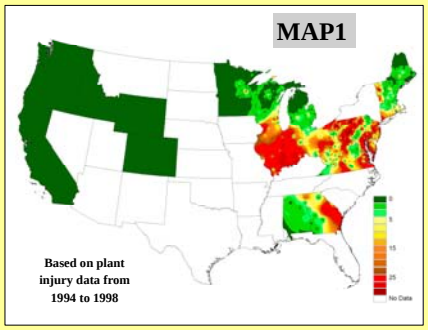
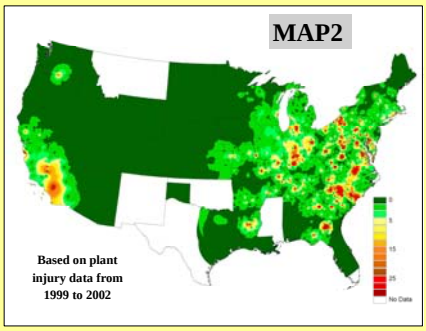
# OZONE AND FOREST HEALTH - USDA FOREST SERVICE

**http://fia.fs.fed.us**

## BIOSITE MAPS




## SAMPLING METHODS AND ESTIMATION

**Sampling rules**

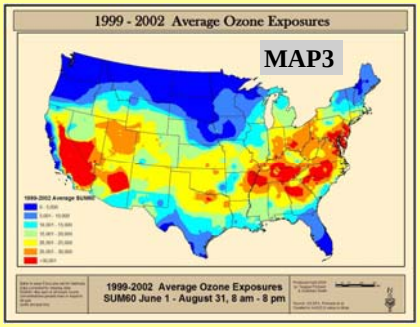
1. **Biosites are wide open areas, at least 1 acre in size, alongside forested areas that contain at least 30 individual plants of two bioindicator species.**
2. **Biosites must be free of significant soil compaction and other man-made disturbance.**
3. **Individual plants are selected at random for injury evaluations.**
4. **Each plant is rated for the percent of the plant that is injured and the average severity of injury using a modified Horsfall-Barrett scale.**
5. **Pressed leaves with symptoms are collected for each species for expert validation of the ozone injury symptom.**

**Estimation procedures**

1. **Plant injury data from each biosite is quantified by calculating a biosite index (BI).**
2. **The BI at each biosite is averaged across years. In the example to the left, MAP1 = 1994 to 1998 and MAP2 = 1999 to 2002.**
3. **Geostatistical procedures are used to create an interpolated bioindicator response surface across the landscape.**
4. **The interpolated map is classified into gradations of response ranging from low (green) to moderate (yellow) to high (red).**

***Change estimation* = Estimates derived from consecutive 5-year periods (MAP1 and MAP2) are used to evaluate long-term trends in bioindicator response.**

## OZONE EXPOSURE MAP




**Building the maps of biosite index estimates and risk:**

**The color-based categorizations of bioindicator response shown in MAP1 and MAP2 are intended to convey a cautionary message of probable ozone injury to forest trees similar to the EPA categorization of human health effects from ambient ozone concentrations (http://www.epa.gov/cgi-bin/airnow.cgi).**

**On MAP1 and MAP2, the risk of probable ozone injury to trees is low in the green areas, moderate in the yellow-orange areas and high in the red-purple areas. Intensified sampling is recommended in those areas where high ozone risk coincides with the spatial distribution of ozone-sensitive tree species.**

## THE NATIONAL BIOSITE NETWORK

| STATE | NUMBER OF PLOTS | START YEAR |
|---|---|---|
| Alabama | 34 | 1994 |
| Alaska | 0 | 2004 |
| Arizona | 25 | 2002 |
| Arkansas | 24 | 2001 |
| California | 65 | 1998 |
| Colorado | 38 | 1997 |
| Connecticut | 5 | 1994 |
| Delaware | 5 | 1995 |
| Florida | 26 | 2002 |
| Georgia | 47 | 1994 |
| Hawaii | 0 | 0 |
| Idaho | 30 | 1997 |
| Illinois | 29 | 1997 |
| Indiana | 18 | 1996 |
| Iowa | 7 | 2000 |
| Kansas | 10 | 2002 |
| Kentucky | 38 | 2001 |
| Louisiana | 28 | 2001 |
| Maine | 16 | 1994 |
| Maryland | 9 | 1994 |
| Massachusetts | 7 | 1994 |
| Michigan | 48 | 1994 |
| Minnesota | 28 | 1994 |
| Mississippi | 25 | 0 |
| Missouri | 37 | 2000 |
| Montana | 42 | 2003 |
| Nebraska | 8 | 2002 |
| Nevada | 13 | 2000 |
| New Hampshire | 8 | 1994 |
| New Jersey | 6 | 1994 |
| New Mexico | 27 | 0 |
| New York | 31 | 1999 |
| North Carolina | 46 | 1998 |
| North Dakota | 8 | 2002 |
| Ohio | 32 | 1997 |
| Oklahoma | 19 | 0 |
| Oregon | 38 | 1998 |
| Pennsylvania | 48 | 1995 |
| Rhode Island | 5 | 1994 |
| South Carolina | 26 | 1998 |
| South Dakota | 12 | 2002 |
| Tennessee | 41 | 1998 |
| Texas - East | 27 | 2001 |
| Texas - West | 25 | 2004 |
| Utah | 21 | 2000 |
| Vermont | 6 | 1994 |
| Virginia | 40 | 1994 |
| Washington | 28 | 1998 |
| West Virginia | 23 | 1995 |
| Wisconsin | 30 | 1994 |
| Wyoming | 25 | 1997 |

## RESULTS

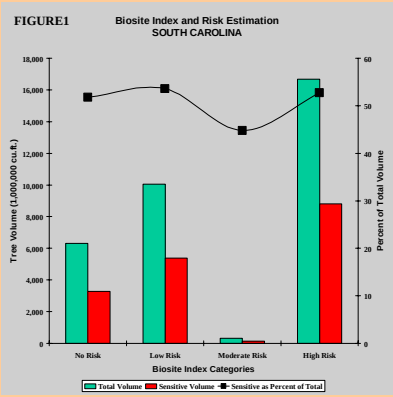



**FIGURE1: Biosite Index Categories on the X axis represent the risk of probable ozone injury to ozone sensitive tree species.**

**In this example of state-level results, over 16 million cubic feet of tree volume falls into the high risk zone in South Carolina and 53 percent of this total includes tree species that are ozone sensitive.**

**For More Information on Sampling and Estimation Procedures:**
***Environmental Monitoring and Assessment* 83: 113-127, 2003**

**PROGRAM CONTACT**

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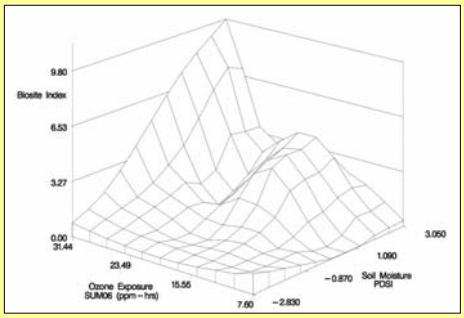
**http://fiaozone.net**

## WHY DOES THE BIOSITE INDEX WORK?

**The graph below shows the relationship among ozone-induced foliar injury to bioindicator species (Biosite Index), ambient ozone exposures (SUM06) and soil moisture availability (PDSI).**

**Elevated ozone exposure results in an increase in the Biosite Index when soil moisture levels are above normal (PDSI > 0). When PDSI values are less than zero (i.e, drought conditions), increasing ozone exposures do not result in increasing injury.**

**For forest health assessment, the Biosite Index provides a biologically meaningful indication of ozone exposure as shown in MAP1 and MAP2; better than the SUM06 statistic shown in MAP3 when used alone.**




***Environmental Monitoring and Assessment* 87: 271-291, 2003.**

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