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Goal: After learning of the potential harm ozone can cause as a pollutant to humans in high tropospheric quantities, I was curious how vegetation and plant life would respond to the same pollution, since plants play a large role in helping to regulate and control the atmosphere.

Effects on Plants:

- At first, damage can be onset with no visible signs. Ozone can enter the plants through the stomata when it opens, just like other atmospheric gasses.
- The ozone will dissolve in water inside the plant and begin causing trouble.
 - Ozone can rupture cell membranes and cause them to leak.
 - Photosynthesis will slow down and ultimately reduce water use efficiency.
 - Ozone can also oxidize compounds in the plant that can disrupt the energy production in the mitochondria. This can also reduce the yield of most species of plants, depending on the concentration of O₃
 - Ultimately this will weaken the plant, and make it more susceptible to things like bugs, disease, and drought.
- At higher concentrations, the effects of ozone can finally be visualized.
 - Plants will show flecking of light tan spots about 1 mm in diameter and they will show reddish spots about 4mm in diameter.
 - Over the past 25 years numerous countries have reported increased damage to crops from ozone.



- Forests are hard to study because there aren't many areas not effected. Although, it has been noticed that ozone can damage the stomata and allow more water to be transpired from the tress. This causes more water uptake and practically robs any watersheds of their supply.

More than Plants:

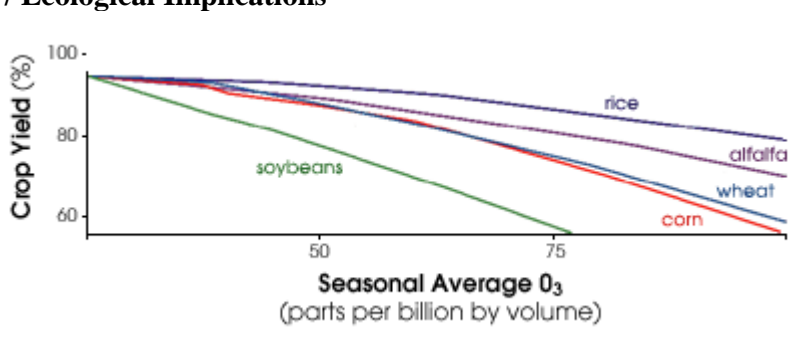
- Studies have shown that increased ozone can cause a lot of plants to metabolize less carbon dioxide. This in turn slows nitrogen fixation so they will leech it from the ground and eventually not have enough nitrogen to maximize their growth and yield. Farmers will add more nitrogen to their feedings and eventually it will runoff the soil.
 - For starters O₃, indirectly causes more CO₂ to stay in the atmosphere.

- Plants will also send less carbon to their roots and soil which beneficial microorganisms feed on, potentially sterilizing the soil.
- If Nitrogen leeches into a nearby water source, it can stimulate too much plant and algae growth that can diminish sunlight, life, and biodiversity in a lake.
- It can also contaminate drinking water, and severely effect young children and young farm animals.

Plant Exceptions:

- Since ozone is a major oxidizer, plants with antioxidants can withstand more damage.
- Plants with smaller stomata will also have reduced damage since they will take less O₃.
- Plants that emit isoprene can also avoid damage.
 - The catch is that, isoprene emission can produce ozone when NO_x is present.
 - Believe that isoprene protect membrane integrity (prevent leaky membrane) which ultimately protects it from the flecking seen above.

Social / Economic / Ecological Implications



- Reduced crop yields can hurt farmers financially, especially in developing countries that are just chugging out pollution.
- Note a relatively acceptable amount of 75 ppb in ozone can cause a 40% drop in soybean yield.
- This will only exacerbate the starvation problem globally, especially if we manage to sterilize land in certain locations.
- Aquatic life could be endangered if farmers use excessive nitrogen to make up for their loss.
- Isoprene emitting plants could potentially dominate an area if excessive levels are reached that could severely affect non isoprene emitting plants. This then could cycle and produce even more ozone by isoprene reacting with NO_x

Sources

- <https://www.epa.gov/ozone-pollution/ecosystem-effects-ozone-pollution>
- <https://scied.ucar.edu/blog/how-does-ozone-damage-plants>
- <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2701830/>
- [https://earthobservatory.nasa.gov/Features/OzoneWeBreathe/ozone we breathe3.php](https://earthobservatory.nasa.gov/Features/OzoneWeBreathe/ozone_we_breathe3.php)
- <https://water.usgs.gov/edu/nitrogen.html>