CRITERION 3—

Chapter 5. Ozone Bioindicator

John W. Coulston and
Mark J. Ambrose

Why Is Ozone Important?

Ground-level ozone occurs at phytotoxic levels in the United States (Lefohn and Pinkerton 1988). Elevated levels of ozone can cause foliar injury to several tree species, may cause growth loss, and can make trees more susceptible to insects and pathogens (Chappelka and Samuelson 1998). However, tree species have varying degrees of sensitivity to ozone, and ozone can induce foliar injury only if tree stomata are open. Thus, the overall impact of elevated ozone concentrations depends on the amount of ozone, climatic conditions such as drought, and the composition of the forest.

Methods

The protocols suggested by Coulston and others (2003) were used to calculate an ozone biosite index that describes the amount and severity of ozone injury to biomonitoring plants on ozone biomonitoring plots (1999-2002). Next, a map of potential ozone injury and risk was created using the categories in table 5.1 (Coulston and others 2003, Smith and others 2003) and inverse distance weighted interpolation of the biosite index. Forest Inventory and Analysis (FIA) phase 2 plots (using approximate locations) were then spatially intersected with the ozone injury risk

Table 5.1—Classification scheme for the Forest Inventory and Analysis biosite index

Biosite value	Bioindicator response	Assumption of risk	Possible impact	Relative air quality
0 – < 5	Little or no foliar injury	None	Visible injury to highly sensitive species, e.g. black cherry	Good
5 – < 15	Light to moderate foliar injury	Low	Visible injury to moderately sensitive species, e.g. yellow-poplar	Moderate
15 – < 25	Moderate to severe foliar injury	Moderate	Visible and invisible injury; tree-level response	Unhealthy for sensitive species
≥ 25	Severe foliar injury	High	Visible and invisible injury; ecosystem-level response	Unhealthy

map. Each tree species on the FIA phase 2 plots was then classified as either ozone sensitive, moderately ozone sensitive, insensitive to ozone, or having unknown sensitivity based on a literature review by Smith and others (in press). We used the interpolated risk map to determine the distribution of five commercially important, ozone-sensitive tree species (loblolly pine, white ash, quaking aspen, black cherry, and ponderosa pine) across ozone biosite classes. We also used the interpolated risk map together with the ozone sensitivity classifications to determine the distribution of tree species by ozone sensitivity within areas predicted to have relatively high ozone biosite index scores.

What Do the Data Show?

In general, the amount and severity of ozone injury to bioindicator plants was higher in the Eastern United States than the Western United States for the 1999 to 2002 period (fig. 5.1). Almost all of the basal area of quaking aspen and ponderosa pine was located in areas predicted to have little or no ozone injury (table 5.2). Of the tree species analyzed, black cherry had the lowest proportion (approximately 0.66) of its basal area in the little or no injury category. The proportion of black cherry in the highest risk category was 0.02. Both loblolly pine and white ash had the same proportion (0.76) of their basal areas in the little or no injury category, but their proportions in the high-risk category were 0.02 and 0, respectively.

The five commercially important species examined did not have a majority of their basal areas at high risk to ozone injury. However, this does not mean that specific "localized" areas may not be at risk. In the Northeast and South Forest Health Monitoring (FHM) regions, forests predicted to be in the high and moderate risk categories consisted of > 40 percent ozone-sensitive species (by basal area) (fig. 5.2). High- and moderate-risk areas in the North Central FHM region had about 30 percent of basal area in sensitive species, while high- and moderate-risk areas in the West Coast region had only about 6 percent of basal area in sensitive species.

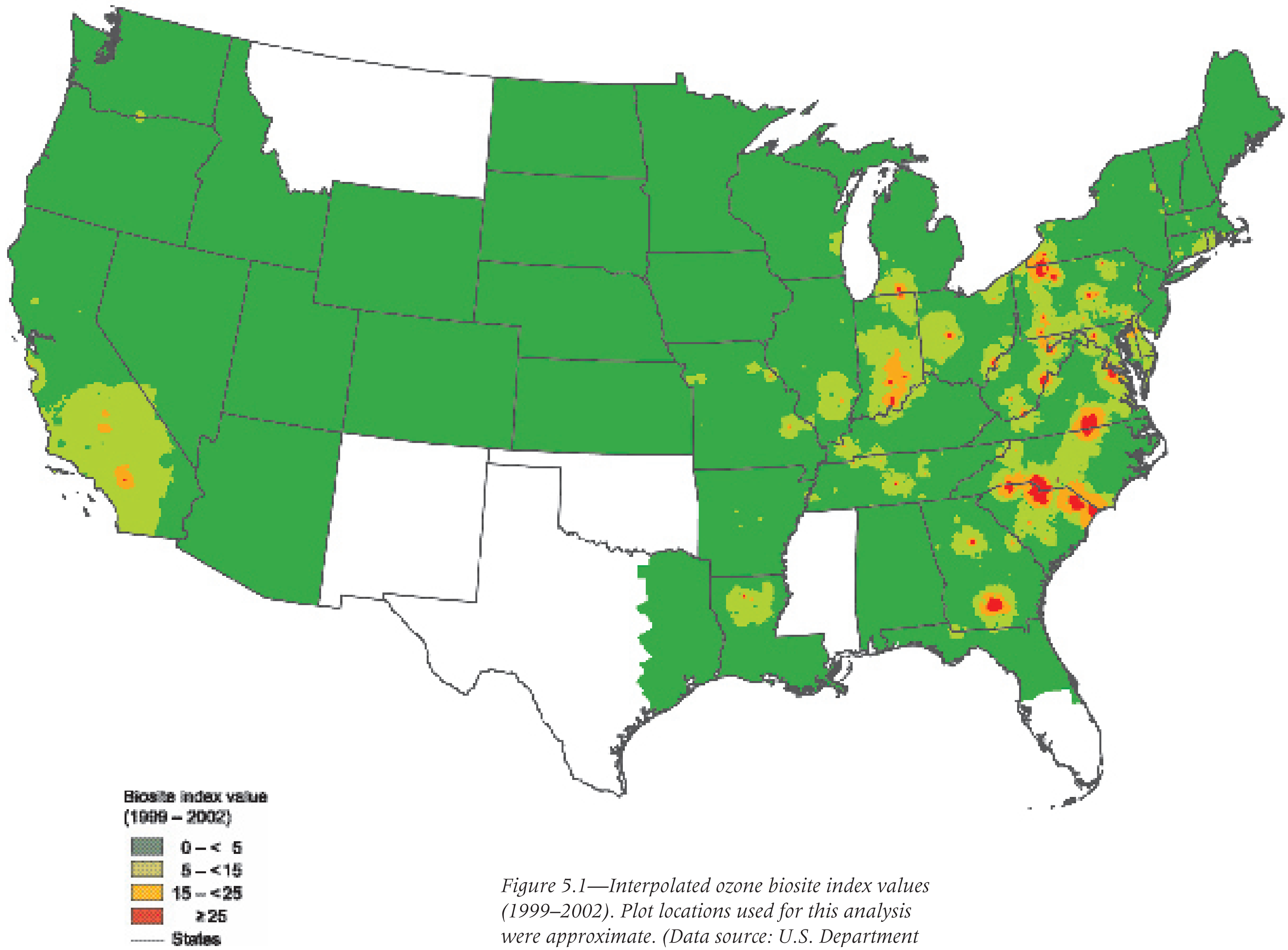

Figure 5.1—Interpolated ozone biosite index values (1999–2002). Plot locations used for this analysis were approximate. (Data source: U.S. Department of Agriculture Forest Service, Forest Inventory and Analysis program.)

Table 5.2—Basal area proportion of five commercially important species in each biosite index category for the Eastern and Western United States

Biosite index	Eastern United States: Loblolly pine	White ash	Quaking aspen	Black cherry	Western United States: Ponderosa pine	Quaking aspen
0 – 5	0.76	0.76	0.99	0.66	0.99	1.00
5 – 15	0.18	0.21	0.01	0.25	0.01	0.00
15 – 25	0.05	0.03	0.00	0.07	0.00	0.00
≥ 25	0.02	0.00	0.00	0.02	0.00	0.00

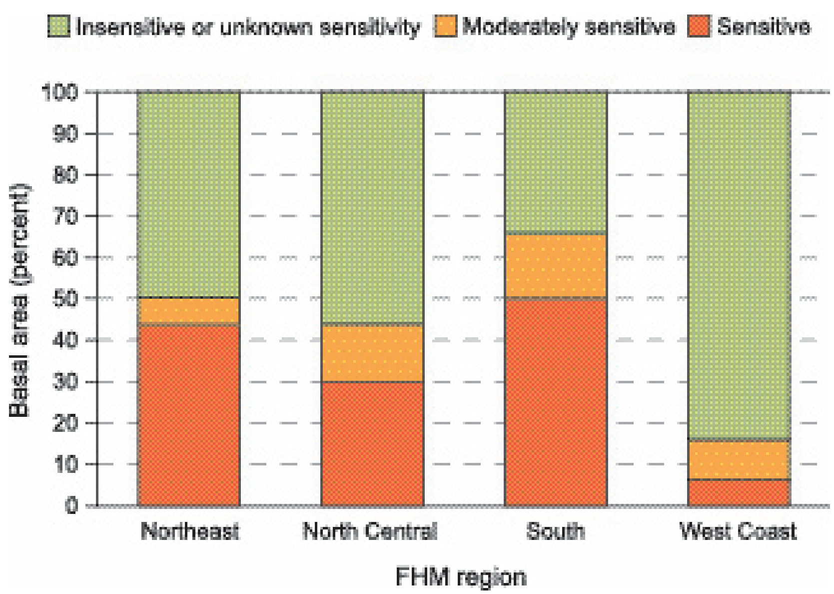

Figure 5.2—Ozone sensitivity of tree species in the high and moderate ozone risk areas of the conterminous United States by Forest Health Monitoring (FHM) region. Note: The Interior West FHM region did not have any area predicted to be in either the moderate or high ozone risk category. (Data source: U.S. Department of Agriculture Forest Service, Forest Inventory and Analysis program.)

Overall, most of the forested FIA plots (86 percent) were classified in the lowest biosite index category, and tropospheric ozone does not appear to pose a large-scale threat to the five commercially important species examined. However, there are specific areas where bioindicator plant injury from ozone was severe and where there is, therefore, a higher risk of impact. For example, in the high-risk areas of the South region, sensitive or moderately sensitive tree species accounted for approximately 66 percent of the basal area. The probability of negative effects (e.g., change in species composition, reduced growth rates, and increased susceptibility to insects and pathogens) is greater in such areas.

Literature Cited

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Appendix—Common and scientific names of cited tree species

Common name	Scientific name
Black cherry	*Prunus serotina*
Loblolly pine	*Pinus taeda*
Ponderosa pine	*Pinus ponderosa*
Quaking aspen	*Populus tremuloides*
White ash	*Fraxinus americana*