

SOURCES OF ERROR IN FIELD ASSESSMENTS OF O₃ INJURY IN WESTERN YELLOW PINE

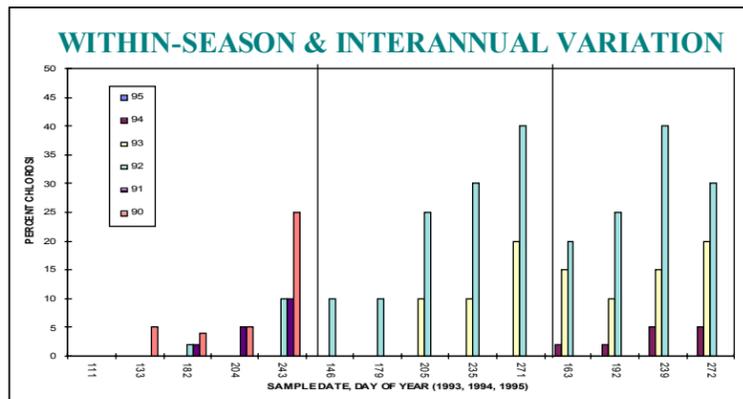
RIGHT: needle chlorotic mottle in ponderosa pine;
FAR RIGHT: Early needle senescence in previous whorl due to drought. Yellow needles were lost by August. If assessed then, tree would be erroneously scored healthier than in July, and healthier than in a wet year.



Abstract: There are two methods generally used for field assessments of yellow pine (ponderosa and Jeffrey) response to O₃ exposure in the western US: Ozone Injury Index (OII) and Forest Pest Management (FPM). For both methods, chlorotic mottle and needle retention form the basis of the assessment. Field examples of how these two attributes vary temporally and spatially are given for both species. Changes in O₃ injury scores may not indicate forest decline or improvement depending on the total annual precipitation in the year of measurement, or when the assessment was conducted relative to the tree species' growth patterns. Specific suggestions are offered for court-defensible field assessments of O₃ injury.

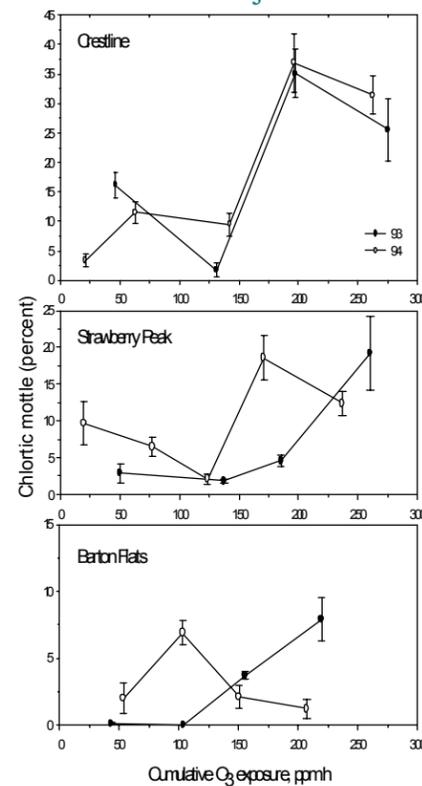


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ABOVE: Within-growing season changes in chlorotic mottle on one branch. Chlorotic mottle can decline over-winter, or even between months in the summer due to within-whorl needle loss.

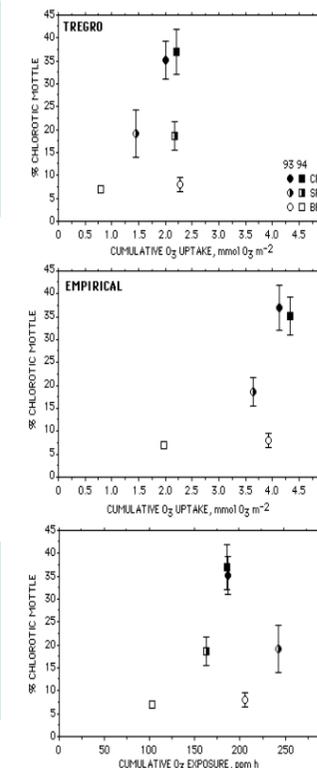
EFFECT OF O₃ METRIC ON CHLOROTIC MOTTLE AT THREE SITES IN A WET AND DRY YEAR



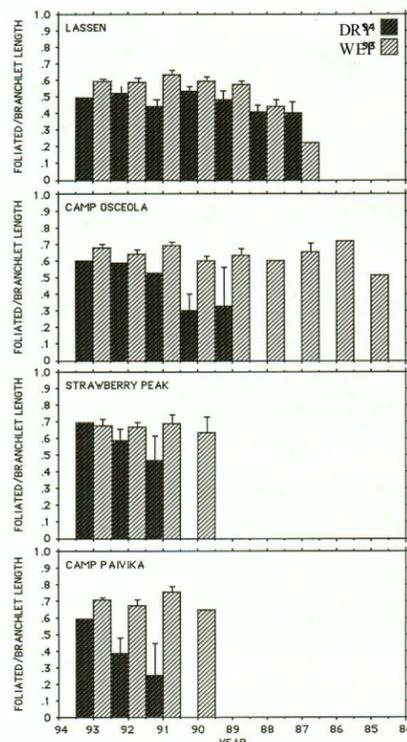
RIGHT: Chlorotic mottle development is more highly correlated to cumulative O₃ uptake (modeled with a physiological model, TREGRO or calculated EMPIRICALLY) than to cumulative O₃ exposure, but considerable variation in maximum expression of injury occurs between wet and dry years.



LEFT: Seasonal chlorotic mottle as a function of cumulative O₃ exposure at a high, moderately high, and moderate pollution site (top to bottom). Perceived lower chlorotic mottle in dry years is not due to "protection" from closed stomata but from early senescence of injured needles.



INTER-SITE & INTERANNUAL VARIATION

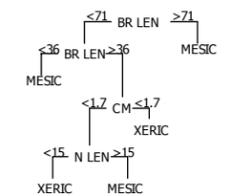


LEFT: Needle retention of ponderosa pine at 4 sites varying in pollution from clean (top) to highly polluted (bottom) in 2 years. High O₃ exposure and N deposition reduces both needle retention on the branch and within a whorl. Within-whorl retention of Jeffrey pine should be estimated visually, because needle loss within a whorl is not regular. Male cones leave scars similar to needles that alter the estimated needle retention in both species.

WITHIN-CANOPY VARIATION

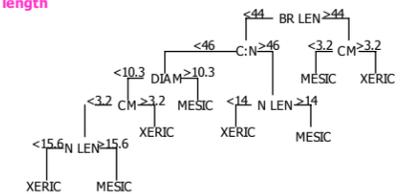
UPPER CANOPY

branchlet length
 chlorotic mottle
 needle length



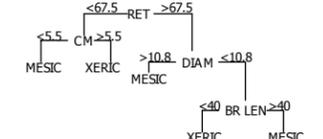
MID CANOPY

branchlet length
 foliar C:N
 chlorotic mottle
 branchlet diameter
 needle length



LOWER CANOPY

foliar retention
 chlorotic mottle
 branchlet diameter
 branchlet length



ABOVE: Tree models for upper, mid, and lower canopy levels to illustrate the relative contribution of foliar and branch attributes in an O₃ assessment of Jeffrey pine. Canopy position alters injury expression.

Assessment recommendations for western yellow pine:

- * Assess Jeffrey and ponderosa pine separately
 - * Conduct assessments in mid-canopy
 - * Assess branches without male or female cones
 - * Conduct assessments in average precipitation years, or in mesic sites
 - * Conduct assessments near the same sampling date each year
 - * Interpret scores carefully:
- O₃, N deposition, and drought stress interact to alter injury expression**

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