogen and oxygen, surrounding the earth that plants and animals breathe.

Acidic: Solution with more Hydrogen ions, measuring lower than 7 on the pH scale.

Alkaline or Base: Solution with less Hydrogen ions, measuring higher than 7 on the pH scale.

Atmosphere: Gaseous envelope surrounding the earth.

Biennial: Happening every two years.

Bioindicator: Any living thing that shows the health of an environment.

Chalky: Shallow, stony, alkaline soil that quickly dries out.

Clay: Fine-grained, firm soil that sticks together when wet and hardens when heated.

Crepuscular: Active at dawn and dusk.

Data: Facts that can be used to make decisions.

Diurnal: Most active during the day.

Leaf Vein: Small channels or lines that transport water and minerals from the leaf to the plant.

Loamy: Rich, crumbly soil with less clay and nearly equal parts of sand and silt.

Logarithmic Scale: Method of showing data spanning a broad range of values.

Nocturnal: Most active at night.

Ozone: Reactive form of oxygen gas also known as O₃.

Pollution: Contamination of soil, water, or air from the release of harmful substances.

pH Scale: The power of Hydrogen logarithmic scale indicating acidic or alkaline levels with 7 as neutral.

Respiration: Act of inhaling and exhaling or breathing.

Riparian: Relating to the bank of rivers or natural course of water.

Rosette: Circle or spiral of leaves growing from the same base.

Soil: Mixture of minerals and organic material that covers much of Earth's surface.

Spindly: Long, slender, or thin.

Stalk: The main stem of a plant.

Stippling or Purpling: Leaf scars appear as dots or spots in between leaf veins.

Stoma: (plural – Stomata) Tiny openings on a leaf that allow it to absorb carbon dioxide and expel oxygen.

Build Your Ozone Indicator Garden

Yellow Evening Primrose (*Oenothera elata*)

Native to Southern California riparian areas, this fast-growing, tall, leafy, biennial has nocturnal bright yellow flowers with four heart-shaped petals that open in the evening and wither the following morning. Primarily pollinated at night by the **Sphinx Moth** (*Hyles lineata*), these blooms may also attract crepuscular birds, bees, butterflies, and moths near dawn and dusk. Starting in the second year of growth, it blooms from early summer through fall and will produce seeds for the next generation.

Set-Up

- Sow seeds in late fall with full-sun to partial shade and enough room for your plants.
- Allow 2 to 3 square feet for each adult plant with approximately 30-36 inches in between.
- A protective border or stepping stones may help preserve and provide access to plants.

Seeds

- Seeds can be purchased at a nursery or CA Native Seeds: <https://www.canativeseeds.com>.
- Start seeds in trays or sown directly into well-drained, chalky, sandy, loamy, or clay soil.
- This is a non-toxic, safe for people and dogs, plant that is fairly drought tolerant once established.

Soil and Care

- Determine your soil composition using **RockD**: <https://rockd.org/explore> (phone app available).
- **Evening Primrose** grows to be about 3 to 5 ft. high and 3 ft. wide and may need to be thinned.
- Water regularly, if over-watered, browning from root rot may develop spreading across leaf veins.
- Mulch and fertilize as required.
- After its second summer, the original plant will die back and new plants will grow.

New Sprout



Adult Plant



Full Bloom



Sphinx Moth



Bee Pollinator



Sphinx Moth



Monitor Ozone Damage

Regularly record ozone damage that is visible on the leaf using the same set of plants and leaves during the growing season. You can begin to monitor ozone damage once each plant has at least six leaves.

Count Your Leaves

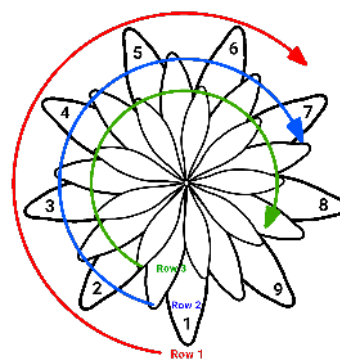
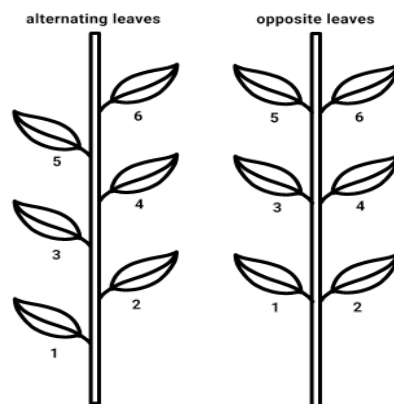
As your plant grows, it may be tall and spindly or low and round. How you count the leaves depends on how the plant grows.

Spindly – Straight, Tall, and Upright Plant

- From the ground, start at the first leaf and count it as (#1).
- The leaf directly above the first one, count as (#2), and so on.

Rosette – Low and Round Plant

- Count the lowest and oldest leaf on the outer ring as leaf (#1).
- Continue clockwise around the plant.
- Count each leaf as you move upwards towards the plant's center.



Measure Ozone Damage

Using the **Ozone Damage Level Chart** compare each leaf on your plant and give the leaf a “grade” according to its ozone stippling. How many leaves are damaged? How much of each leaf is damaged? Detail these and any other plant damage in the chart’s **Notes** column.

Ozone Damage Grades

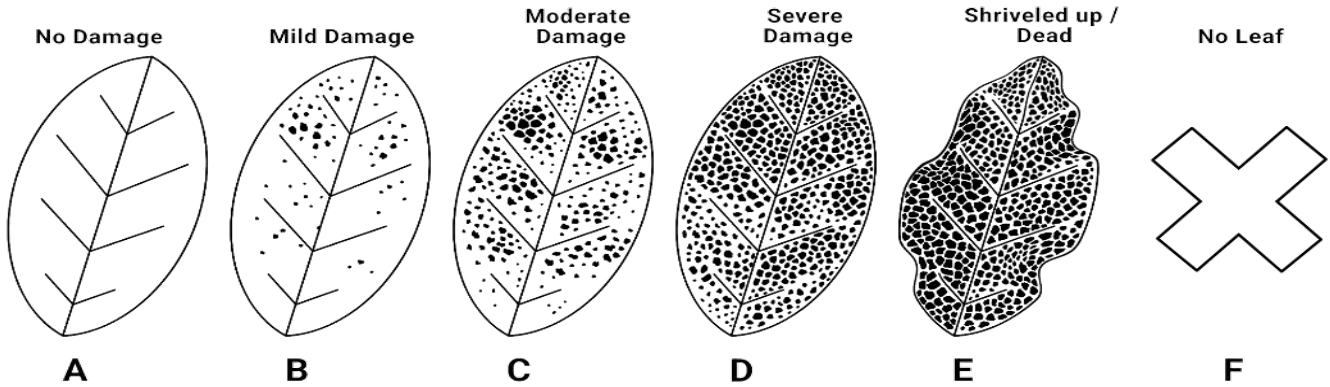
- None – No damage
- Mild – Few stippling spots
- Moderate – Half of the leaf is damaged
- Severe – Most of the leaf is damaged, wilting, or yellowed
- Dead – Leaf is still on the stalk, but shriveled
- Gone – Leaf has dropped, but a stem scar is visible

Record Ozone Damage

- Name or number your plants to ensure data accuracy.
- Measure the plant’s height and record its shape (*Spindly* or *Rosette*).
- Make observations regarding insect damage, over-watering, or odd growth.
- Regularly note and perhaps draw or photograph the leaves to compare damage levels over time.
- Find and report on today’s ozone level using: Airnow.gov.
- Determine the Ozone Damage level and grade the leaf damage using the “A” to “F” scale.
- Compare your results to the ozone levels found to see if air pollution affects your garden’s health.

Record Your Plants Ozone Level

Ozone Damage Level Chart



Name / Group: _____ Date: _____ Temperature: _____ Ozone Level / [Airnow.gov](https://www.airnow.gov): _____

[illegible]