



Trends in ozone-induced foliar injury across Virginia, 1997 - 2006

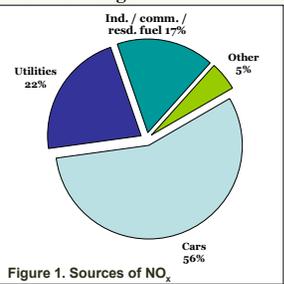
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Introduction

Ozone is the product of chemical reactions that take place in the atmosphere when volatile organic compounds (VOCs) mix and react with nitrogen oxides (NO_x) in the presence of sunlight.

Anthropogenic emissions, primarily through the combustion of organic compounds (i.e. gasoline and coal), account for a large majority of NO_x inputs to the environment (fig. 1).



In contrast, VOCs come primarily from natural sources, such as trees and other vegetation, although a sizable portion of the total input of VOCs does come from industrial and vehicular emissions. Weather plays a key role in the formation of ozone, with hot, dry, calm, cloudless days providing ideal conditions for VOCs and NO_x to combine and react to form ozone (U.S. Environmental Protection Agency 2004).

During the summer months, ozone concentrations at known phytotoxic levels can occur. A number of plants are sensitive to ozone exposures above normal background levels. These bioindicator species, such as yellow-poplar and sweetgum, exhibit an upper surface foliar injury symptom that can be distinguished from other foliar injuries. FIA tracks foliar injury with the goal of determining where negative impacts to forest trees may be occurring.

Methods

- O₃ injury was tallied on open areas (Biosites), at least 1 acre in size (USDA Forest Service, 2005).
- At each biosite 30 plants of at least 2 indicator species were inspected for amount and severity of ozone injury
 - Amount = % of leaves on plant with injury (all leaves)
 - Severity = % of leaf area with injury (injured leaves)
- Biosite Index (B. I.) (Smith et al. 2003) (table 1) was calculated as:
 - B. I. = avg. score (amount * severity) for each species, averaged across all species on each biosite.

Table 1. Injury categories for Biosite Index

Category	Biosite Index	Bioindicator response
1	0 to 4.9	Little or no injury
2	5.0 to 14.9	Light to moderate injury
3	15.0 to 24.9	Moderate to severe injury
4	> 24.9	Severe foliar injury

Results

Between 1997 and 2006, 20,685 plants from various locations across Virginia (biosites) were evaluated for ozone injury (table 2). The highest % of plants with injury occurred in 1997 and 1998 (fig. 2).

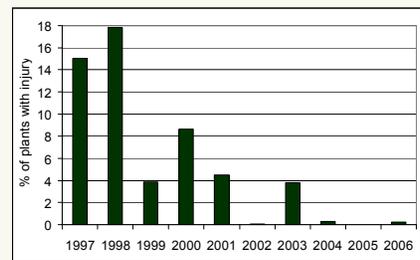


Figure 2. Percentage of plants with ozone injury by year.

Table 2. Number of plants & biosites evaluated for ozone injury by year.

	Evaluated		With injury	
	plants	biosites	plants	biosites
	number			
1997	366	9	55	3
1998	977	16	174	7
1999	1268	26	49	6
2000	1122	25	97	10
2001	1936	30	87	11
2002	1820	24	1	1
2003	2634	32	100	8
2004	3822	39	11	5
2005	3128	39	0	0
2006	3612	38	9	2

While 1997 had the 2nd highest % of plants with injury, average biosite index was highest in 1998 and 2000 (fig. 3).

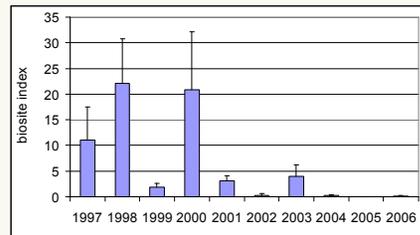


Figure 3. Average biosite index by year. Bars represent 1 standard error of the mean.

Biosites with injury category 3 and 4 occurred in 5 of the 10 years (fig. 4). However, < 5% of plants have had injury, and average B.I. has been < 5 since 2001. In addition, little or no injury was detected in 2004 through 2006.

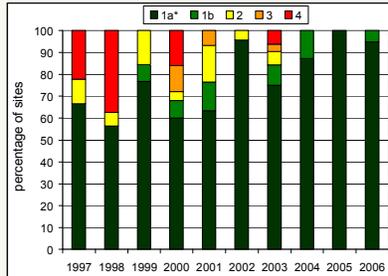


Figure 4. Percentage of biosites by category and year. *sites with no injury

When it occurred, ozone-induced foliar injury was often prevalent on the Coastal Plain (fig. 5).

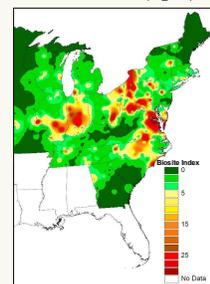


Figure 5. Estimated risk of ozone injury in 2000. (Based on individual biosites) (Courtesy of John Coulston)

Symptoms of ozone-induced foliar injury

- Conspicuous stippling on upper surface of leaves (USDA FS 2005)
- Leaf yellowing or premature senescence

Conclusions

Except for 2003, these field studies indicate that very little foliar injury due to ozone occurred across the State of Virginia, between 2002 and 2006. This was a change from the previous 5 years (1997 – 2001) when between 7 percent and 38 percent of biosites in every year, except for 1999, exhibited moderate to severe ozone injury. Hopefully, this trend of decreasing or very little ozone-induced injury will continue in the future. The continued collection of this type of data will aid our ability to determine what, if any, impacts from ozone injury are occurring in the US.

References

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