

Geographic Extent and Severity of Air Pollution Injury in Saguaro National Monument (Rincon Unit)



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Geographic Extent and Severity of Air Pollution Injury in Saguaro National Monument (Rincon Unit)

by

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ABSTRACT

Twenty-three permanent plots of 15 trees each were established in the Rincon Mountains of Arizona and evaluated for air pollution injury. The species investigated included Ponderosa pine, Gambel's oak, quaking aspen, Arizona sycamore, and Arizona black walnut. The results indicate that foliar symptoms of ozone injury are common and widespread in pines. Symptoms observed on pines include chlorotic mottle, banding, and general chlorosis and necrosis of needles. Of the 225 pine trees examined, all exhibited some form of chlorosis on the foliage which was interpreted to represent ozone injury. The average occurrence of visual injury observed in the lower crown of all pines sampled was 12.5% of the total leaf area. An average of 15% or more of the total needle area of whorls three or more years old was injured by ozone. Injury was greater at higher elevations than at lower elevations. Oaks and walnuts exhibited very slight symptoms, with small chlorotic lesions evident on a few oak and walnut leaves. No air pollution injury could be detected on aspen or sycamores, though one sycamore plot contained trees with prematurely senescent foliage, and the foliage of the aspens was severely injured by other agents. This study provides a data base for future evaluation of air pollution injury and documents the presence and location of ozone injury symptoms on pines and hardwoods in Saguaro National Monument.

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SECTION 1

INTRODUCTION

Saguaro National Monument lies in southern Arizona near the city of Tucson. The Rincon Unit of the Monument contains the Rincon Mountains which rise to over 5000 ft above the desert floor. These mountains, a major wilderness resource, possess six distinct vegetational zones, including conifer forests, riparian woodland, and oak-pine woodland. Within these zones grow species of trees with documented sensitivity to atmospheric pollution. Because of the proximity of the Rincons to the large and rapidly growing metropolitan area of Tucson, degradation of the air quality within the monument can be expected. A recent study (Hutchinson *et al.* 1984) indicated that diurnal air flow patterns are typified by upslope daytime flow from the city of Tucson into the mountains of the Rincon Unit.

Saguaro also possesses wilderness or "Class I" status under the 1977 Amendments to the Clean Air Act. Monitoring of ambient atmospheric pollution and its effects on the environment are required to detect any resource degradation. This study initiates the establishment of long-term biomonitoring plots to evaluate the effects of air pollution on selected tree species in the upper elevations of the Rincon Mountains.

SECTION 2

OBJECTIVES

The first objective of this study was to survey plant species sensitive to air pollution. This survey included the establishment of long-term relocatable plots, the evaluation of randomly selected trees within the plots for symptoms of injury, and the documentation of site localities and methods used. Second, this study will begin to establish baseline data on air pollution effects in this area. The plots should be utilized for future air pollution monitoring so that any increases or decreases in these effects may be detected and quantified. A third objective was to collect data on tree size, vigor, and symptoms of injury caused by agents other than air pollution. These data may be used to identify interactions which may exist between all variables measured and will give a better understanding of the overall vigor of the species studied.

SECTION 3

METHODS

3.1 SPECIES SELECTION

Gaseous air pollution causes visible injury to the foliage of many plant species. The amount and type of injury depend on the pollutant, the dose, environmental conditions, and the susceptibility of the species. Possible sources of atmospheric pollution in the Rincon Mountains include automobile exhaust from the city of Tucson and the by-products of the San Manuel copper smelter. Automobile internal combustion engines emit oxides of nitrogen, carbon monoxide, and hydrocarbons, and are the chief source of the precursors of photochemical oxidants (ozone and peroxyacetyl nitrate). Ore smelters may emit oxides of sulfur, fluorides, and trace metals.

Several species with documented susceptibility to one or more of these pollutants occur within Saguaro National Monument. Ponderosa pine (*Pinus ponderosa* Laws.) is perhaps the most well-documented species. The distinct foliar injury this species exhibits when exposed to ozone has been described in detail (Miller *et al.* 1963). Surveys conducted in California (Miller and Millecan 1971; Pronos and Vogler 1981; Wallner and Fong 1982) and in the Denver, CO, area (James and Staley 1980) have revealed ozone injury symptoms of chlorotic mottle and banding on the needles, as well as premature needle abscission, suppressed radial growth of stems, greater susceptibility to root rot and beetle attack, and increased mortality. In the Rincon Mountains of Arizona, two varieties of Ponderosa pine have been identified: Arizona pine (*P. ponderosa* var. *arizonica* [Engelm.] Shaw), which possesses fascicles of five needles, and Rocky Mountain ponderosa pine (*P. ponderosa* var. *scopulorum* [Engelm.]), which has fascicles of three or two shorter needles and smaller cones (Little 1976).

The leaves of the deciduous California black oak (*Quercus kelloggii* Newb.) have been shown to exhibit pigmented lesions when exposed to ozone (Miller *et al.* 1984). Similar symptoms have been recorded on Gambel's oak (*Quercus gambelii* Nutt.) (Treshow 1970). The symptoms are characterized by chlorotic, bronzed, orange or red pigmented, and necrotic intravascular areas on the upper leaf surface. Gambel's oak occurs sporadically in the Rincons at altitudes above 6500 ft.

Quaking aspen (*Populus tremuloides* Michx.) has been shown to be sensitive to ozone and sulfur dioxide (Jacobson and Hill 1970; Treshow 1970). Foliar injury is characterized by dark brown or black necrotic lesions, commonly bifacial. Two isolated groves of this species occur in the upper elevations of the Rincons.

Two other broadleaf species were selected for the survey: Arizona sycamore (*Platanus wrightii* S. Wats) and Arizona black walnut (*Juglans major* [Torr.] Heller). The sensitivity of these species to ambient air pollution is not extensively documented, but they are included because of suggested susceptibility to ozone injury based on foliar characteristics and for the purpose of surveying a greater elevational range.

3.2 PLOT ESTABLISHMENT

Methods for establishing and evaluating permanent biomonitoring plots on national park lands have been proposed by Stolte and Bennett (1984). All plots in the Rincons were located in the back country along hiking trails. Plot locations were selected to provide geographical and altitudinal coverage of the area within the constraints of the distribution of the species selected. Fifteen pine plots, three oak plots, two plots each of aspen and sycamore, and one walnut plot were established, for a total of 23 plots. Their locations are plotted in Figure 1. The pine plots range in altitude from 6100 to 8450 ft. The hardwoods are located at elevations between 3360 and 8100 ft. Nearly all the pine plots are located on or near the crest of the range. Most of the hardwood plots are on the southwestern slopes of the mountains, and one aspen plot is located on the east slope. Each plot contains 15 trees; 345 trees were selected and tagged. A field guide fully documenting the location and characteristics of all plots and trees was prepared. The reader is encouraged to refer to the field guide (Duriscoe and Selph, unpublished report) for a more detailed description of plot establishment and evaluation methods.

3.3 PLOT EVALUATION

The evaluation of a particular tree involved the collection of the following data: diameter at breast height (dbh), upper and lower crown density, bole condition, fruit crop, and, for broadleaf species, tree height in addition to foliage data. Diameters were measured using dbh tape. Both upper and lower crown densities were estimated on a zero to ten scale using a system documented in the field guide. Similar systems were used for estimates of fruit crop bole condition. Heights of trees were estimated with a clinometer.

Foliar symptoms were observed visually and recorded as a percentage of the total leaf area affected. For pines, individual needle whorls were examined as a unit, and percentage evaluations represent the portion of the entire surface area of the whorl affected. Symptoms were separated into three classes: chlorosis (caused by air pollution), necrosis (caused by air pollution), and other injury. Values recorded in the class "other injury" may thus reflect the sum of two or more symptoms caused by agents other than air pollution.

Needle or leaf lengths were recorded to the nearest centimeter. On pines, for each whorl the percentage of the total whorl retained on the branch was estimated by examining the branches for abscission scars.

Five branches from the lower crown of each tree were examined where possible; a minimum of three branches was set for trees with thin lower crowns. On hardwoods, branches that most nearly defined five compass points – 72°, 144°, 216°, 288°, and 360° (with the tree's main stem used as a reference) – were selected in an attempt to detect any effects of directional exposure.

3.4 DATA ANALYSIS

Bennett and Stolte (1984) have described techniques for the analysis of pine plot data for the National Park Service. This analysis involves the categorization of the data collected into dependent and independent variables and a subsequent set of statistical calculations based on these categories. Table 1 lists the variables involved and their abbreviations, as referred to in this paper. Printouts from statistical analyses are included in the appendices; the variable labels on these are in the abbreviated form. Percentage values were transformed using a square root transformation ($\sqrt{y + \frac{1}{2}}$) before analyses with parametric tests. A nested analysis of variance was conducted on each species' data set using the hierarchy of independent variables, "plots, trees, and whorls" for pines and "plots, trees, and branches" for broadleaf species. The error term in the analysis corresponds to branches for pines; leaves are treated as replicates on a particular branch for broadleaves. Correlation matrices were also generated for each data set as a means of identifying interactions between dependent variables and covariables. The reader should refer to the National Park Service document for a more detailed description of statistical methods.

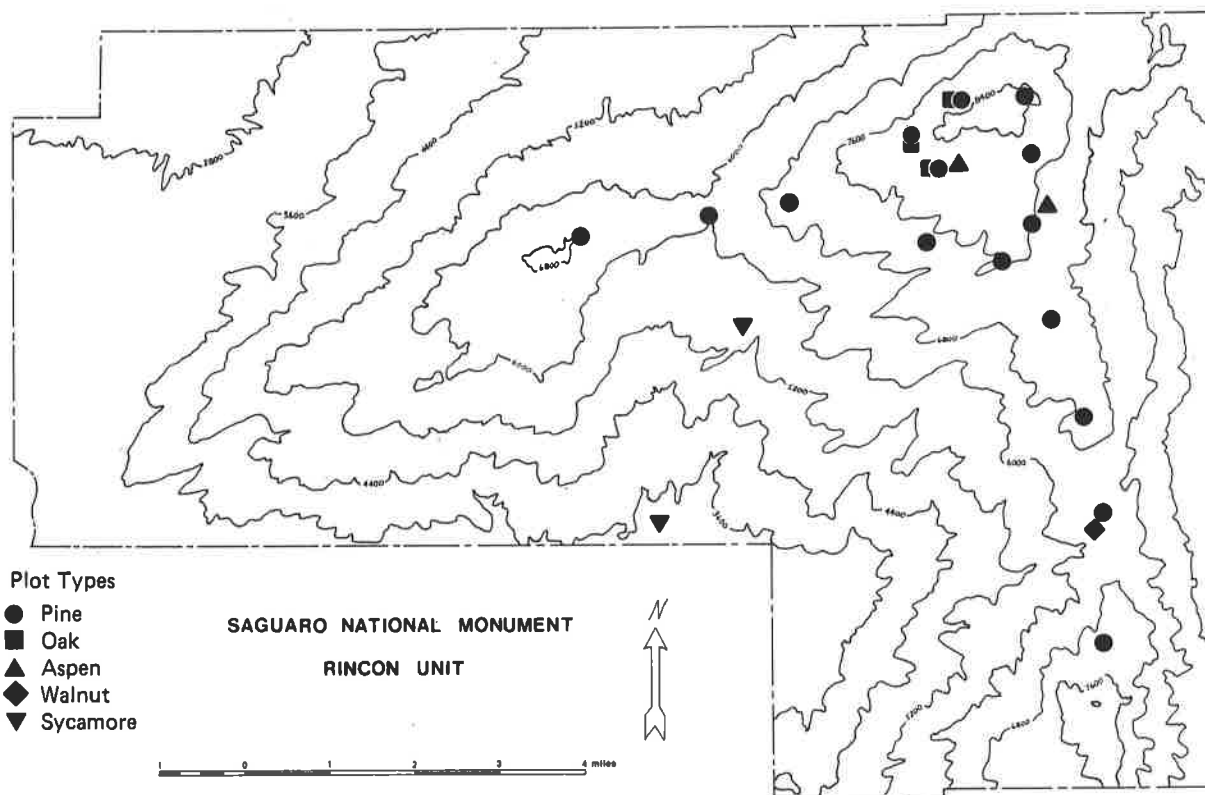


Figure 1. Plot Types and Locations in the Rincon Unit.

TABLE 1. VARIABLES USED IN DATA ANALYSIS

Variables	Abbreviation
<i>Independent Variables</i>	
Plot number	PT
Tree number	TN
Branch number	BN
Whorl (or leaf) number	WN or LN
<i>Dependent Variables</i>	
Chlorosis	PC or CHL (transformed)
Necrosis	PN or NEC (transformed)
Needle (or leaf) length	NL or LL
Percent needle retention	PR or RET (transformed)
Other injury	OI, OI, or INJ (transformed)
Number of whorls retained	NW or WH
Crown density (upper plus lower)	CD or DN
Cone (or fruit) crop	CC or FC or SC or AC or CR or AN
Bole condition	BI or BC
<i>Covariables</i>	
Plot elevation	ELEV or ALT
Plot aspect	ASP or APT
Plot slope	SL or SP
Tree diameter	DBH or DIA

SECTION 4

RESULTS AND DISCUSSION

4.1 SYMPTOMS OBSERVED

Both varieties of Ponderosa pine possessed needles exhibiting chlorosis, necrosis, evidence of sucking and chewing insects, evidence of scale insects, and mechanical injury. Chlorosis or yellowing of individual needles took the form of mottling and bands, and involved most or all of the needle. Considerable general chlorosis was observed often affecting only a few needle bundles on a particular needle whorl, but always on the older whorls.

There is some doubt as to whether or not the general form of chlorosis is completely ozone-induced. In many cases, it was apparent that generally chlorotic needles were the result of a coalescence of chlorotic bands, as younger whorls on the same branch would exhibit mottling and banding. In such instances, all visible chlorosis was attributed to ozone injury. Where isolated, generally chlorotic needles were observed without evidence of mottling or banding, needle senescence was deemed to be the cause. Necrotic tissue at times was associated with generally chlorotic needles, especially on the oldest whorls. Again, if mottling or banding was present on younger whorls, the cause of the necrosis was attributed to ozone. Consultation with other researchers has implied that this interpretation may be somewhat biased; normal needle senescence may be responsible for all or part of the generally chlorotic and necrotic appearance of older needles, despite the increased stress brought on by ozone injury (P.R. Miller *et al.*, personal communication). While no symptoms were recorded as ozone injury unless the mottling or banding were seen somewhere on the branch, the actual values recorded for older whorls may be artificially high as a result of this interpretation. Figures 2-5 illustrate some of the symptoms observed on pines.

Chlorotic intravascular spots and areas were observed on a small percentage of the Gambel's oak sampled. These types of lesions that were obviously abiotic and bounded by veins were interpreted to represent air pollution injury because of their similarity to ozone injury observed in *Quercus kelloggii* in California. Figure 6 is a photograph of Gambel's oak leaf exhibiting these symptoms. Other types of foliar injury were observed in oaks. Small necrotic spots or cracks in the leaf surface were interpreted as wind damage. Evidence of skeletonizing insects and oak leaf miner were also observed.

Three types of injury were observed on aspen leaves: a chlorotic yellow-white stippling or fleck of dot-like lesions; dark brown or black blotchy areas at times covering nearly the entire leaf surface; and small necrotic spots and holes. These symptoms were interpreted to be caused by small sucking insects, anthracnose or rot, and chewing insects, respectively. No symptoms were observed

on quaking aspen that could definitely be identified as pollution-induced. This was due in part to the extensiveness of the other injury symptoms previously described. Some bifacial necrotic areas were observed that might be interpreted as ozone injury in the absence of the anthracnose. However, these symptoms were evaluated as extensions of the fungal injury (Figure 7).

Premature senescence was commonly observed on the leaves of the Arizona sycamore at the higher elevation plot (Grass Shack). While this in itself may be interpreted as a symptom of air pollution stress, it is not certain that this is the case, as other variables may be involved. Small yellow-white spots or fleck were observed in great numbers, in some cases, very similar to those observed on aspen leaves. They were also interpreted to be injury caused by aphids or mites; a few of each of these insects were observed on the leaves. No lesions that could be definitely identified as ozone injury were found on sycamore leaves. Figure 8 displays a typical leaf.

A spotty chlorosis was observed on the leaflets of Arizona black walnut (Figure 9). These pale green intravenal areas were interpreted to represent air pollution injury because of the apparent abiotic nature and frequency of occurrence at specific locations in the leaves. Both insect and fungal injury were also observed on walnut leaves.

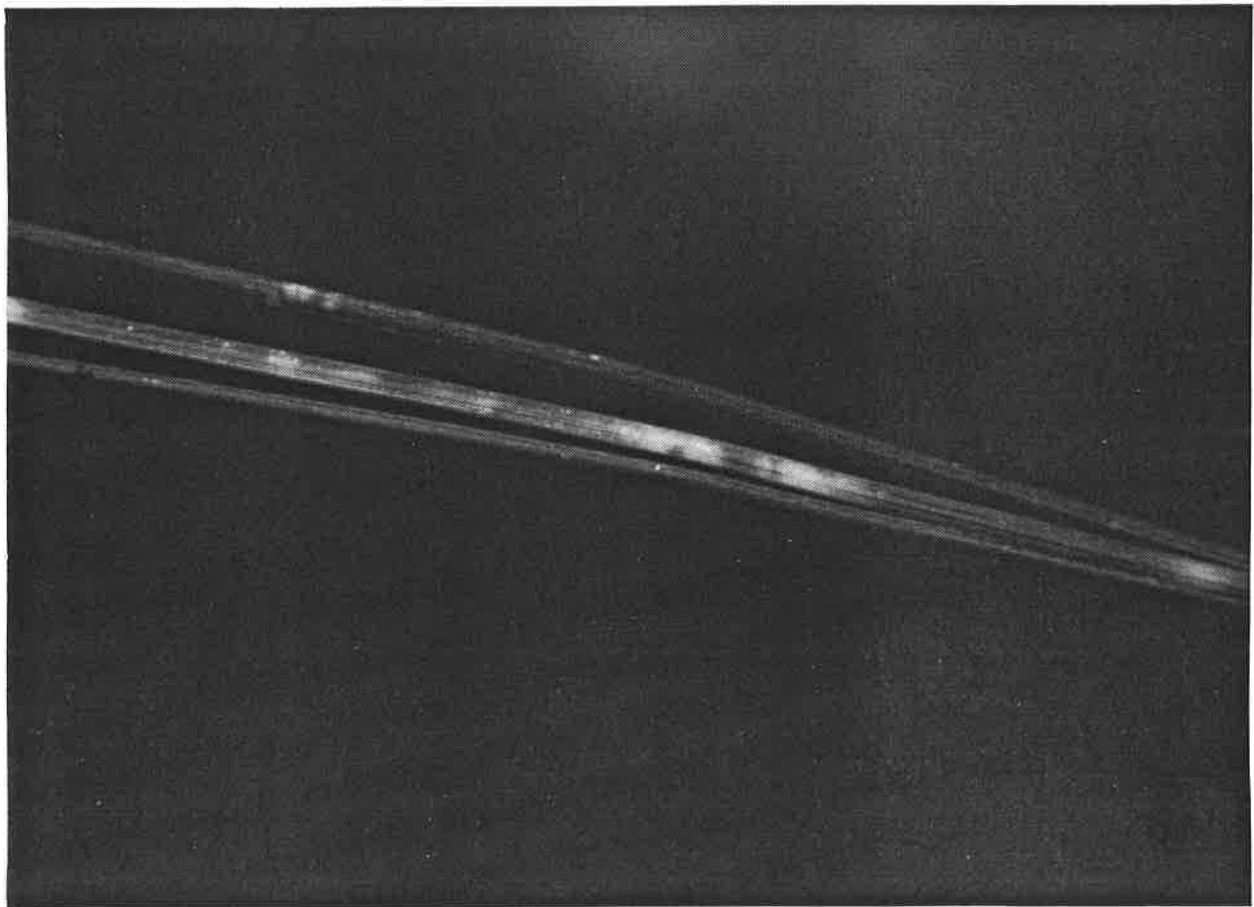


Figure 2. Chlorotic Mottle and Banding on *P. ponderosa* Attributed to Ozone Injury.

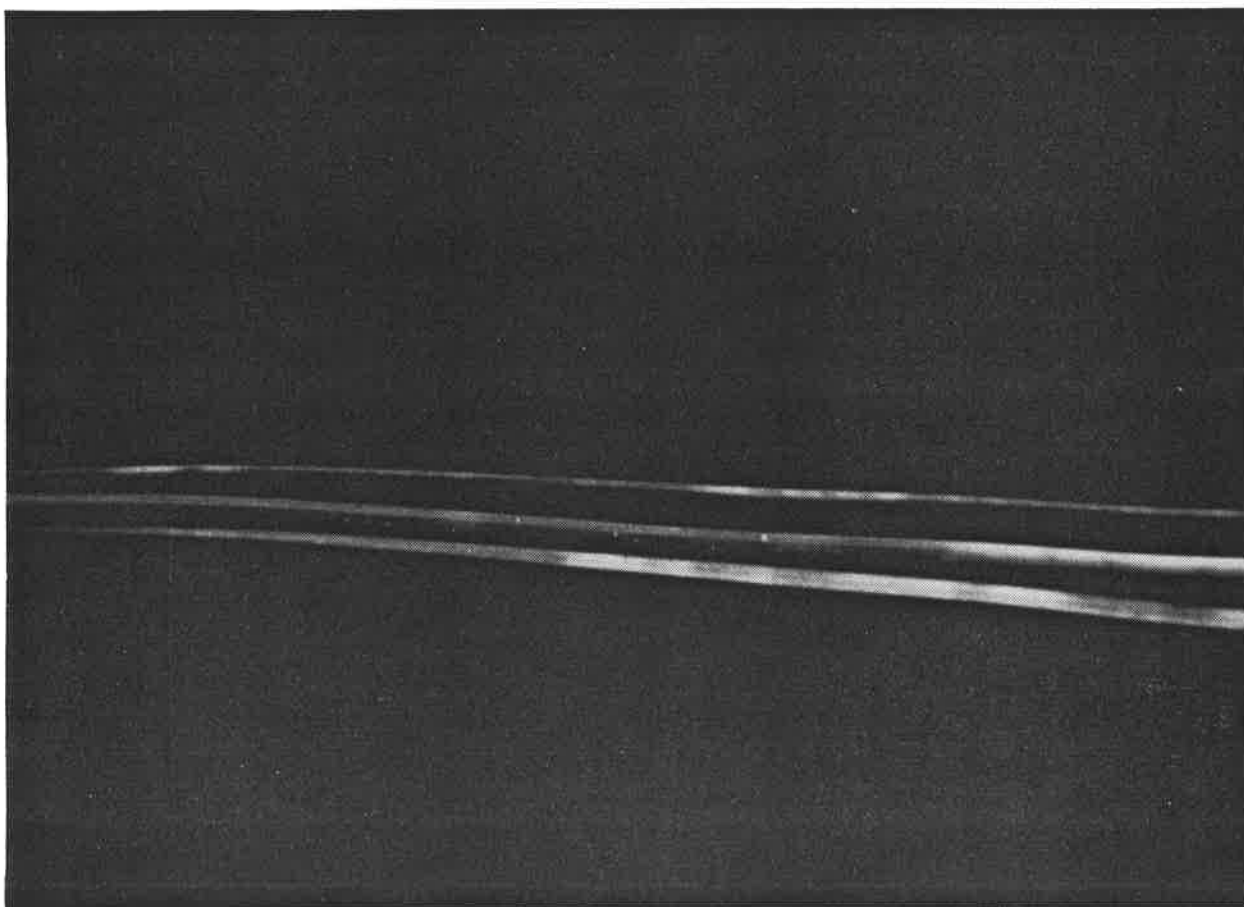


Figure 3. Chlorotic and Necrotic Bands on *P. ponderosa* Attributed to Ozone Injury.

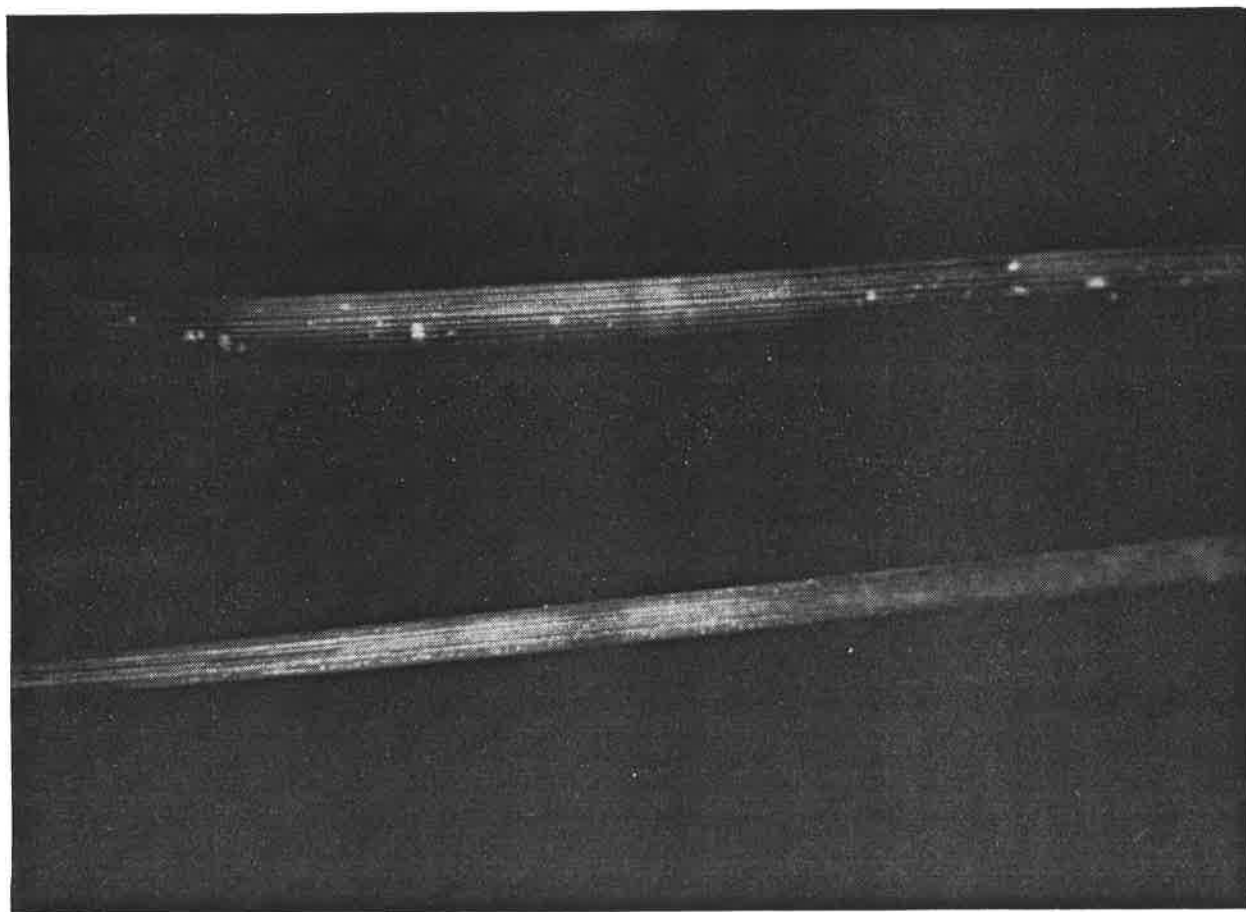


Figure 4. Close-up of Ozone Injury on *P. ponderosa* – Chlorotic Banding.

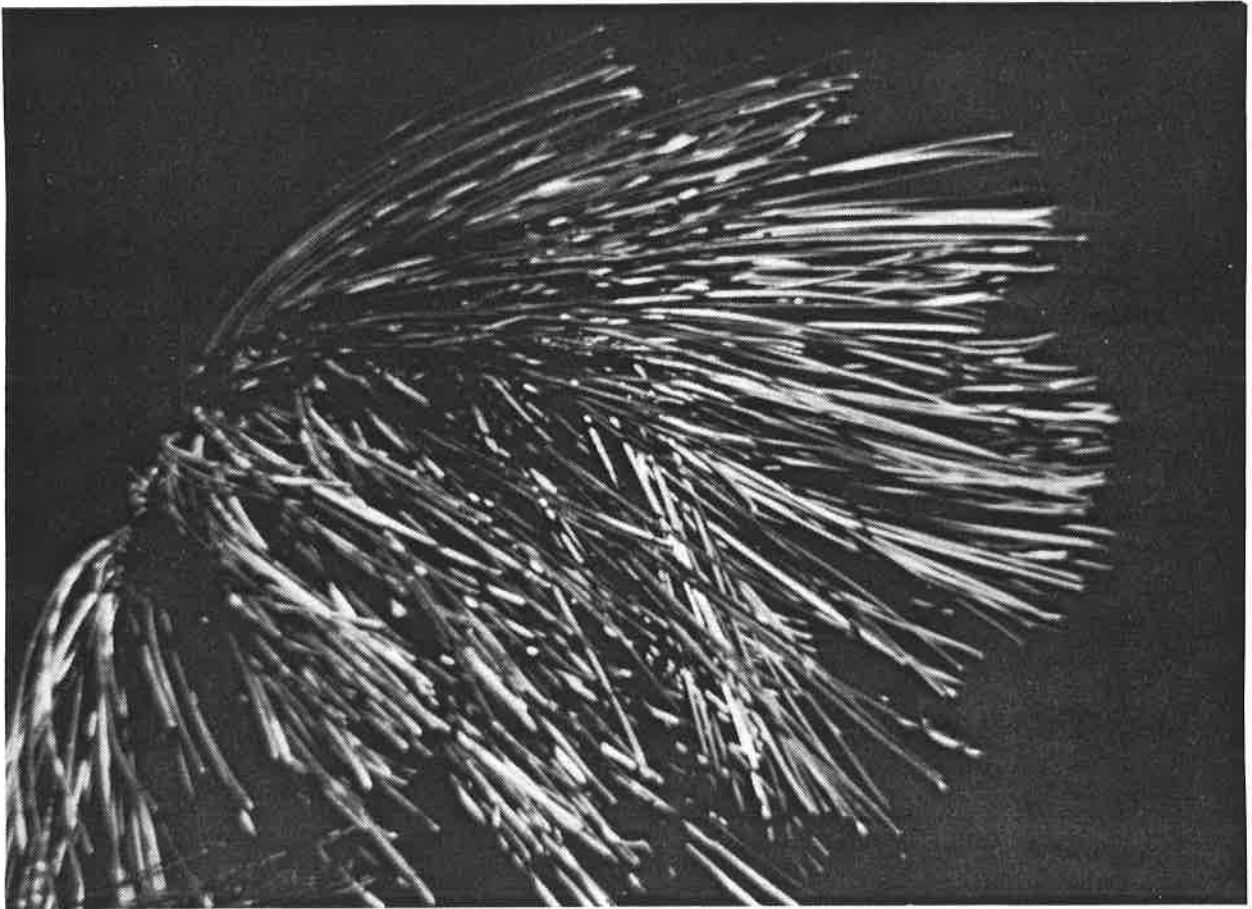


Figure 5. Branch of *P. ponderosa* Showing Large Areas of Chlorosis on Older Needles.

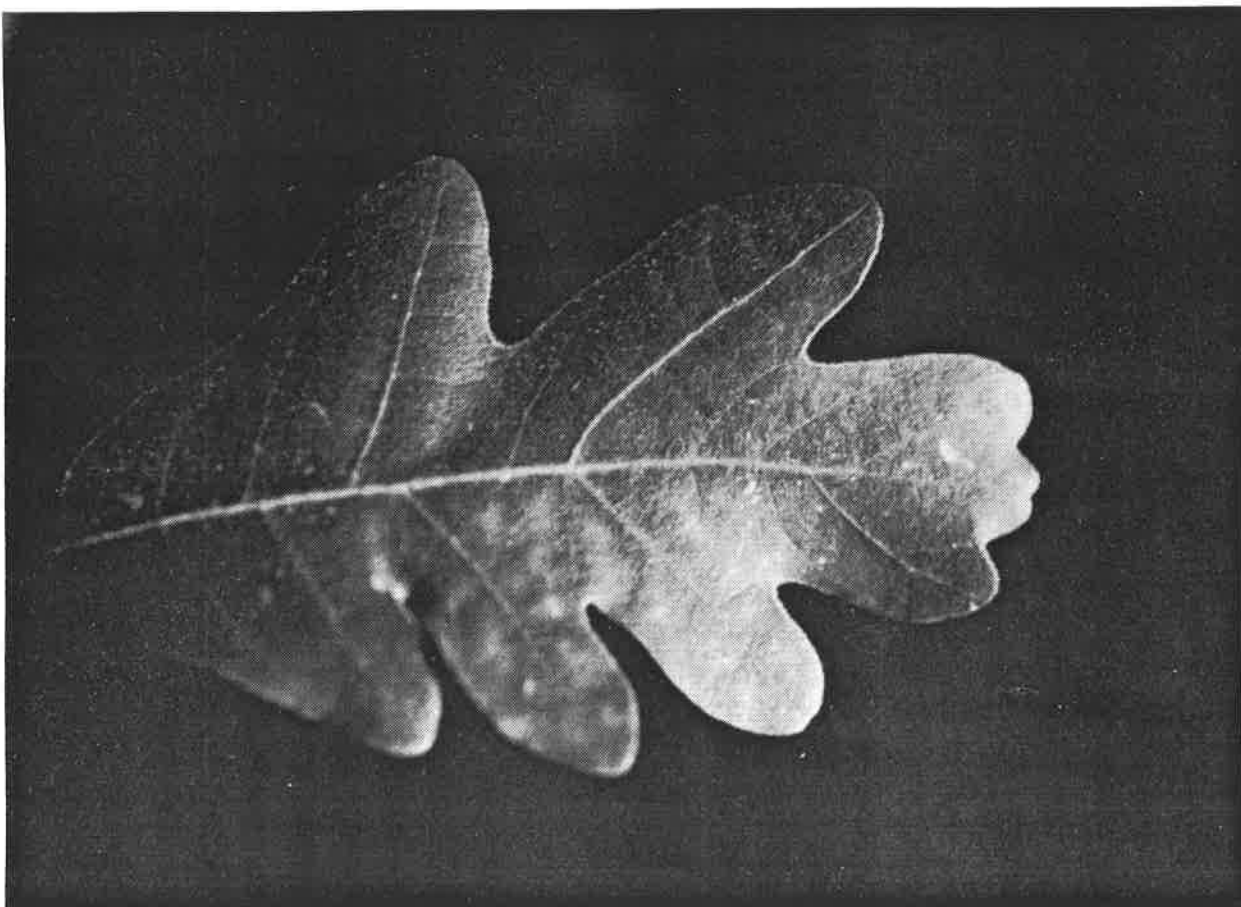


Figure 6. Ozone Injury on *Q. gambelii* – Chlorotic Intravascular Areas.

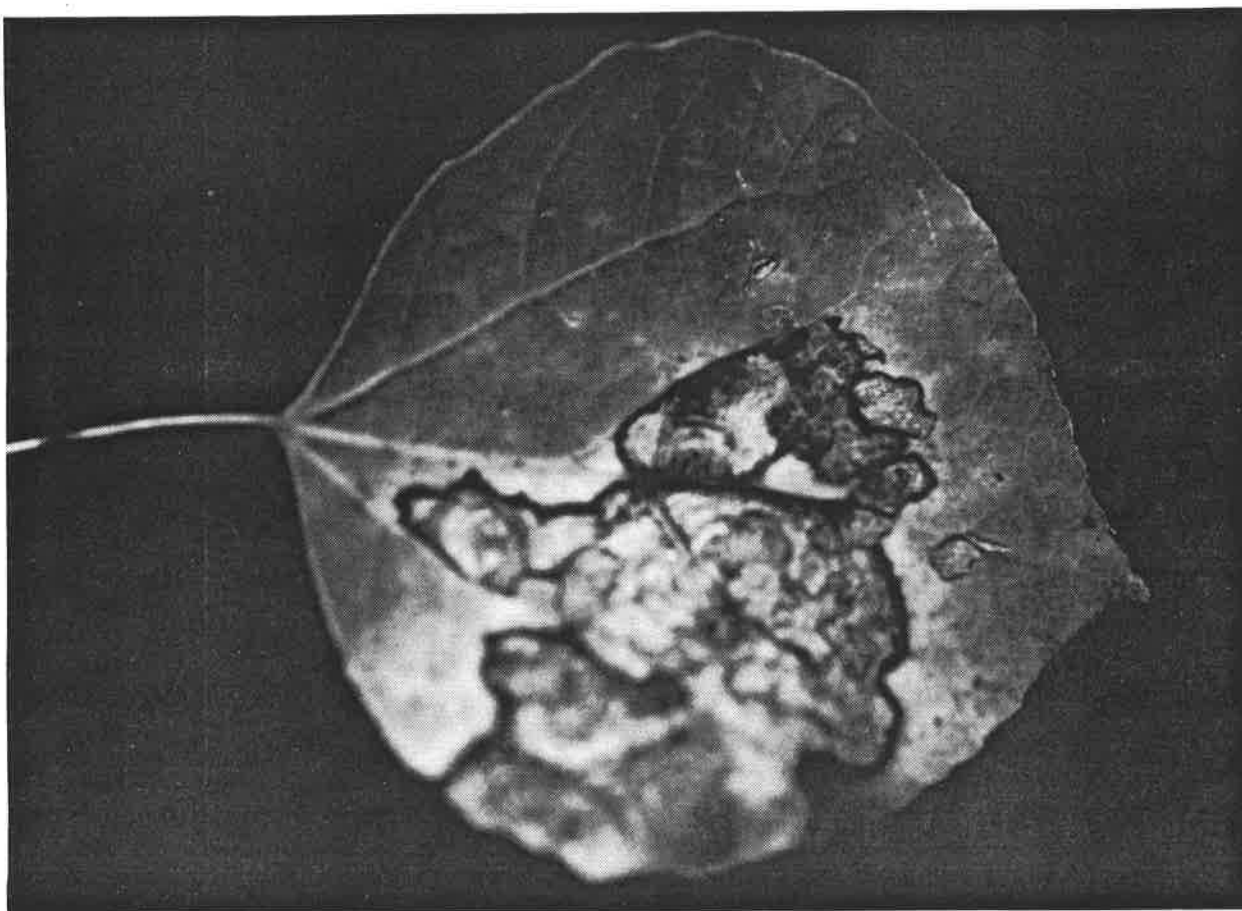


Figure 7. Fungal Injury on *Populus tremuloides*.

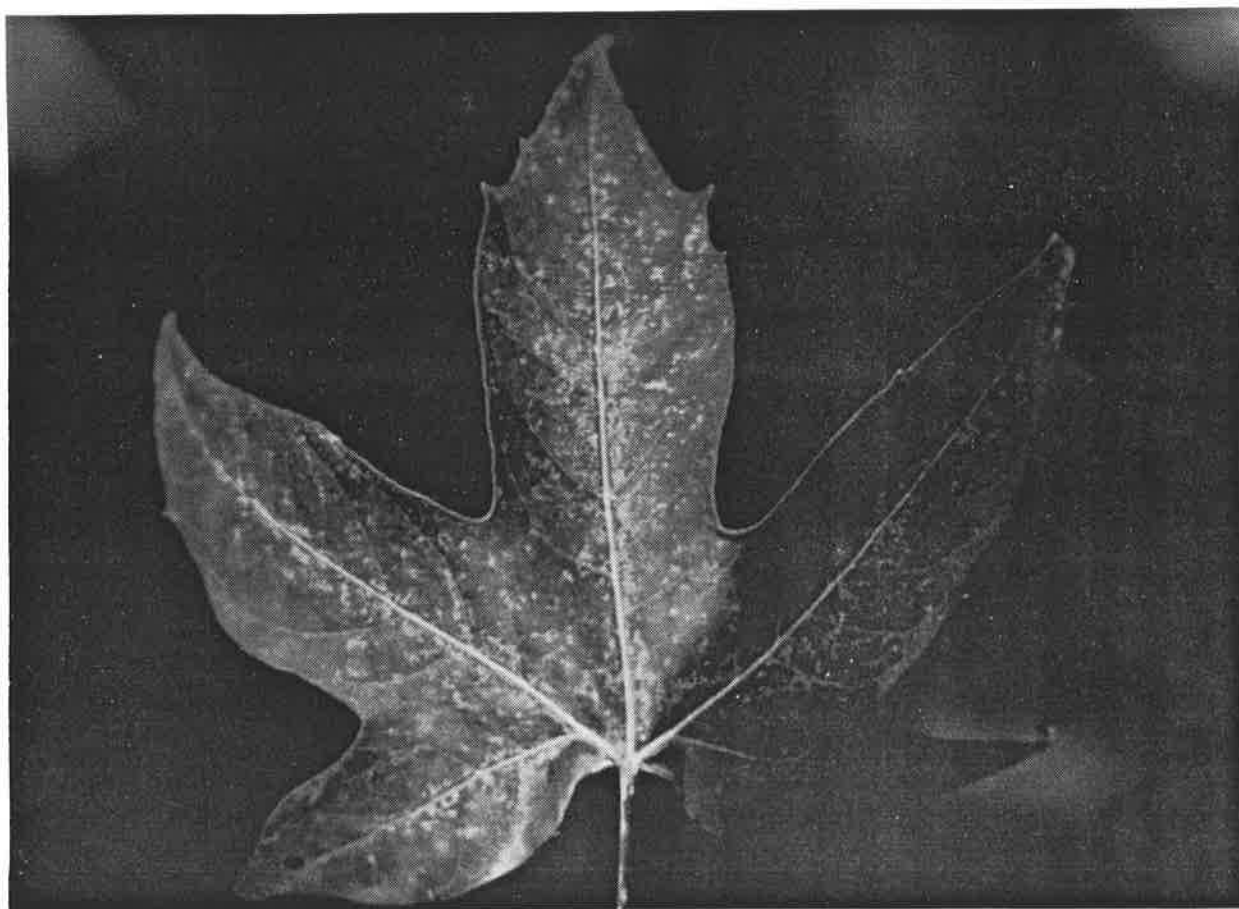


Figure 8. Leaf of *Platanus wrightii* Showing Aphid Injury.

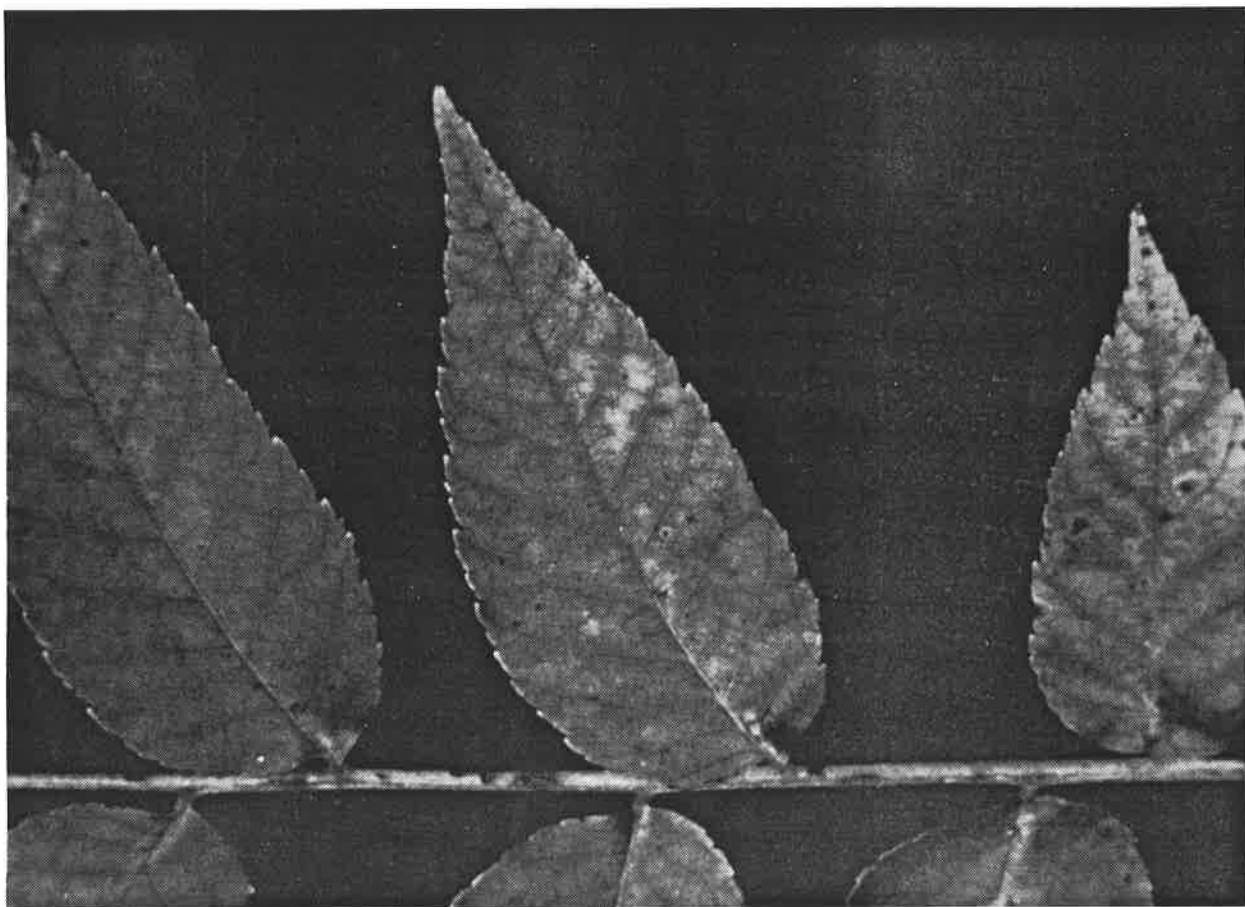


Figure 9. Chlorotic Areas on *Juglans major* Attributed to Ozone Injury.

4.2 DATA SUMMARY AND ANALYSIS

The great volume of data (approximately 33,000 discrete numbers) collected during this study may be summarized by first separating it into meaningful classes (Figure 10). First, a distinction between pines and hardwoods is made based on a fundamental difference in morphology. Pine data may then be classified into any of several subclasses. Ordering the data by whorl number should provide a means of describing the results in terms of foliar age. Ordering by plot number will illustrate the locational aspects of the data. Processing the data in terms of trees should provide information on the variability among individual organisms of the same species. Since branches were intended to provide replicate measurements, this class of data will give an indication of the error or variability that exists within a single individual. The classes are similar for hardwood species, except that branches were sampled with the intent of examining the effects of directional exposure while the sampling of five leaves on a branch provided the error term.

The two varieties of *Pinus ponderosa* were treated as one in the analysis of the data – no attempt was made to define differences between the two for any of the variables measured.

Descriptive statistics were obtained for each of the dependent variables and covariables by species for the park as a whole, by foliar age (whorl) for pines, and by location (plot). Complete tables appear in Appendix A. Table 2 lists some important variables, the mean value for each, the standard deviation, and the number of observations for the pine data set. This data set is by far the largest of all the species investigated, as data are obtained from 225 trees. The mean values listed are for the entire park and may be examined to get a general idea of the health and vigor of the trees sampled. Foliar vigor is indicated by the following variables: number of whorls retained, mean percent retention of needles on a whorl, needle length, and crown density (which is the sum of both upper and lower densities, with a maximum possible score of 20). The number of whorls retained on a particular branch was fairly consistent throughout the range, as indicated by a rather small standard deviation of 0.89 about the mean of 4.0 whorls. Sargent (1965) has stated that *P. ponderosa* begins to drop its needles after the third year, so this number is not abnormally low for this species. It would be interesting to compare this number with data from other areas, however. A mean crown density of 7.92 (out of 20) seems low; trees with thin crowns might be expected in the semiarid environment of southern Arizona. The mean needle length of 14.55 cm is about average for this species in the Desert Southwest (Little 1976). Means for the variables bole condition and cone crop indicate tree boles in relatively good condition (score of 1.4 out of 10) and a very meager cone crop (score 0.6 out of 10).

The total mean foliar injury observed (chlorosis + necrosis + other injury) is 27.0%, of which 12.5% was attributed to ozone injury (chlorosis + necrosis). The ozone injury data may be further

described by the examination of a frequency histogram of the variable chlorosis (Figure 11). A strongly right-skewed distribution is evident as might be expected from percentage data in a dose-response experiment. The table accompanying the histogram shows that almost 85% of the cases yielded values in the range 0-20%.

A summary of some important variables by whorl age is shown in Table 3. Mean needle length is fairly consistent regardless of age. Needle retention decreases with age as might be expected producing an "S-shaped" curve when plotted as a line graph (Figure 12). Figure 13 is a histogram of the same data separated into the two plots with greatest and least retention of needles to give an indication of the variability observed in this parameter. Plot 1 exhibited the greatest retention of needles with some trees possessing seven years of foliage. The oldest whorls seen on trees of plot 2 were four years old; the average percent retention of needles on whorls 3 and 4 were lower for plot 2 than for plot 1. Curiously, whorls 1 and 2 were more full in plot 2, even though the older whorls were missing.

Mean visible ozone injury values are best illustrated as a histogram (Figure 14). A general increase in total visible injury with age is apparent, with necrosis comprising a greater percentage of total visible injury on older whorls than on younger ones. It should be noted that the necrotic appearance attributed to ozone injury may be partly caused by natural senescence of the needles, as described previously.

Ozone injury data may be further examined at the tree level. Figure 15 illustrates the frequency of occurrence of percentage of various classes for the variable chlorosis. All of the 225 trees examined exhibited some type of chlorotic injury which was attributed to ozone. The minimum mean percent chlorosis for an individual tree was 1.4%, the maximum was 33.2%. The histogram displays a slightly right-skewed distribution with a mean of 11.6%.

The geographic variation of the variables measured in this study may be inferred by examining the data at the plot level. The 15 pine plots are widely distributed over the area of the Rincon Mountains in which *Ponderosa pine* is found. Table 4 lists the means of the following variables: total ozone visible injury, percent needle retention, and number of whorls retained, along with the elevation for each of the 15 plots. Figure 16 graphically depicts these values as a line graph with plots arranged in order of increasing altitude in the x axis. The only variable with any apparent correlation with elevation is the percent ozone injury, as revealed by the upward trend of its line. The lines of the other two variables seem generally flat over the entire elevational range. The geographic variation in these parameters might best be illustrated by plotting points on a map. Figures 17 and 18 are topographic maps of the Rincon Unit with point symbols representing pine plot locations. The different symbols represent the degree of ozone injury observed (Figure 17) and

the quantity of needles retained on whorls (Figure 18). Other than the correlation of ozone injury with elevation already observed, no definite patterns emerged from these maps.

Data from hardwood species were summarized for the park as a whole and at the plot level. Because of the small number of plots of each species (one to three) and the limited range of each species within the Rincon Unit, geographic variation in the data is not apparent or meaningful. Some comments may be made on the general condition of each species, however.

Table 5 compares mean values for ozone injury, other injury, crown density, fruit crop, and elevation for each species. It can be seen that walnuts exhibited the most ozone injury of the hardwoods sampled; oaks show very slight ozone injury symptoms, while no ozone injury symptoms were detected on aspens and sycamores. However, high numbers for other injury are apparent for aspen and sycamore trees, possibly masking ozone injury. Sycamores had the fullest crowns and the greatest crop of seeds. No nuts or catkins were observed on the walnut and aspen trees sampled. Walnuts appeared to have the greatest bole injury of all the species studied (mean of 4.9 out of 10); dead limbs and broken branches were commonly observed.

Three hypotheses for each of the nine dependent variables measured were tested using a nested analysis of variance of each species' data set. The hypotheses tested were for any significant differences between (1) plots, (2) trees within plots, and (3) whorls (or branches for broadleaf species) of trees within plots. The null hypotheses state that there are no significant differences for these classes. The F-ratios and corresponding probability of incorrectly rejecting the null hypotheses are given for each variable at each class level for each species in Tables 6-10. For pines (Table 6), all variables except number of whorls retained were significantly different for the class "plots" at the 99% confidence level. Only needle length was significant at the tree level, and all variables showed significant variation between whorls. Some of the cells in each table are blank because the number of whorls retained can only be applied at the tree level or higher, and the last three variables (bole condition, fruit crop, and crown density) are unique to each tree, thus their variance can only be analyzed at the plot level. The complete analysis of variance (ANOVA) printouts appears in Appendix B.

Some possible explanations of the observed phenomena may be postulated from the results of the ANOVAs. Significant differences among plot data (Table 6) indicate that a locational factor or possibly a site characteristic is important in determining the variation in the parameters investigated. Site characteristics measured include slope, aspect, elevation, soil type, and moisture regime. In even-aged stands, an average tree diameter (tree age) may have some effect as well. An obvious location factor which might be important is the distance of each plot from the suspected ozone source - Tucson. The distance of the 15 pine plots ranges from 19.6 to 26.0 miles from the corner of

Broadway and Highway 89. A correlation analysis of the two variables, ozone chlorosis and distance, produced a very inconclusive correlation coefficient of -0.059. Correlation analyses of other variables are described in a later section of this report.

Significant variation among tree data (Table 6) indicates a genetic difference in the response or growth characteristics of individuals. Needle length (the only variable that yielded a significant F-ratio in the "tree" class of the pine ANOVA) is a factor that may be genetically determined, a function of tree diameter, or both. Among broadleaf trees (Tables 7-10), the variable leaf length and other injury showed significant variability among individual trees within plots. A possible explanation for the "other injury" results is that certain individuals may have a tolerance to fungal and/or insect attack, or are located in more favorable or sheltered areas.

Significant variation among whorls (Table 6) might be expected, as more injury and less needle retention would accompany the aging of needle whorls. These explanations are confirmed by the high F-ratios for nearly all variables tested in the class "whorls."

An interesting test useful in describing the variability of class means is the Student-Newman-Keuls (SNK) means separation test. This test was conducted for all dependent variables and classes that showed significant variability in the ANOVA for pine data. A few interesting facts do lend statistical credence to the inferences made in the preceding pages.

The results of the SNK tests appear as lists of the units within classes (plot number or whorl number) and their transformed mean values ranked in descending order (Appendix C). Adjacent to this list are letters indicating groups of means that are not statistically different. In some cases, only two groups are defined. This is the case in the test of the variable needle length by whorl number. The test shows that, while there is significant variation among the values of needle length over whorls of different ages, only two (whorl 6 and whorl 3) are actually separate at the 95% confidence level. On the other hand, a test of the variable crown density defines 11 groups out of 15 plots as separate, indicating considerable variability in this parameter over the range of plots surveyed. The SNK test of the variable ozone chlorosis confirms the elevational effects on visible injury; the six groups of plot means that are separated are groups of plots at similar elevations. Locational factors accounting for variation among plots for the variables needle length, other injury, and percent needle retention are not clear; no pattern is apparent. Plot groups at the high end for the variable bole injury and at the low end for the variable crown density include plots with dwarf-mistletoe infestations.

SNK tests by whorl number of the variables chlorosis, necrosis, percent needle retention, and other injury reveal no surprises, though whorls 1 and 2 conspicuously fall within the same grouping for all variables except other injury. This may be interpreted to indicate that ozone injury was

observed on the third-year whorl in a sufficient number of cases to warrant using this whorl as an indicator of overall injury in the Rincon Mountains. This fact may be used to compare the results of this study with the California surveys of *P. ponderosa* which used the presence or absence of ozone injury symptoms on a particular whorl number in rating ozone injury on individual trees. The SNK test for the variable other injury by whorls gave an interesting result, placing whorls of three years and older all in the same group. This may indicate that most insect injury occurs during the first two years of a needle's lifetime.

Some of the relationships postulated in the preceding discussion may be quantified through the use of a correlation matrix. Such matrices were generated for all dependent variables and covariables; each species was treated individually. The pine data matrix (Table 11) reveals many correlations between these variables. The highest r -value in the matrix is $+0.84$ for chlorosis and plot elevation. The strong positive correlation between ozone injury and elevation supports previous observations (Figures 16 and 17). The occurrences of necrotic symptoms also show a positive correlation with elevation ($r = +0.54$). A puzzling positive correlation between ozone chlorosis and needle retention is also apparent ($r = +0.62$). Possibly, needle whorls with poor retention have lost most of the needles possessing chlorotic symptoms leaving the healthier needles to be examined and yielding a relatively low percentage of chlorosis for the entire whorl.

Other correlations that may be significant include chlorosis with other injury ($r = +0.47$) and needle retention with other injury ($r = +0.51$). Relationships of ecological interest include a negative correlation between elevation and needle length ($r = -0.71$), and a positive correlation between cone crop and plot aspect ($r = +0.56$).

The data on hardwoods produced matrices with rather low r -values for air pollution-related variables (Tables 12-15). A possible negative correlation between chlorosis and crown density is revealed in oaks ($r = -0.33$). All values on the walnut matrix (Table 12) should be interpreted with caution because of the small sample size (only 15 trees).

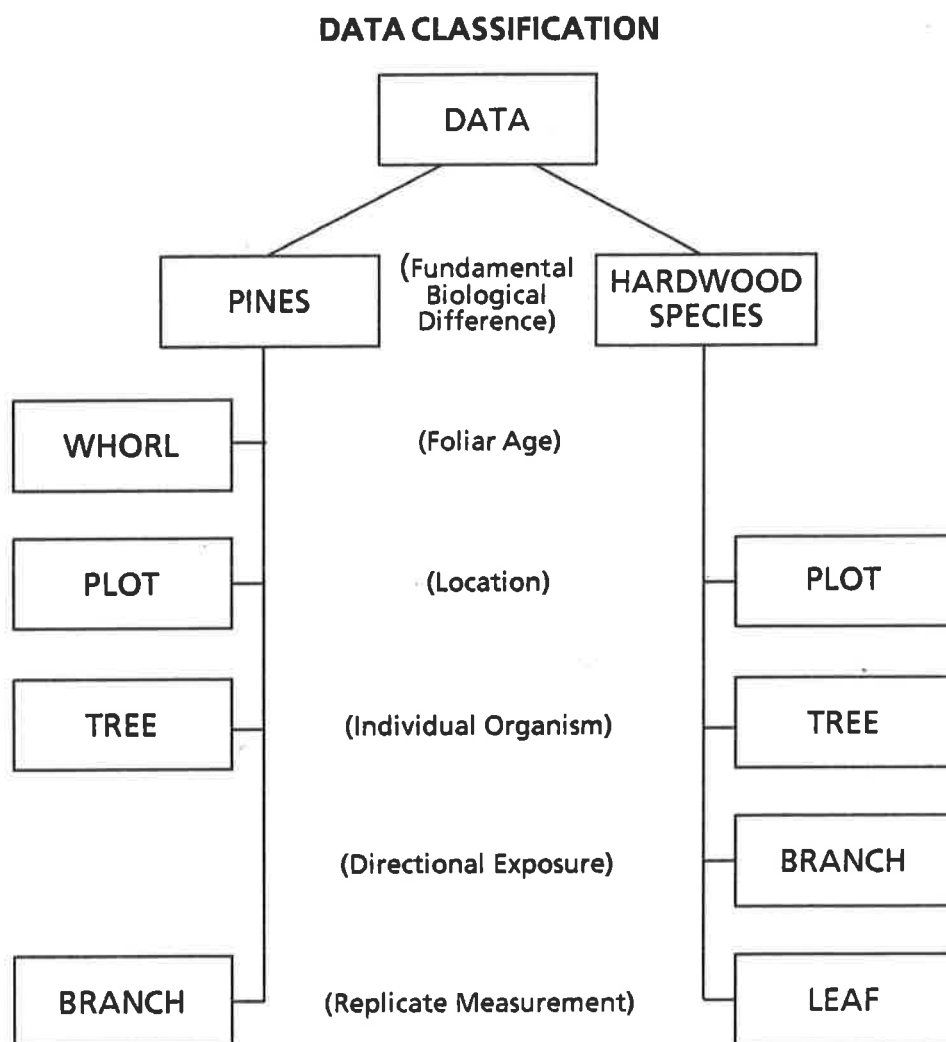


Figure 10. Classification of Data into Descriptive Categories.

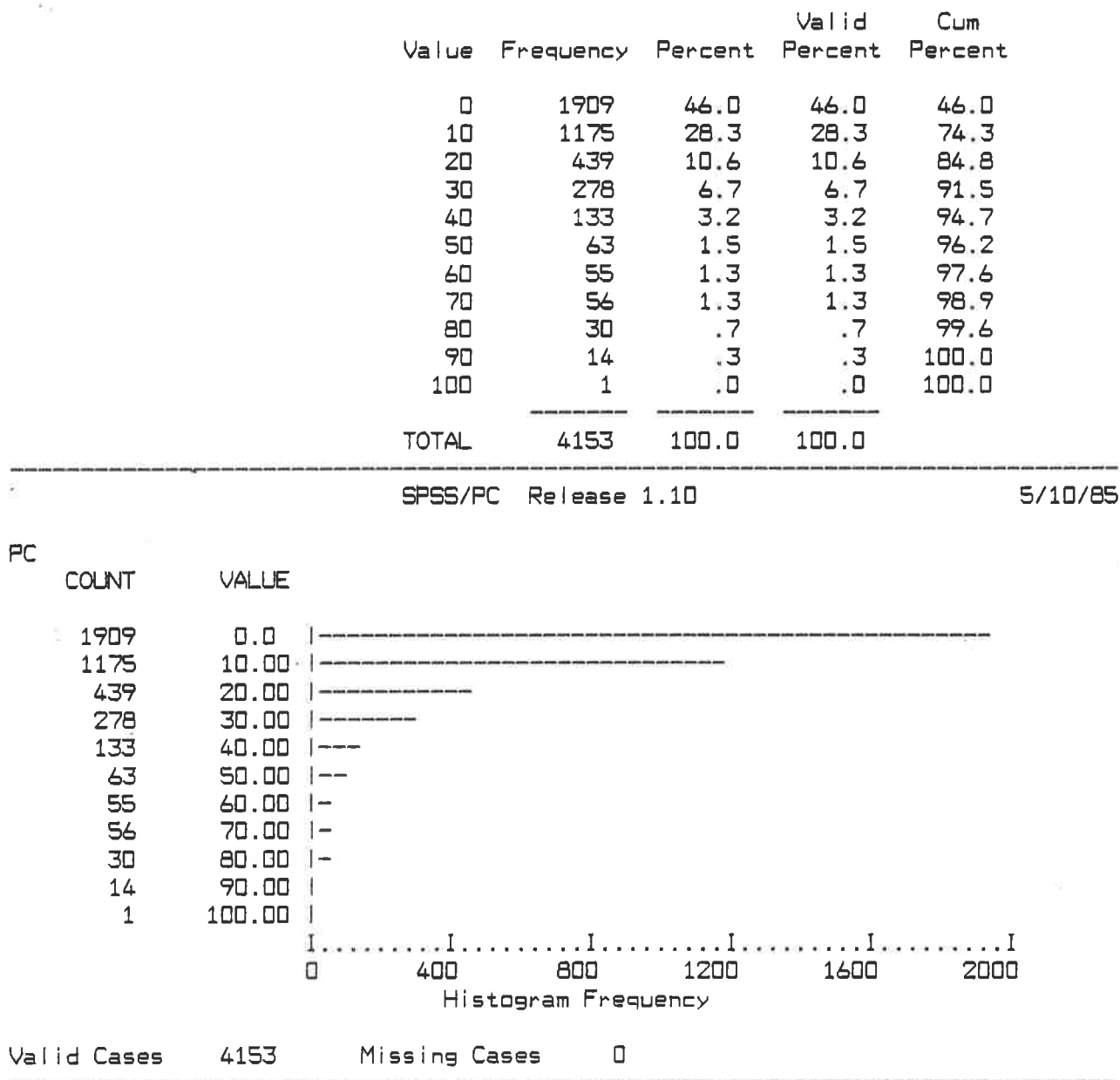


Figure 11. Frequency Table and Histogram for Data on the Percentage of Ozone Chlorosis Observed on Pine Needle Whorls. (All observations are included, irrespective of tree, branch, whorl age, or plot location.)

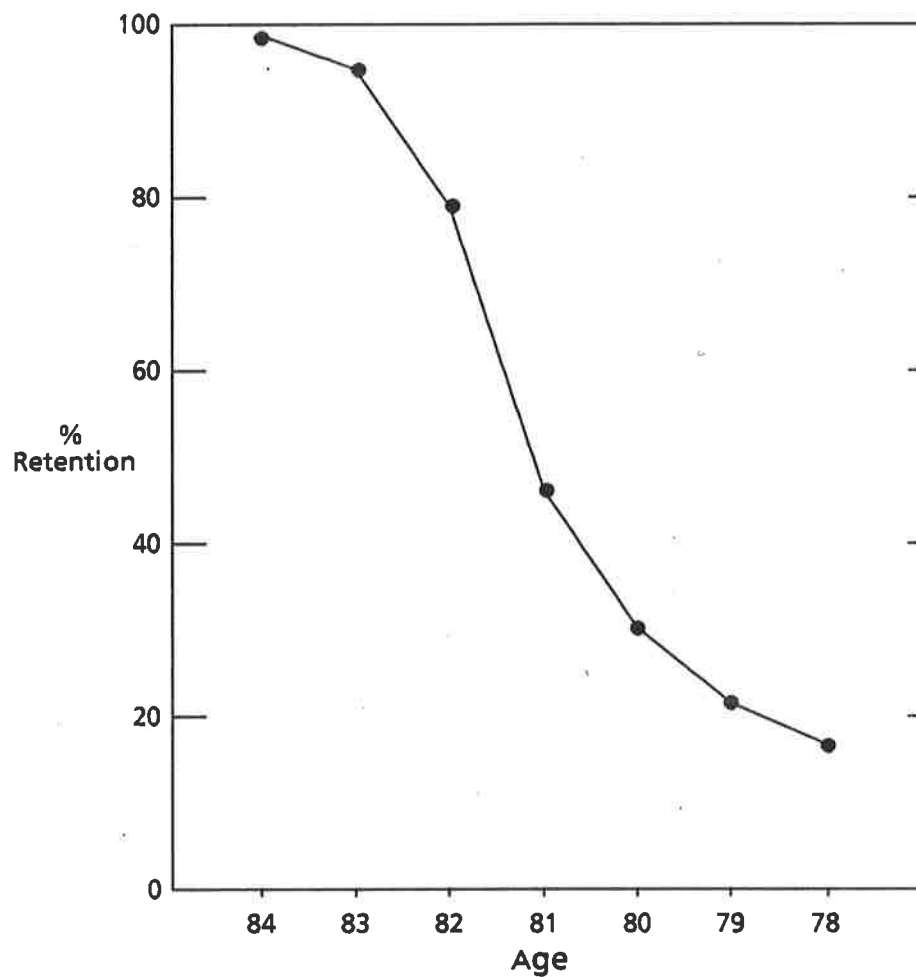


Figure 12. Plot of Mean Needle Retention vs. Needle Whorl Age.

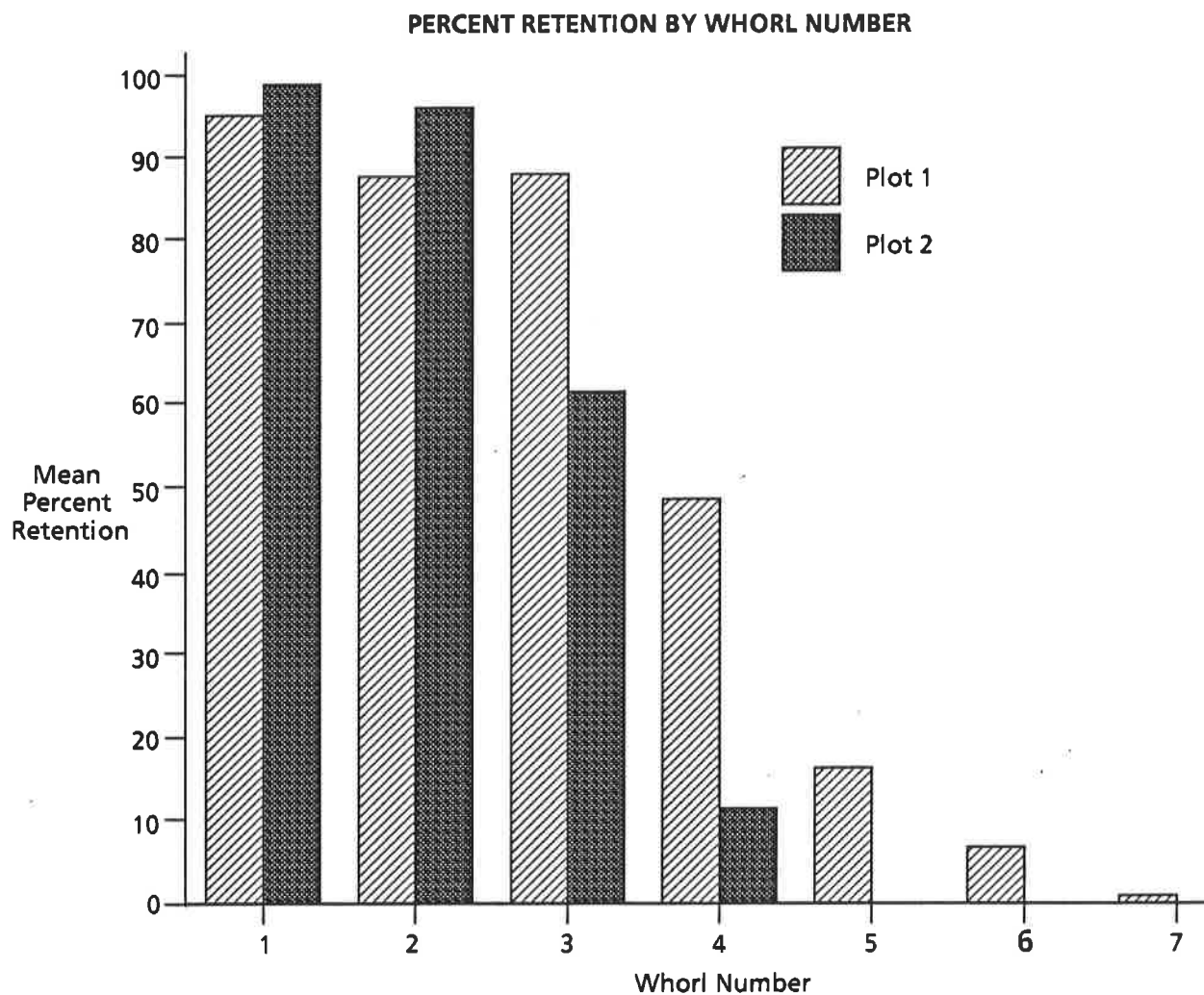


Figure 13. Needle Retention by Whorl Number Compared for Plots with Greatest and Least Mean Values.

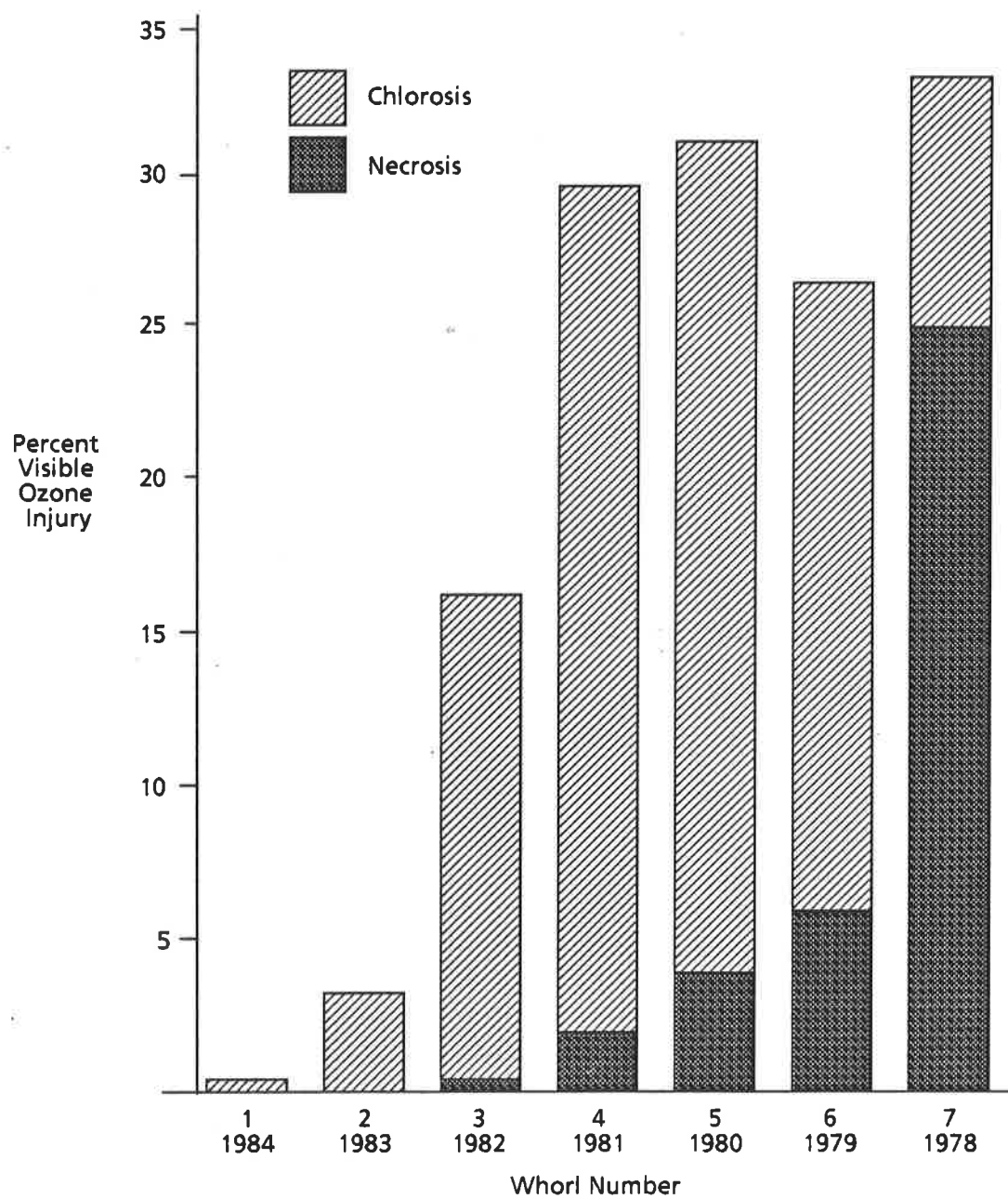


Figure 14. Percent Visible Ozone Injury by Whorl Number Averaged over All Plots.

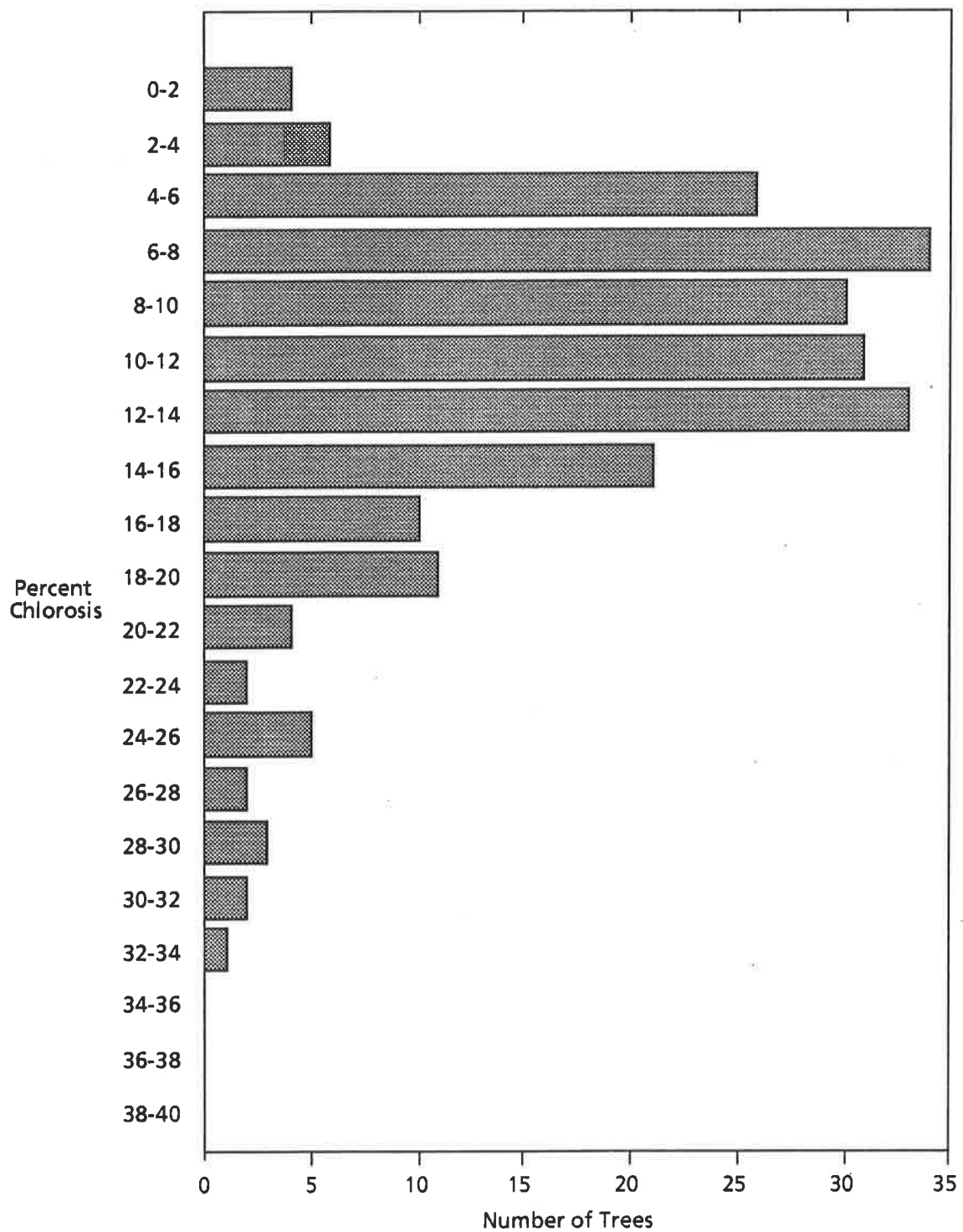


Figure 15. Average Chlorosis by Tree (All Whorls).

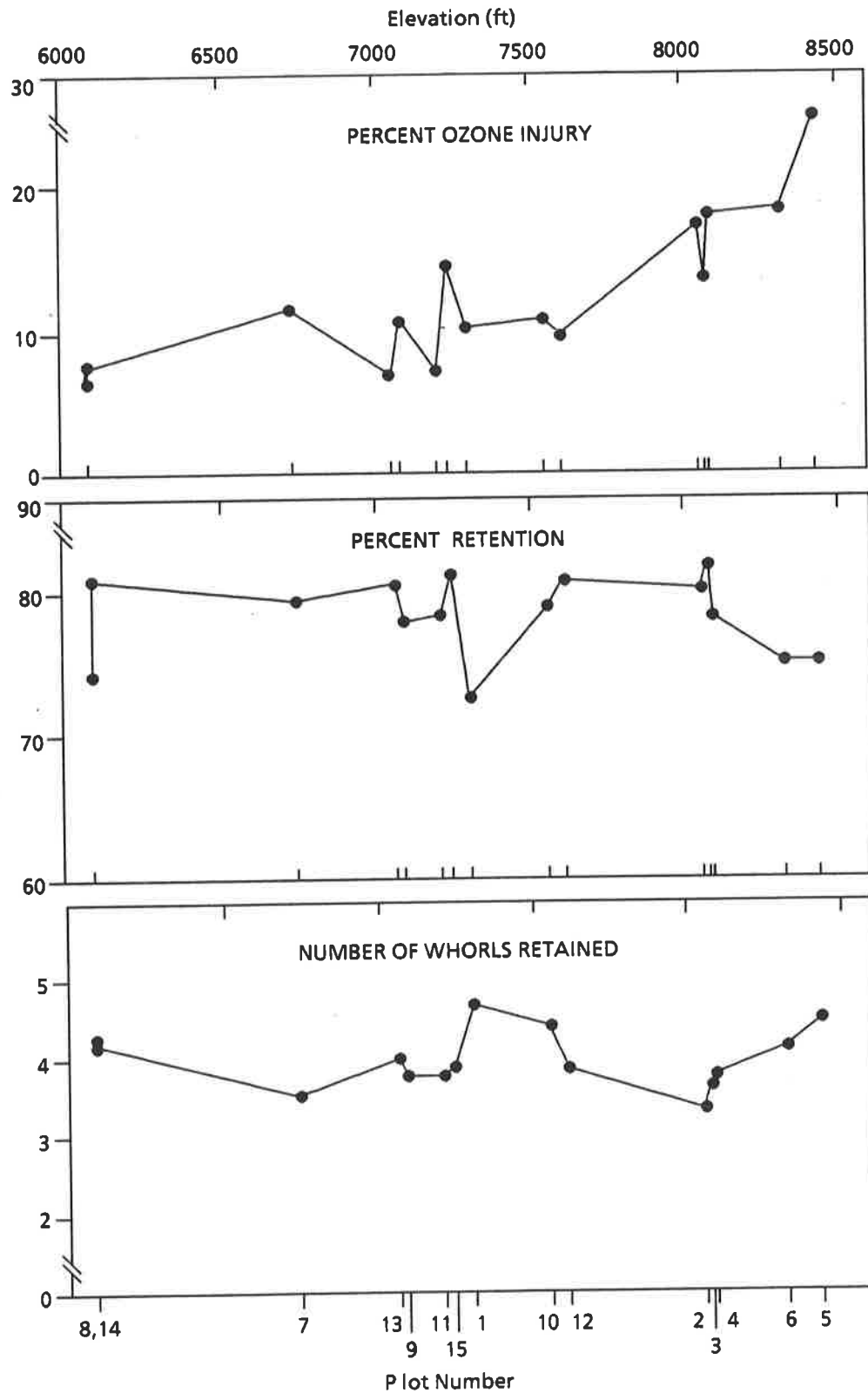


Figure 16. Graph of Selected Variables Averaged over Plots Shown in Order of Increasing Elevation.

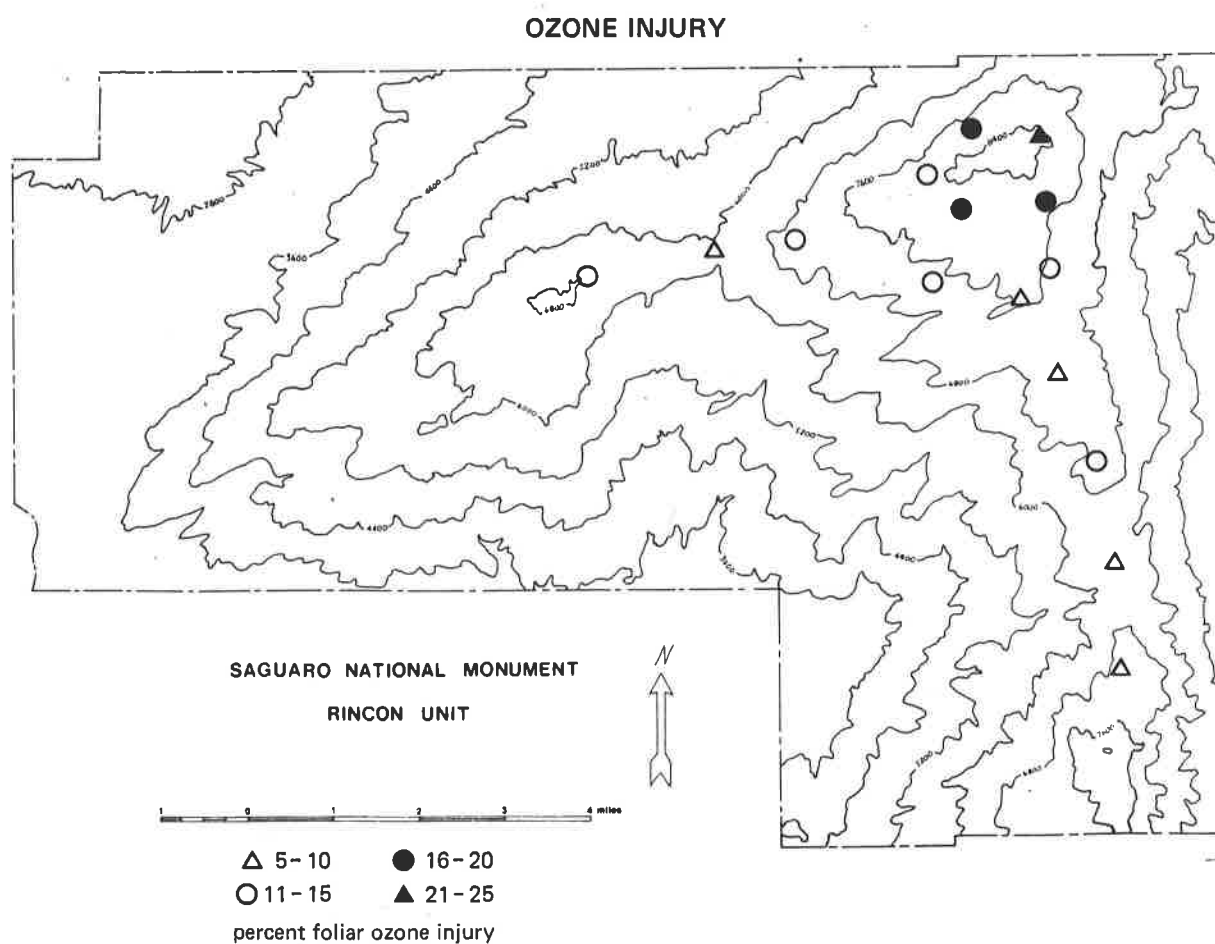


Figure 17. Ozone Injury Observed in Pine Plots of the Rincon Unit.

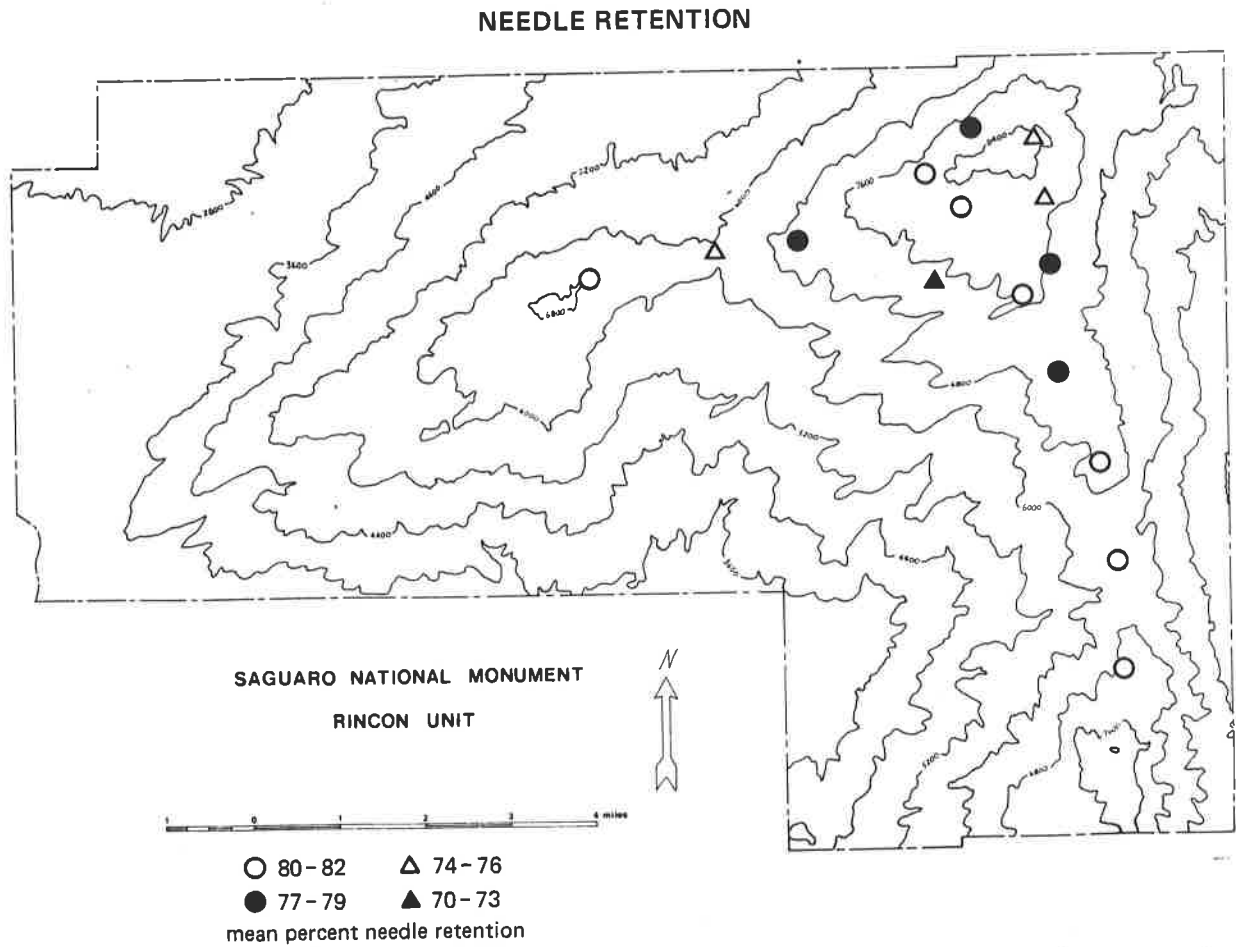


Figure 18. Needle Retention Observed in Pine Plots of the Rincon Unit.

TABLE 2. SELECTED DESCRIPTIVE STATISTICS ON THE PINE DATA SET

Variable	Mean	Std. Dev.	N
PC	11.63%	16.57	4,153
PN	0.85%	5.71	4,153
NL	14.55 cm	3.13	4,153
PR	78.13%	29.71	4,153
OI	15.90%	10.90	4,153
NW	4.00	0.89	1,039
CD	7.92	2.99	225
CC	0.60	1.45	225
BC	1.41	2.05	225
DIA	26.90 cm	11.69	225
ELEV	7,404.67 ft	711.30	15

TABLE 3. MEANS OF SELECTED VARIABLES BY WHORL AGE

Variable	Whorl Number (Year)						
	1 (1984)	2 (1983)	3 (1982)	4 (1981)	5 (1980)	6 (1979)	7 (1978)
PC	0.31	3.16	15.60	27.89	27.27	18.99	8.33
PN	0.00	0.05	0.55	1.85	3.92	5.94	25.00
OI	6.29	13.44	19.71	23.60	25.01	23.91	20.00
PR	98.94	94.25	79.32	46.24	30.46	22.03	16.67
NL	14.05	15.54	13.77	14.66	14.98	15.87	14.83

TABLE 4. MEANS OF SELECTED VARIABLES BY PLOT

Plot #	Elevation	% Ozone Injury	% Retention	Number of Whorls Retained
8	6100	7.57	74.22	4.28
14	6100	6.54	80.76	4.17
7	6760	11.59	79.36	3.55
13	7080	6.99	80.42	4.03
9	7100	10.64	77.84	3.79
11	7220	7.29	78.43	3.78
15	7260	14.47	81.21	3.91
1	7320	10.23	72.63	4.67
10	7580	10.87	78.95	4.42
12	7620	9.51	80.63	3.88
2	8080	17.39	80.18	3.36
3	8090	13.88	81.58	3.63
4	8100	18.22	78.23	3.79
6	8330	18.34	75.22	4.13
5	8450	24.84	75.16	4.49

TABLE 5. MEANS OF SELECTED VARIABLES FOR HARDWOOD SPECIES

	Oak	Aspen	Sycamore	Walnut
Ozone visible injury	0.88	0	0	4.96
Other injury	7.15	32.9	40.4	11.2
DBH	22.3	11.3	30.6	15.9
Crown Density	9.3	7.4	10.1	6.0
Bole injury	3.7	1.3	2.5	4.9
Fruit crop	1.22	0	3.77	0
Elevation	8,070	7,730	4,330	6,090

TABLE 6. F-RATIOS AND PROBABILITIES

Pine Data Nested Analysis of Variance									
Var.	Plots			Trees			Whorls		
	df	F test	PR H ₀	df	F test	PR H ₀	df	F test	PR H ₀
CHL	14	14.05	<0.001	210	0.37	>0.10	803	15.19	<0.001
NEC	14	5.71	<0.001	210	0.71	>0.10	803	5.37	<0.001
RET	14	2.96	<0.001	210	0.23	>0.10	803	14.83	<0.001
NL	14	14.60	<0.001	210	6.59	<0.001	803	2.11	<0.001
OINJ	14	6.22	<0.001	210	0.75	>0.10	803	5.87	<0.001
NW	14	0.35	>0.10	210	0.78	>0.10	-	-	-
BI*	14	10.44	<0.001	-	-	-	-	-	-
CD*	14	6.57	<0.001	-	-	-	-	-	-
CC*	14	4.19	<0.001	-	-	-	-	-	-

H₀ : There is no difference in the measured variables between classes (plots, trees, and whorls).

* F-ratios were obtained with a one way ANOVA (BI CD CC = PLOT).

TABLE 7. OAK NESTED ANOVA

Var.	Plots			Trees			Branches		
	df	F Ratio	PR H ₀	df	F Ratio	PR H ₀	df	F Ratio	PR H ₀
CHL	2	0.52	>0.10	42	1.65	>0.10	175	2.02	<0.001
NEC	2	0.52	>0.10	42	1.65	>0.10	175	2.02	<0.001
LL	2	2.26	0.10	42	4.52	<0.001	175	3.57	<0.001
OINJ	2	18.9	<0.001	42	1.72	0.01>PR>0.005	175	2.17	<0.001
BI	2	2.01	0.146	-	-	-	-	-	-
CD	2	4.65	0.015	-	-	-	-	-	-
FC	2	9.32	0.0004	-	-	-	-	-	-

TABLE 8. ASPEN NESTED ANOVA

Var.	Plots			Trees			Branches		
	df	F Ratio	PR H ₀	df	F Ratio	PR H ₀	df	F Ratio	PR H ₀
LL	1	5.2	0.025 < PR < 0.05	28	3.4	< 0.001	117	3.62	< 0.001
OINJ	1	111.9	< 0.001	28	3.6	< 0.001	117	2.39	< 0.001
BI	1	15.26	0.0005	-	-	-	-	-	-
CD	1	0.24	0.63	-	-	-	-	-	-
FC	-	-	-	-	-	-	-	-	-

TABLE 9. SYCAMORE NESTED ANOVA

Var.	Plots			Trees			Branches		
	df	F Ratio	PR H ₀	df	F Ratio	PR H ₀	df	F Ratio	PR H ₀
LL	1	.257	> 0.10	28	4.97	< 0.001	120	3.8	< 0.001
OINJ	1	8.8	0.01 > PR > 0.005	28	3.24	< 0.001	120	2.1	< 0.001
BI	1	2.82	0.104	-	-	-	-	-	-
CD	1	0.4	0.527	-	-	-	-	-	-
FC	1	4.74	0.038	-	-	-	-	-	-

TABLE 10. WALNUT NESTED ANOVA

Var.	Trees			Branches		
	df	F Ratio	PR H ₀	df	F Ratio	PR H ₀
CHL	14	1.69	0.10 > PR > 0.05	60	2.62	< 0.001
NEC	14	1.69	0.10 > PR > 0.05	60	2.62	< 0.001
LL	14	3.09	< 0.001	60	3.18	< 0.001
OINJ	14	3.03	0.005 > PR > 0.001	60	1.24	> 0.10

TABLE 11. PINE DATA CORRELATION MATRIX
(CORRELATION COEFFICIENTS / PROB > |r| UNDER H₀:RH₀ = 0)

	CHL	NEC	NL	RET	OINJ	NW	DIA	CD	CC	BI	SL	ASP	ELEV
CHL	1.000	0.241	-0.153	0.615	0.437	0.190	-0.213	0.086	-0.233	0.254	-0.193	-0.290	0.838
NEC	0.000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0013	0.1963	0.0004	0.0001	0.4910	0.2940	0.0001
NL	0.241	1.000	0.035	0.254	0.104	0.126	-0.098	0.2187	-0.154	0.127	-0.240	-0.214	0.536
RET	0.0001	0.000	0.0235	0.0001	0.0001	0.0001	0.143	0.0010	0.0207	0.0569	0.3894	0.4447	0.0392
OINJ	-0.153	-0.035	1.000	-0.018	0.003	0.108	0.405	0.087	0.339	-0.313	-0.228	0.029	-0.708
NW	0.0001	0.0235	0.000	0.2532	0.8481	0.0005	0.0001	0.1918	0.0001	0.0001	0.4135	0.9187	0.0031
DIA	0.615	0.254	-0.018	1.000	0.514	0.525	0.133	0.096	0.079	-0.036	-0.336	-0.343	0.051
CD	0.0001	0.0001	0.2532	0.000	0.0001	0.0001	0.0455	0.1518	0.2375	0.5953	0.2207	0.2112	0.8570
CC	0.437	0.104	0.003	0.514	1.000	0.276	0.110	0.160	0.173	-0.222	0.167	0.083	0.099
BI	0.0001	0.0001	0.8481	0.0001	0.000	0.0001	0.0996	0.0161	0.0091	0.0008	0.5575	0.7676	0.7260
SL	0.190	0.126	0.108	0.525	0.276	1.000	0.006	0.229	0.008	-0.228	-0.256	-0.147	-0.113
ASP	0.0001	0.0001	0.0005	0.0001	0.0001	0.000	0.9286	0.0005	0.8994	0.0006	0.3565	0.6005	0.6885
ELEV	-0.213	-0.098	0.405	0.133	0.110	0.006	1.000	0.248	0.389	-0.078	-0.405	0.353	0.154
	0.0013	0.143	0.0001	0.0455	0.0996	0.9286	0.000	0.0002	0.0001	0.2433	0.1339	0.1965	0.5838
	0.086	0.219	0.087	0.096	0.160	0.229	0.248	1.000	0.285	-0.266	-0.036	0.197	0.263
	0.1963	0.0010	0.1918	0.1518	0.0161	0.0005	0.0002	0.000	0.0001	0.0001	0.8993	0.4820	0.3442
	-0.233	-0.154	0.339	0.079	0.173	0.008	0.389	0.285	1.000	-0.106	0.061	0.563	-0.174
	0.0004	0.0207	0.0001	0.2375	0.0091	0.8994	0.0001	0.0001	0.000	0.112	0.8281	0.0289	0.5357
	0.254	0.127	-0.313	-0.036	-0.222	-0.228	-0.078	-0.266	-0.106	1.000	-0.179	0.094	0.531
	0.0001	0.0569	0.0001	0.5953	0.0008	0.0006	0.2433	0.0001	0.1112	0.000	0.5241	0.7390	0.0418
	-0.193	-0.240	-0.228	-0.336	0.167	-0.256	-0.405	-0.036	0.061	-0.179	1.000	0.141	-0.281
	0.491	0.3894	0.4135	0.2207	0.5575	0.3565	0.1339	0.8993	0.8281	0.5241	0.000	0.6158	0.3112
	-0.290	-0.214	0.029	-0.343	0.083	-0.147	0.353	0.197	0.563	0.094	0.141	1.000	0.019
	0.2940	0.4447	0.9187	0.2112	0.7676	0.6005	0.1965	0.4820	0.289	0.7390	0.6158	0.000	0.9440
	0.838	0.536	-0.708	0.051	0.099	-0.113	0.154	0.263	-0.174	0.531	-0.281	0.019	1.000
	0.0001	0.0392	0.0031	0.8570	0.7260	0.6885	0.5838	0.3442	0.5357	0.0418	0.3112	0.9440	0.000

N = 225 (trees)

N = 15 (plots)

N = 4,153 (whorls)

N = 1,039 (branches)

TABLE 12. OAK DATA CORRELATION MATRIX
(CORRELATION COEFFICIENTS / PROB > |r| UNDER $H_0: \rho_{HO} = 0$)

	CHL	NEC	OINJ	LL	DBH	HT	CD	FC	BI
CHL	1.000	1.000	-0.078	-0.035	-0.047	0.170	-0.331	0.169	0.197
NEC	0.0000	0.0001	0.0098	0.2491	0.7595	0.2633	0.0264	0.2664	0.1938
OINJ	1.000	1.000	-0.078	-0.035	-0.047	0.170	-0.331	0.169	0.197
LL	0.0001	0.0000	0.0098	0.2491	0.7595	0.2633	0.0264	0.2664	0.1938
DBH	-0.078	-0.078	1.000	-0.011	0.062	0.090	-0.197	0.360	0.005
HT	0.0098	0.0098	0.0000	0.7075	0.6838	0.5571	0.1943	0.0150	0.9701
CD	-0.035	-0.035	-0.011	1.000	0.162	0.606	-0.193	-0.125	0.035
FC	0.2491	0.2491	0.7075	0.0000	0.2887	0.0001	0.2034	0.4107	0.8192
BI	-0.047	-0.047	0.062	0.162	1.000	0.359	0.149	0.283	0.169
	0.7595	0.7595	0.6838	0.2887	0.0000	0.0164	0.3287	0.0599	0.2666
	0.170	0.170	0.090	0.606	0.359	1.000	0.020	0.136	-0.334
	0.2633	0.2633	0.5571	0.0001	0.0164	0.0000	0.8983	0.3738	0.0250
	-0.331	-0.331	-0.197	-0.193	0.149	0.020	1.000	-0.137	-0.334
	0.0264	0.0264	0.1943	0.2034	0.3287	0.8983	0.0000	0.3705	0.0248
	0.169	0.169	0.360	-0.125	0.283	0.136	-0.137	1.000	0.003
	0.2664	0.2664	0.0150	0.4107	0.0599	0.3738	0.3705	0.0000	0.9820
	0.197	0.197	0.005	0.035	0.169	-0.334	-0.334	0.003	1.000
	0.1938	0.1938	0.9701	0.8192	0.2666	0.0250	0.0248	0.9820	0.0000

☐ N = 45

☐ N = 1,100

TABLE 13. SYCAMORE DATA CORRELATION MATRIX
(CORRELATION COEFFICIENTS/PROB > |R| UNDER $H_0: \rho_{H_0} = 0$)

	CHL	NEC	OINJ	LL	DBH	HT	CD	FC	BI
CHL	1.000 0.00000	0 0.00000	0 0.00000	0 0.00000	0 0.00000	0 0.00000	0 0.00000	0 0.00000	0 0.00000
NEC		1.000 0.00000	0 0.00000	0 0.00000	0 0.00000	0 0.00000	0 0.00000	0 0.00000	0 0.00000
OINJ			1.000 0.00000	-0.319 0.0001	-0.252 0.1796	0.104 0.5853	-0.196 0.2999	0.049 0.7984	0.016 0.9312
LL				1.000 0.0000	0.012 0.9503	0.043 0.8221	-0.091 0.6309	0.129 0.4975	-0.062 0.7466
DBH					1.000 0.0000	0.640 0.0001	0.558 0.0014	0.128 0.4994	0.526 0.0028
HT						1.000 0.0000	0.210 0.0000	0.468 0.0091	0.105 0.5815
CD							1.000 0.0000	0.119 0.5291	0.201 0.2866
FC								1.000 0.0000	-0.407 0.0255
BI									1.000 0.0000

N = 750

N = 30

TABLE 14. ASPEN DATA CORRELATION MATRIX
(CORRELATION COEFFICIENTS / PROB > |R| UNDER $H_0: R H_0 = 0$)

	CHL	NEC	OINJ	LL	DBH	HT	CD	FC	BI
CHL	1.000 0.0000	0	0	0	0	0	0	0	0
NEC	0	1.000 0.0000	0	0	0	0	0	0	0
OINJ	0	0	1.000 0.0000	0.029 0.4368	0.253 0.1776	0.654 0.0001	0.031 0.8707	0	-0.506 0.0043
LL	0	0	0.029 0.4368	1.000 0.0000	0.254 0.1758	0.341 0.0650	-0.192 0.3083	0	-0.157 0.4076
DBH	0	0	0.253 0.1776	0.254 0.1758	1.000 0.0000	0.711 0.0001	0.163 0.3900	0	0.167 0.3876
HT	0	0	0.654 0.0001	0.341 0.0650	0.711 0.0001	1.000 0.0000	0.162 0.3937	0	-0.194 0.3034
CD	0	0	0.031 0.8707	-0.192 0.3083	0.163 0.3900	0.162 0.3937	1.000 0.0000	0	0.233 0.2160
FC	0	0	0	0	0	0	0	1.000 0.0000	0
BI	0	0	-0.506 0.0043	-0.157 0.4076	0.167 0.3876	-0.194 0.3034	0.233 0.2160	0	1.000 0.0000

N = 735

☐ N = 30

TABLE 15. WALNUT DATA CORRELATION MATRIX
(CORRELATION COEFFICIENTS / PROB > |R| UNDER $H_0: \rho = 0$)

	CHL	NEC	OINJ	LL	DBH	HT	CD	FC	BI
CHL	1.000	1.000	0.162	-0.017	0.705	0.737	-0.023	0	-0.026
NEC	0.0000	0.0001	0.0017	0.7455	0.0034	0.0017	0.9189	0	0.9260
OINJ	1.000	1.000	0.162	-0.017	0.705	0.737	-0.023	0	-0.026
LL	0.0001	0.0000	0.0017	0.7455	0.0034	0.0017	0.9189	0	0.9260
DBH	0.162	0.162	1.000	-0.038	0.134	-0.041	0.097	0	-0.441
HT	0.0017	0.0017	0.0000	0.4617	0.6331	0.8856	0.7299	0	0.0997
CD	-0.017	-0.017	-0.038	1.000	0.145	0.303	0.253	0	0.453
FC	0.7455	0.7455	0.4617	0.0000	0.6070	0.2715	0.3621	0	0.0900
BI	0.705	0.705	0.134	0.145	1.000	0.701	-0.102	0	0.237
	0.0034	0.0034	0.6331	0.6070	0.0000	0.0036	0.7166	0	0.3942
	0.737	0.737	-0.041	0.303	0.701	1.000	0.083	0	0.200
	0.0017	0.0017	0.8856	0.2715	0.0036	0.0000	0.7691	0	0.4740
	-0.023	-0.023	0.097	0.253	-0.102	0.083	1.000	0	-0.256
	0.9189	0.9189	0.7299	0.3621	0.7166	0.7691	0.0000	0	0.3568
	0	0	0	0	0	0	0	1.000	0
								0.0000	
	-0.026	-0.026	-0.441	0.453	0.237	0.200	-0.256	0	1.000
	0.9260	0.9260	0.0997	0.0900	0.3942	0.4740	0.3568	0	0.0000

N = 375

N = 15

SECTION 5

CONCLUSIONS

This study has shown that (1) two varieties of Ponderosa pine in the Rincon Mountains exhibit foliar symptoms of ozone injury, (2) this injury covers an average of 15% or more of the total leaf area on whorls three years old or older, (3) very little variation in sensitivity among individual trees within a pine plot exists, (4) visible ozone injury increased with increased site elevation, (5) the foliage of Gambel's oak and Arizona black walnut display symptoms of very slight ozone injury in this area, (6) samples of quaking aspen and Arizona sycamore appear uninjured by air pollution, and (7) a data base including a large number of foliar, tree, and site characteristics, has been established for use in future trend evaluation.

SECTION 6

REFERENCES

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APPENDIX A
DESCRIPTIVE STATISTICS

PINE DATA SET

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt	Skewness	S.E.	Skew	Minimum	Maximum	N
PC	11.63	16.57	4.96	.08	.08	2.12	.04	.04	0.0	100.00	4153
PN	.85	5.71	146.96	.08	.08	11.07	.04	.04	0.0	100.00	4153
NL	14.55	3.13	.48	.08	.08	-.02	.04	.04	1.00	28.00	4153
PR	78.13	29.71	.08	.08	.08	-1.22	.04	.04	10.00	100.00	4153
O1	15.90	10.90	2.85	.08	.08	.99	.04	.04	0.0	100.00	4153
WH	4.00	.89	.19	.15	.15	.42	.08	.08	2.00	7.00	1039
DN	7.92	2.99	.65	.32	.32	.88	.16	.16	3.00	17.00	225
CR	.60	1.45	17.35	.32	.32	3.74	.16	.16	0.0	10.00	225
BC	1.41	2.05	1.71	.32	.32	1.61	.16	.16	0.0	8.00	225
ALT	7404.67	711.30	-.43	1.12	1.12	-.39	.58	.58	6100.00	8450.00	15
APT	212.93	118.73	-1.09	1.12	1.12	-.55	.58	.58	5.00	360.00	15
SP	20.60	16.67	-.35	1.12	1.12	.93	.58	.58	3.00	55.00	15
DIA	26.90	11.69	.01	.32	.32	.74	.16	.16	8.60	62.20	225

SPSS/PC Release 1.10

WHCRL #1 (1984)

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt	Skewness	S.E.	Skew	Minimum	Maximum	N
PC	.31	2.73	417.56		.15	17.74		.08	0.0	70.00	1031
PN	0.0	0.0							0.0	0.0	1031
NL	14.05	3.45	.33		.15	-.31		.08	1.00	24.00	1031
PR	98.94	7.40	82.37		.15	-8.74		.08	10.00	100.00	1031
O1	6.29	9.41	25.22		.15	3.82		.08	0.0	100.00	1031

WHCRL #2 (1983)

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt	Skewness	S.E.	Skew	Minimum	Maximum	N
PC	3.16	5.74	35.69		.15	3.83		.08	0.0	80.00	1039
PN	.05	.69	203.79		.15	14.33		.08	0.0	10.00	1039
NL	15.54	3.07	.15		.15	.05		.08	3.00	26.00	1039
PR	94.75	10.77	10.69		.15	-2.89		.08	10.00	100.00	1039
O1	13.44	7.48	20.10		.15	3.40		.08	0.0	90.00	1039

WHCRL #3 (1982)

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt	Skewness	S.E.	Skew	Minimum	Maximum	N
PC	15.60	12.27	4.26		.15	1.79		.08	0.0	80.00	1017
PN	.55	3.95	399.84		.15	17.12		.08	0.0	100.00	1017
NL	13.77	2.76	.67		.15	.35		.08	4.00	28.00	1017
PR	79.32	21.42	1.87		.15	-1.51		.08	10.00	100.00	1017
O1	19.71	8.33	1.75		.15	.93		.08	0.0	60.00	1017

WHCRL #4 (1981)

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt	Skewness	S.E.	Skew	Minimum	Maximum	N
PC	27.89	20.79	.68		.18	1.15		.09	0.0	100.00	731
PN	1.85	6.92	49.81		.18	6.34		.09	0.0	70.00	731
NL	14.66	2.96	.83		.18	.08		.09	3.00	25.00	731
PR	46.24	27.31	-1.24		.18	.17		.09	10.00	100.00	731
O1	23.60	8.84	1.14		.18	.64		.09	0.0	70.00	731

WHORL #5 (1980)

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt	Skewness	S.E.	Skew	Minimum	Maximum	N
PC	27.27	21.54	.56		.30	1.13		.15	0.0	90.00	260
PN	3.92	13.06	26.20		.30	4.83		.15	0.0	100.00	260
NL	14.98	2.65	.14		.30	.05		.15	7.00	22.00	260
PR	30.46	23.69	-.13		.30	1.00		.15	10.00	100.00	260
O1	25.01	9.90	.61		.30	.48		.15	0.0	60.00	260

WHORL #6 (1979)

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt	Skewness	S.E.	Skew	Minimum	Maximum	N
PC	18.99	18.80	2.79		.57	1.57		.29	0.0	90.00	69
PN	5.94	17.68	11.15		.57	3.45		.29	0.0	80.00	69
NL	15.87	2.74	-.22		.57	.33		.29	10.00	23.00	69
PR	22.03	18.52	2.94		.57	1.80		.29	10.00	90.00	69
O1	23.91	8.44	-.38		.57	.35		.29	10.00	40.00	69

WHORL #7 (1978)

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt	Skewness	S.E.	Skew	Minimum	Maximum	N
PC	8.33	16.02	4.64		1.74	2.15		.85	0.0	40.00	6
PN	25.00	41.83	1.43		1.74	1.54		.85	0.0	100.00	6
NL	14.83	2.32	-1.42		1.74	.30		.85	12.00	18.00	6
PR	16.67	8.16	-.30		1.74	.86		.85	10.00	30.00	6
O1	20.00	10.95	2.50		1.74	-1.37		.85	0.0	30.00	6

PINE PLOT 1

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt	Skewness	S.E.	Skew	Minimum	Maximum	N
PC	9.94	11.33	2.78	.26	.26	1.45	.13	.13	0.0	60.00	350
PN	.29	1.83	54.49	.26	.26	7.02	.13	.13	0.0	20.00	350
VI	10.23	12.04	4.52	.26	.26	1.71	.13	.13	0.0	90.00	350
NL	15.10	2.98	.93	.26	.26	-.01	.13	.13	3.00	24.00	350
PR	72.63	31.06	-.62	.26	.26	-.91	.13	.13	10.00	100.00	350
O1	17.71	12.95	3.65	.26	.26	1.26	.13	.13	0.0	90.00	350
WH	4.67	.89	-.15	.55	.55	.60	.28	.28	3.00	7.00	75
CD	9.00	2.75	-.78	1.12	1.12	-.17	.58	.58	4.00	13.00	15
CR	1.20	1.52	7.36	1.12	1.12	2.42	.58	.58	0.0	6.00	15
BC	.87	1.30	7.61	1.12	1.12	2.52	.58	.58	0.0	5.00	15

PINE PLOT 2

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt	Skewness	S.E.	Skew	Minimum	Maximum	N
PC	15.90	20.75	1.70	.33	.33	1.56	.16	.16	0.0	80.00	222
PN	1.49	3.81	5.52	.33	.33	2.47	.16	.16	0.0	20.00	222
NL	12.36	2.25	1.50	.33	.33	-.63	.16	.16	3.00	18.00	222
PR	80.18	27.77	.70	.33	.33	-1.38	.16	.16	10.00	100.00	222
O1	11.67	9.53	.61	.33	.33	.70	.16	.16	0.0	50.00	222
WH	3.36	.57	-.71	.58	.58	-.20	.29	.29	2.00	4.00	66
DN	7.80	2.11	-1.09	1.12	1.12	-.22	.58	.58	4.00	11.00	15
CR	0.0	0.0							0.0	0.0	15
BC	3.27	2.31	-.17	1.12	1.12	.78	.58	.58	0.0	8.00	15
DIA	25.07	7.54	1.09	1.12	1.12	-.10	.58	.58	10.40	41.10	15

PINE PLOT 3

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt	Skewness	S.E.	Skew	Minimum	Maximum	N
PC	13.43	18.23	2.21		.30	1.58		.15	0.0	90.00	265
PN	.45	2.57	71.14		.30	7.54		.15	0.0	30.00	265
NL	13.07	2.65	.97		.30	.06		.15	5.00	23.00	265
PR	81.58	26.96	1.03		.30	-1.48		.15	10.00	100.00	265
O1	14.04	10.44	3.77		.30	1.16		.15	0.0	70.00	265
WH	3.63	.75	1.52		.56	.54		.28	2.00	6.00	73
DN	6.93	2.09	.14		1.12	.92		.58	4.00	11.00	15
CR	.13	.52	15.00		1.12	3.87		.58	0.0	2.00	15
BC	2.80	2.60	-.42		1.12	.82		.58	0.0	8.00	15
DIA	31.80	14.91	-.55		1.12	.41		.58	13.20	61.70	15

PINE PLOT 4

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt	Skewness	S.E.	Skew	Minimum	Maximum	N
PC	16.62	23.29	1.50		.32	1.52		.16	0.0	90.00	231
PN	1.60	7.01	52.49		.32	6.64		.16	0.0	70.00	231
NL	11.73	2.38	.20		.32	-.17		.16	2.00	17.00	231
PR	78.23	28.47	.31		.32	-1.23		.16	10.00	100.00	231
O1	16.58	12.85	3.87		.32	1.13		.16	0.0	90.00	231
WH	3.79	.66	-.70		.60	.26		.31	3.00	5.00	61
DN	5.73	1.94	-.60		1.12	.10		.58	3.00	9.00	15
CR	.07	.26	15.00		1.12	3.87		.58	0.0	1.00	15
BC	4.40	1.99	.31		1.12	-1.20		.58	0.0	6.00	15
DIA	25.19	8.74	.03		1.12	1.21		.58	17.20	42.90	15

PINE PLOT 5

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt	Skewness	S.E.	Skew	Minimum	Maximum	N
PC	20.83	26.10	.26		.27	1.18		.14	0.0	100.00	314
PN	4.01	15.22	20.95		.27	4.55		.14	0.0	100.00	314
NL	13.75	2.11	3.96		.27	-.98		.14	1.00	19.00	314
PR	75.16	32.63	-.42		.27	-1.09		.14	10.00	100.00	314
O1	19.84	12.24	4.99		.27	1.19		.14	0.0	100.00	314
WH	4.49	.85	1.00		.57	.93		.29	3.00	7.00	70
DN	10.73	4.22	-.98		1.12	-.14		.58	4.00	17.00	15
CR	.13	.35	4.35		1.12	2.40		.58	0.0	1.00	15
BC	.13	.35	4.35		1.12	2.40		.58	0.0	1.00	15
DIA	24.33	9.21	.30		1.12	.97		.58	12.70	45.20	15

PINE PLOT 6

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt	Skewness	S.E.	Skew	Minimum	Maximum	N
PC	17.23	23.06	.94		.29	1.36		.14	0.0	90.00	289
PN	1.11	4.43	58.57		.29	6.56		.14	0.0	50.00	289
NL	12.65	2.79	.83		.29	-.23		.14	3.00	22.00	289
PR	75.22	32.29	-.58		.29	-.99		.14	10.00	100.00	289
O1	13.98	9.34	1.84		.29	.88		.14	0.0	60.00	289
WH	4.13	.85	-.04		.57	.19		.29	2.00	6.00	70
DN	8.07	2.69	.41		1.12	.63		.58	4.00	14.00	15
CR	.27	.80	11.39		1.12	3.33		.58	0.0	3.00	15
BC	3.47	3.07	-1.59		1.12	.48		.58	0.0	8.00	15
DIA	28.41	11.31	-1.39		1.12	-.10		.58	11.90	45.40	15

PINE PLOT 7

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt	Skewness	S.E.	Skew	Minimum	Maximum	N
PC	11.27	10.86	3.15		.33	1.49		.16	0.0	60.00	220
PN	.32	3.08	134.52		.33	11.20		.16	0.0	40.00	220
NL	14.15	2.81	1.22		.33	-.47		.16	3.00	22.00	220
PR	79.36	28.98	.46		.33	-1.32		.16	10.00	100.00	220
O1	16.73	11.91	4.22		.33	1.33		.16	0.0	70.00	220
UH	3.55	.64	-.41		.60	.76		.30	3.00	5.00	62
DN	5.87	2.03	-.96		1.12	-.03		.58	3.00	9.00	15
CR	0.0	0.0							0.0	0.0	15
BC	1.00	1.46	.68		1.12	1.42		.58	0.0	4.00	15
DIA	18.37	4.14	-.82		1.12	.45		.58	13.00	25.70	15

PINE PLOT 8

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt	Skewness	S.E.	Skew	Minimum	Maximum	N
PC	7.54	10.26	12.26		.28	2.79		.14	0.0	80.00	308
PN	.03	.57	308.00		.28	17.55		.14	0.0	10.00	308
NL	15.39	3.23	.95		.28	-.33		.14	3.00	28.00	308
PR	74.22	32.24	-.60		.28	-.97		.14	10.00	100.00	308
O1	13.70	7.74	-.17		.28	.06		.14	0.0	40.00	308
UH	4.28	1.10	-.47		.56	.33		.28	2.00	7.00	72
DN	6.33	1.72	.12		1.12	.67		.58	4.00	10.00	15
CR	.27	.80	11.39		1.12	3.33		.58	0.0	3.00	15
BC	.60	.63	-.38		1.12	.55		.58	0.0	2.00	15
DIA	23.01	5.10	.86		1.12	-.01		.58	12.40	33.50	15

PINE PLOT 9

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt Skewness	S.E. Skew	Minimum	Maximum	N
PC	10.08	10.29	1.50	.31	1.19	.15	0.0	50.00	250
PN	.56	3.18	97.21	.31	8.76	.15	0.0	40.00	250
NL	15.88	2.80	1.30	.31	-.10	.15	3.00	24.00	250
PR	77.84	31.06	-.05	.31	-1.22	.15	10.00	100.00	250
O1	14.24	10.36	1.87	.31	1.00	.15	0.0	60.00	250
WH	3.79	.97	-.18	.58	.23	.29	2.00	6.00	66
DN	5.73	1.71	-.97	1.12	.58	.58	4.00	9.00	15
CR	0.0	0.0	.	.	.	.	0.0	0.0	15
BC	.67	1.11	5.44	1.12	2.21	.58	0.0	4.00	15
DIA	21.09	5.74	-.53	1.12	.04	.58	11.20	32.00	15

PINE PLOT 10

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt Skewness	S.E. Skew	Minimum	Maximum	N
PC	10.70	13.54	2.17	.29	1.53	.14	0.0	70.00	287
PN	.17	1.31	53.36	.29	7.42	.14	0.0	10.00	287
NL	15.71	2.76	1.46	.29	-.51	.14	3.00	24.00	287
PR	78.95	29.39	.31	.29	-1.31	.14	10.00	100.00	287
O1	15.61	11.01	.32	.29	.71	.14	0.0	50.00	287
WH	4.42	.66	-.35	.59	-.35	.30	3.00	6.00	65
DN	7.27	1.83	2.07	1.12	1.00	.58	5.00	12.00	15
CR	.40	.63	1.26	1.12	1.41	.58	0.0	2.00	15
BC	.53	.92	2.90	1.12	1.82	.58	0.0	3.00	15
DIA	26.77	15.89	-.10	1.12	1.16	.58	11.70	59.20	15

PINE PLOT 11

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt	Skewness	S.E.	Skew	Minimum	Maximum	N
PC	7.29	8.91	2.48		.29	1.42		.15	0.0	50.00	280
PN	0.0	0.0							0.0	0.0	280
NL	15.75	2.54	1.42		.29	-.62		.15	4.00	23.00	280
PR	78.43	29.58	.14		.29	-1.23		.15	10.00	100.00	280
O1	13.82	9.28	-.54		.29	.23		.15	0.0	40.00	280
WH	3.78	.93	-.32		.55	.13		.28	2.00	6.00	74
DN	8.00	1.46	.97		1.12	-.32		.58	5.00	11.00	15
CR	1.20	1.52	2.04		1.12	1.58		.58	0.0	5.00	15
BC	.87	1.41	1.82		1.12	1.69		.58	0.0	4.00	15
DIA	32.70	7.95	.39		1.12	-.62		.58	15.50	46.40	15

PINE PLOT 12

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt	Skewness	S.E.	Skew	Minimum	Maximum	N
PC	9.41	13.84	4.16		.29	1.93		.14	0.0	70.00	287
PN	.10	1.02	92.30		.29	9.68		.14	0.0	10.00	287
NL	15.83	2.38	-.12		.29	.25		.14	10.00	23.00	287
PR	80.63	28.96	.41		.29	-1.36		.14	10.00	100.00	287
O1	19.90	10.69	-.05		.29	.63		.14	0.0	60.00	287
WH	3.88	.88	.08		.55	.62		.28	2.00	6.00	74
DN	8.60	3.58	1.10		1.12	1.27		.58	5.00	17.00	15
CR	2.33	2.72	3.84		1.12	1.84		.58	0.0	10.00	15
BC	1.13	1.68	.59		1.12	1.31		.58	0.0	5.00	15
DIA	36.02	11.73	.44		1.12	.70		.58	17.50	62.20	15

PINE PLOT 13

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt	Skewness	S.E.	Skew	Minimum	Maximum	N
PC	6.92	8.92	9.17		.29	2.17		.14	0.0	70.00	286
PN	.07	.83	140.47		.29	11.89		.14	0.0	10.00	286
NL	14.33	2.82	-.32		.29	.05		.14	7.00	22.00	286
PR	80.42	27.27	.58		.29	-1.36		.14	10.00	100.00	286
O1	17.13	9.71	.15		.29	.51		.14	0.0	50.00	286
WH	4.03	.81	.21		.56	.28		.28	2.00	6.00	71
DN	9.27	2.79	-.56		1.12	.50		.58	6.00	15.00	15
CR	1.40	2.85	6.17		1.12	2.53		.58	0.0	10.00	15
BC	.60	1.06	2.23		1.12	1.80		.58	0.0	3.00	15
DIA	32.86	17.40	-1.51		1.12	-.20		.58	8.60	57.10	15

PINE PLOT 14

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt	Skewness	S.E.	Skew	Minimum	Maximum	N
PC	5.56	9.16	6.51		.29	2.23		.15	0.0	60.00	275
PN	.98	6.35	102.25		.29	9.41		.15	0.0	80.00	275
NL	18.22	2.92	.70		.29	-.49		.15	7.00	26.00	275
PR	80.76	26.22	.81		.29	-1.37		.15	10.00	100.00	275
O1	16.11	11.10	1.93		.29	1.01		.15	0.0	70.00	275
WH	4.17	.74	-.16		.58	.20		.29	3.00	6.00	66
DN	7.73	2.09	-.69		1.12	.03		.58	4.00	11.00	15
CR	.73	1.39	3.08		1.12	2.03		.58	0.0	4.00	15
BC	.80	1.26	1.98		1.12	1.65		.58	0.0	4.00	15
DIA	30.49	13.90	-1.21		1.12	.17		.58	12.70	55.10	15

PINE PLOT 15

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt	Skewness	S.E.	Skew	Minimum	Maximum	N
PC	12.91	17.07	2.58		.29	1.67		.14	0.0	80.00	289
PN	1.56	8.04	86.47		.29	8.36		.14	0.0	100.00	289
NL	13.37	2.34	.71		.29	-.51		.14	4.00	19.00	289
PR	81.21	28.79	.63		.29	-1.43		.14	10.00	100.00	289
O1	15.81	9.69	-.23		.29	.32		.14	0.0	40.00	289
UH	3.91	.88	-.14		.55	.31		.28	2.00	6.00	74
DN	10.80	2.68	-1.44		1.12	.04		.58	7.00	15.00	15
CR	.60	1.30	2.89		1.12	2.01		.58	0.0	4.00	15
BC	.13	.35	4.35		1.12	2.40		.58	0.0	1.00	15
DIA	15.32	5.04	-.10		1.12	1.04		.58	10.20	25.10	15

OAK DATA SET

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt	Skewness	S.E.	Skew	Minimum	Maximum	N
PC	.81	3.74	116.89		.15	8.41		.07	0.0	70.00	1100
PN	.07	1.35	713.97		.15	25.20		.07	0.0	40.00	1100
O1	7.15	8.37	8.71		.15	2.02		.07	0.0	80.00	1100
DIA	22.29	8.82	-.80		.69	.23		.35	9.20	40.60	45
HI	9.23	3.28	-.64		.69	.01		.35	3.00	16.20	45
LL	8.69	2.02	-.20		.15	.18		.07	3.00	16.00	1100
CD	9.29	2.85	-.62		.69	-.40		.35	3.00	15.00	45
AN	1.22	1.74	1.92		.69	1.58		.35	0.0	7.00	45
BC	3.73	2.52	-.80		.69	.51		.35	0.0	9.00	45
SP	18.33	10.02	.		.	-1.43		1.22	7.00	26.00	3
APT	274.67	49.65	.		.	1.21		1.22	234.00	330.00	3
ALT	8070.00	43.59	.		.	-1.63		1.22	8020.00	8100.00	3

OAK PLOT 1

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt	Skewness	S.E.	Skew	Minimum	Maximum	N
PC	.56	2.63	28.18		.25	5.13		.13	0.0	20.00	375
PN	0.0	0.0	.		.	.		.	0.0	0.0	375
O1	3.84	6.60	9.05		.25	2.37		.13	0.0	50.00	375
DIA	19.65	11.15	-1.18		1.12	.67		.58	9.20	40.60	15
HI	8.39	2.24	.25		1.12	-.45		.58	3.40	11.90	15
LL	8.50	2.06	-.32		.25	.12		.13	3.00	15.00	375
CD	10.27	3.03	.46		1.12	-.93		.58	4.00	15.00	15
AN	0.0	0.0	.		.	.		.	0.0	0.0	15
BC	2.80	2.21	-1.39		1.12	.43		.58	0.0	6.00	15

OAK PLOT 2

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt Skewness	S.E.	Skew	Minimum	Maximum	N
PC	.99	3.78	20.42		.25	4.33	.13	0.0	30.00	375
PN	.21	2.30	242.72		.25	14.69	.13	0.0	40.00	375
O1	8.32	8.87	12.53		.25	2.30	.13	0.0	80.00	375
DIA	22.84	8.42	.01		1.12	.65	.58	11.40	40.60	15
HI	7.85	3.46	-.31		1.12	.42	.58	3.00	14.00	15
LL	8.40	2.10	.14		.25	.48	.13	4.00	16.00	375
CD	10.00	1.85	.04		1.12	-.47	.58	6.00	13.00	15
AN	1.33	1.40	-.16		1.12	.94	.58	0.0	4.00	15
BC	4.60	2.23	-1.70		1.12	.14	.58	2.00	8.00	15

CAK PLOT 3

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt Skewness	S.E.	Skew	Minimum	Maximum	N
PC	.89	4.61	146.52		.26	10.54	.13	0.0	70.00	350
PN	0.0	0.0						0.0	0.0	350
O1	9.43	8.44	5.16		.26	1.66	.13	0.0	50.00	350
DIA	24.38	6.08	.06		1.12	-.14	.58	12.70	36.30	15
HI	11.44	2.95	-.39		1.12	-.59	.58	5.80	16.20	15
LL	9.22	1.80	-.26		.26	.10	.13	4.00	14.00	350
CD	7.60	2.87	-.54		1.12	.40	.58	3.00	13.00	15
AN	2.33	2.16	-.28		1.12	.83	.58	0.0	7.00	15
BC	3.80	2.88	-.40		1.12	.89	.58	0.0	9.00	15

ASPEN DATA SET

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt	Skewness	S.E.	Skew	Minimum	Maximum	N
PC	0.0	0.0	.	.	.	.	.	.	0.0	0.0	735
PN	0.0	0.0	.	.	.	.	.	.	0.0	0.0	735
O1	32.94	23.57	-.65	.	.18	.59	.	.09	0.0	90.00	735
DIA	11.26	2.53	-.98	.	.83	.37	.	.43	7.60	16.00	30
HI	12.36	3.60	-.67	.	.83	.16	.	.43	6.10	19.50	30
LL	4.09	.93	2.41	.	.18	.52	.	.09	1.00	8.20	735
DN	7.43	1.85	-.10	.	.83	.43	.	.43	4.00	12.00	30
SD	0.0	0.0	.	.	.	.	.	.	0.0	0.0	30
BC	1.27	1.48	2.14	.	.83	1.41	.	.43	0.0	6.00	30
SP	14.00	11.31	.	.	.	.	.	.	6.00	22.00	2
APT	206.00	149.91	.	.	.	.	.	.	100.00	312.00	2
ALT	7730.00	494.97	.	.	.	.	.	.	7380.00	8080.00	2

ASPEN PLOT 1

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt	Skewness	S.E.	Skew	Minimum	Maximum	N
PC	0.0	0.0	.	.	.	.	.	.	0.0	0.0	360
PN	0.0	0.0	.	.	.	.	.	.	0.0	0.0	360
O1	16.83	14.39	5.03	.26	1.12	1.85	.13	.13	0.0	90.00	360
DIA	10.35	2.86	-.22	1.12	1.07	1.07	.58	.58	7.60	16.00	15
HI	10.04	3.04	2.85	1.12	1.33	1.33	.58	.58	6.10	18.30	15
LL	3.88	.99	4.64	.26	1.12	1.16	.13	.13	1.00	8.20	360
DN	7.60	2.03	-.13	1.12	.69	.69	.58	.58	5.00	12.00	15
SD	0.0	0.0	.	.	.	.	.	.	0.0	0.0	15
BC	2.13	1.55	1.31	1.12	1.07	1.07	.58	.58	0.0	6.00	15

ASPEN PLOT 2

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt	Skewness	S.E.	Skew	Minimum	Maximum	N
PC	0.0	0.0	.	.	.	.	.	.	0.0	0.0	375
PN	0.0	0.0	.	.	.	.	.	.	0.0	0.0	375
O1	48.40	20.04	-.82	.25	1.12	.15	.13	.13	10.00	90.00	375
DIA	12.17	1.82	-1.28	1.12	.60	.60	.58	.58	10.10	15.20	15
HI	14.67	2.48	.27	1.12	.27	.27	.58	.58	10.70	19.50	15
LL	4.28	.84	.46	.25	1.12	.25	.13	.13	2.00	7.00	375
DN	7.27	1.71	-.30	1.12	1.12	-.08	.58	.58	4.00	10.00	15
SD	0.0	0.0	.	.	.	.	.	.	0.0	0.0	15
BC	.40	.74	1.32	1.12	1.63	1.63	.58	.58	0.0	2.00	15

SYCAMORE DATA SET

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt	Skewness	S.E.	Skew	Minimum	Maximum	N
PC	0.0	0.0	.	.	.	.	.	.	0.0	0.0	750
PN	0.0	0.0	.	.	.	.	.	.	0.0	0.0	750
O1	40.36	24.28	-.89	.18	.83	.38	.09	.43	0.0	90.00	750
DIA	30.56	19.63	2.05	.83	.83	1.23	.43	.43	7.10	92.40	30
HI	10.28	2.86	-.28	.18	.83	-.25	.09	.43	3.90	15.20	30
LL	13.39	4.73	-1.00	.18	.83	-.35	.43	.43	3.00	23.00	750
DN	10.10	3.10	1.99	.83	.83	1.06	.43	.43	6.00	20.00	30
SD	3.77	2.76	-1.23	.83	.83	-.08	.43	.43	0.0	9.00	30
BC	2.50	2.13	.47	.83	.83	1.01	.43	.43	0.0	8.00	30
APT	195.00	21.21	.	.	.	.	.	.	180.00	210.00	2
SP	4.00	1.41	.	.	.	.	.	.	3.00	5.00	2
ALT	4330.00	1371.79	.	.	.	.	.	.	3360.00	5300.00	2

SYCAMORE PLOT 1

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt	Skewness	S.E.	Skew	Minimum	Maximum	N
PC	0.0	0.0	.	.	.	.	.	.	0.0	0.0	375
PN	0.0	0.0	.	.	.	.	.	.	0.0	0.0	375
O1	46.21	26.11	-1.10	.	.25	.02	.	.13	0.0	90.00	375
DIA	27.08	15.91	-1.52	.	1.12	.34	.	.58	7.60	51.10	15
HI	10.25	3.15	-.19	.	1.12	-.13	.	.58	3.90	15.20	15
LL	13.13	4.66	-.98	.	.25	-.20	.	.13	3.00	23.00	375
DN	9.73	2.60	-1.48	.	1.12	.06	.	.58	6.00	14.00	15
SD	2.73	2.76	-1.55	.	1.12	.34	.	.58	0.0	7.00	15
BC	3.13	2.39	-.07	.	1.12	.69	.	.58	0.0	8.00	15

SYCAMORE PLOT 2

Variable	Mean	Std Dev	Kurtosis	S.E.	Kurt	Skewness	S.E.	Skew	Minimum	Maximum	N
PC	0.0	0.0	.	.	.	.	.	.	0.0	0.0	375
PN	0.0	0.0	.	.	.	.	.	.	0.0	0.0	375
O1	34.51	20.73	-.36	.	.25	.69	.	.13	0.0	90.00	375
DIA	34.04	22.78	2.05	.	1.12	1.37	.	.58	7.10	92.40	15
HI	10.31	2.64	-.17	.	1.12	-.48	.	.58	4.90	14.00	15
LL	13.65	4.79	-.97	.	.25	-.49	.	.13	3.00	22.00	375
DN	10.47	3.58	2.46	.	1.12	1.34	.	.58	6.00	20.00	15
SD	4.80	2.43	-.40	.	1.12	-.32	.	.58	0.0	9.00	15
BC	1.87	1.68	1.19	.	1.12	1.27	.	.58	0.0	6.00	15

WALNUT DATA SET

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SPSS/PC Release 1.10

3/1/85

Number of Valid Observations (Listwise) = 15.00

Variable PC

Mean	4.933	Std Dev	8.106
Kurtosis	24.862	S.E. Kurt	.251
Skewness	3.656	S.E. Skew	.126
Minimum	0.0	Maximum	80.000

Valid Observations - 375 Missing Observations - 0

Variable PN

Mean	.027	Std Dev	.516
Kurtosis	375.000	S.E. Kurt	.251
Skewness	19.365	S.E. Skew	.126
Minimum	0.0	Maximum	10.000

Valid Observations - 375 Missing Observations - 0

Number of Valid Observations (Listwise) = 15.00

Variable LL

Mean	8.075	Std Dev	1.838
Kurtosis	-.208	S.E. Kurt	.251
Skewness	.165	S.E. Skew	.126
Minimum	4.000	Maximum	13.000

Valid Observations - 375 Missing Observations - 0

Variable 01

Mean	11.173	Std Dev	9.958
Kurtosis	18.889	S.E. Kurt	.251
Skewness	3.063	S.E. Skew	.126
Minimum	0.0	Maximum	90.000

Valid Observations - 375 Missing Observations - 0

Number of Valid Observations (Listwise) = 15.00

Variable DN

Mean	6.000	Std Dev	2.104
Kurtosis	.747	S.E. Kurt	1.121
Skewness	.531	S.E. Skew	.580
Minimum	2.000	Maximum	10.000

Valid Observations - 15 Missing Observations - 360

Variable CR

Mean	0.0	Std Dev	0.0
Kurtosis	.	S.E. Kurt	.
Skewness	.	S.E. Skew	.
Minimum	0.0	Maximum	0.0

Valid Observations - 15 Missing Observations - 360

Number of Valid Observations (Listwise) = 15.00

Variable BC

Mean	4.933	Std Dev	2.120
Kurtosis	-.730	S.E. Kurt	1.121
Skewness	-.211	S.E. Skew	.580
Minimum	1.000	Maximum	8.000

Valid Observations - 15 Missing Observations - 360

Variable DIA

Mean	15.880	Std Dev	4.212
Kurtosis	-.687	S.E. Kurt	1.121
Skewness	.289	S.E. Skew	.580
Minimum	9.400	Maximum	23.900

Valid Observations - 15 Missing Observations - 360

Number of Valid Observations (Listwise) = 15.00

Variable HI

Mean	6.127	Std Dev	2.089
Kurtosis	-1.067	S.E. Kurt	1.121
Skewness	.528	S.E. Skew	.580
Minimum	3.400	Maximum	9.800

Valid Observations -	15	Missing Observations -	360
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APPENDIX B
ANALYSIS OF VARIANCE

NESTED ANALYSIS OF VARIANCE PINE DATA PAGE 1

SAS

COEFFICIENTS OF EXPECTED MEAN SQUARES

SOURCE	PT ERROR	TN	WN
PT	276.56562 1.00000	19.26589	4.43127
TN	0.0 1.00000	18.39865	4.33928
WN	0.0 1.00000	0.0	3.95425
ERROR	0.0 1.00000	0.0	0.0

SAS

ANALYSIS OF VARIABLE CHL

VARIANCE SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	VARIANCE COMPONENT	PERCENT
TOTAL	4152	37.97884	0.00915	0.01048	100.00
PT	14	2.36749	0.16911	0.00057	5.43
TN	210	2.52749	0.01204	-0.00129	0.0
WN	803	26.34769	0.03281	0.00775	73.99
ERROR	3125	6.73617	0.00216	0.00216	20.57
MEAN			0.779206		
STANDARD DEVIATION			0.046428		
COEFFICIENT OF VARIATION			5.958399		

ANALYSIS OF VARIABLE NEC

VARIANCE SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	VARIANCE COMPONENT	PERCENT
TOTAL	4152	4.42322	0.00107	0.00112	100.00
PT	14	0.15742	0.01124	0.00003	2.98
TN	210	0.41428	0.00197	-0.00006	0.0
WN	803	2.23807	0.00279	0.00057	51.09
ERROR	3125	1.61345	0.00052	0.00052	45.93
MEAN			0.712361		
STANDARD DEVIATION			0.022722		
COEFFICIENT OF VARIATION			3.189721		

ANALYSIS OF VARIABLE RET

VARIANCE SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	VARIANCE COMPONENT	PERCENT
TOTAL	4152	108.15796	0.02605	0.03075	100.00
PT	14	0.97742	0.06982	0.00017	0.57
TN	210	4.95653	0.02360	-0.00469	0.0
WN	803	80.96263	0.10083	0.02378	77.31
ERROR	3125	21.26138	0.00680	0.00680	22.12
MEAN			0.832266		
STANDARD DEVIATION			0.082484		
COEFFICIENT OF VARIATION			9.910802		

SAS

ANALYSIS OF VARIABLE NL

VARIANCE SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	VARIANCE COMPONENT	PERCENT
TOTAL	4152	40595.37684	9.77731	9.96537	100.00
PT	14	10895.50278	778.25020	2.61300	26.22
TN	210	11207.63042	53.36967	2.43810	24.47
WN	803	6501.91031	8.09702	1.07735	10.81
ERROR	3125	11990.33333	3.83691	3.83691	38.50
MEAN			14.551168		
STANDARD DEVIATION			1.958802		
COEFFICIENT OF VARIATION			13.461479		

ANALYSIS OF VARIABLE INJ

VARIANCE SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	VARIANCE COMPONENT	PERCENT
TOTAL	4152	17.83884	0.00430	0.00451	100.00
PT	14	0.74798	0.05343	0.00016	3.59
TN	210	1.80402	0.00859	-0.00020	0.0
WN	803	9.18373	0.01144	0.00240	53.14
ERROR	3125	6.10310	0.00195	0.00195	43.27
MEAN			0.809107		
STANDARD DEVIATION			0.044193		
COEFFICIENT OF VARIATION			5.461906		

CREATION OF BRANCH DATA SET AND NESTED AOV PINE DATA

SAS

VARIABLE	N	MEAN	STD DEV	SUM	MINIMUM	MAXIMUM
BCHL	1039	0.77737	0.043299	807.69	0.70711	1.11030
BNEC	1039	0.71192	0.015829	739.68	0.70711	0.87965
BNL	1039	14.48817	2.606150	15053.20	7.00000	23.50000
BINJ	1039	0.80698	0.034412	838.46	0.72960	0.99760
BRET	1039	0.82514	0.060543	857.32	0.70711	1.06840
NW	1039	3.99711	0.895822	4153.00	2.00000	7.00000

SAS

COEFFICIENTS OF EXPECTED MEAN SQUARES

SOURCE	PT	TN	ERROR
PT	69.24625	4.71082	1.00000
TN	0.0	4.61106	1.00000
ERROR	0.0	0.0	1.00000

SAS

ANALYSIS OF VARIABLE NW

VARIANCE SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	VARIANCE COMPONENT	PERCENT
TOTAL	1038	832.99134	0.80250	0.81070	100.00
PT	14	129.97185	9.28370	0.10737	13.24
TN	210	381.76949	1.81795	0.30867	38.07
ERROR	814	321.25000	0.39466	0.39466	48.68
MEAN			3.997113		
STANDARD DEVIATION			0.628217		
COEFFICIENT OF VARIATION			15.716759		

SAS

VARIABLE	N	MEAN	STD DEV	SUM	MINIMUM	MAXIMUM
TCHL	225	0.77880	0.03443	175.229	0.71489	0.89561
TNEC	225	0.71221	0.01128	160.247	0.70711	0.77313
TNL	225	14.50947	2.39091	3264.632	9.00000	22.17647
TINJ	225	0.80779	0.02548	181.752	0.74760	0.88594
TRET	225	0.82852	0.03743	186.418	0.71836	0.96824
TNW	225	4.06115	0.71577	913.759	2.33333	6.29032
BI	225	1.41333	2.04913	318.000	0	8.00000
CC	225	0.60000	1.44852	135.000	0	10.00000
CD	225	7.92444	2.98636	1783.000	3.00000	17.00000
DBH	225	26.89733	11.69392	6051.900	8.60000	62.20000

SAS

ANALYSIS OF VARIANCE PROCEDURE

CLASS LEVEL INFORMATION

CLASS	LEVELS	VALUES
PT	15	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

NUMBER OF OBSERVATIONS IN DATA SET = 225

13:14 THURSDAY, FEBRUARY 28, 1985 2

SAS
ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: BI

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	14	385.89333333	27.56380952	10.44	0.0001	0.410280	114.9905
ERROR	210	554.66666667	2.64126984		ROOT MSE		BI MEAN
CORRECTED TOTAL	224	940.56000000			1.62519040		1.41333333

SOURCE	DF	ANCOVA SS	F VALUE	PR > F
PT	14	385.89333333	10.44	0.0001

DEPENDENT VARIABLE: CD

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	14	608.78222222	43.48444444	6.57	0.0001	0.304739	32.4536
ERROR	210	1388.93333333	6.61396825		ROOT MSE		CD MEAN
CORRECTED TOTAL	224	1997.71555556			2.57176365		7.92444444

SOURCE	DF	ANCOVA SS	F VALUE	PR > F
PT	14	608.78222222	6.57	0.0001

DEPENDENT VARIABLE: CC

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	14	102.53333333	7.32380952	4.19	0.0001	0.218156	220.4693
ERROR	210	367.46666667	1.74984127		ROOT MSE		CC MEAN
CORRECTED TOTAL	224	470.00000000			1.32281566		0.60000000

SOURCE	DF	ANCOVA SS	F VALUE	PR > F
PT	14	102.53333333	4.19	0.0001

SAS

COEFFICIENTS OF EXPECTED MEAN SQUARES

SOURCE	PT ERROR	TN	BN
PT	366.47727 1.00000	24.61039	5.00000
TN	0.0 1.00000	24.43197	5.00000
BN	0.0 1.00000	0.0	5.00000
ERROR	0.0 1.00000	0.0	0.0

ANALYSIS OF VARIABLE INJ

VARIANCE SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	VARIANCE COMPONENT	PERCENT
TOTAL	1099	3.03735	0.00276	0.00289	100.00
PT	2	0.27507	0.13753	0.00036	12.31
TN	42	0.30597	0.00729	0.00012	4.32
BN	175	0.74123	0.00424	0.00046	15.84
ERROR	880	1.71509	0.00195	0.00195	67.52
MEAN			0.754118		
STANDARD DEVIATION			0.044147		
COEFFICIENT OF VARIATION			5.854132		

SAS

ANALYSIS OF VARIABLE CHL

VARIANCE SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	VARIANCE COMPONENT	PERCENT
TOTAL	1099	0.60679	0.00055	0.00055	100.00
PT	2	0.153062D-02	0.765312D-03	0.194790D-05	0.0
TN	42	0.06195	0.00147	0.00002	4.29
BN	175	0.15651	0.00089	0.00009	16.41
ERROR	880	0.38681	0.00044	0.00044	79.30
MEAN			0.712418		
STANDARD DEVIATION			0.020966		
COEFFICIENT OF VARIATION			2.942882		

ANALYSIS OF VARIABLE NEC

VARIANCE SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	VARIANCE COMPONENT	PERCENT
TOTAL	1099	0.60679	0.00055	0.00055	100.00
PT	2	0.153062D-02	0.765312D-03	0.194790D-05	0.0
TN	42	0.06195	0.00147	0.00002	4.29
BN	175	0.15651	0.00089	0.00009	16.41
ERROR	880	0.38681	0.00044	0.00044	79.30
MEAN			0.712418		
STANDARD DEVIATION			0.020966		
COEFFICIENT OF VARIATION			2.942882		

ANALYSIS OF VARIABLE NL

VARIANCE SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	VARIANCE COMPONENT	PERCENT
TOTAL	1099	4503.75545	4.09805	4.16058	100.00
PT	2	145.59698	72.79849	0.11017	2.65
TN	42	1354.11514	32.24084	1.02781	24.70
BN	175	1247.64333	7.12939	1.02670	24.68
ERROR	880	1756.40000	1.99591	1.99591	47.97
MEAN			8.693636		
STANDARD DEVIATION			1.412766		
COEFFICIENT OF VARIATION			16.250582		

SAS VARIABLE	N	MEAN	STD DEV	SUM	MINIMUM	MAXIMUM
TCHL	45	0.71246	0.007660	32.061	0.70711	0.74343
TNEC	45	0.71246	0.007660	32.061	0.70711	0.74343
TNL	45	8.72393	1.185213	392.577	6.76000	11.64000
TINJ	45	0.75445	0.023098	33.950	0.71521	0.81597
BI	45	3.73333	2.517213	168.000	0	9.00000
FC	45	1.22222	1.743675	55.000	0	7.00000
CD	45	9.28889	2.849420	418.000	3.00000	15.00000
DBH	45	22.28889	8.824945	1003.000	9.20000	40.60000
HT	45	9.22667	3.276667	415.200	3.00000	16.20000

SAS

ANALYSIS OF VARIANCE PROCEDURE

CLASS LEVEL INFORMATION

CLASS	LEVELS	VALUES
PT	3	1 2 3

NUMBER OF OBSERVATIONS IN DATA SET = 45

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SAS

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: B1

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	2	24.40000000	12.20000000	2.01	0.1461	0.087518	65.9230
ERROR	42	254.40000000	6.05714286		ROOT MSE		B1 MEAN
CORRECTED TOTAL	44	278.80000000			2.46112634		3.73333333

SOURCE	DF	ANOVA SS	F VALUE	PR > F
PT	2	24.40000000	2.01	0.1461

DEPENDENT VARIABLE: CU

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	2	64.71111111	32.35555556	4.65	0.0150	0.181140	28.4118
ERROR	42	292.53333333	6.96507937		ROOT MSE		CD MEAN
CORRECTED TOTAL	44	357.24444444			2.63914368		9.28888889

SOURCE	DF	ANOVA SS	F VALUE	PR > F
PT	2	64.71111111	4.65	0.0150

DEPENDENT VARIABLE: FC

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	2	41.11111111	20.55555556	9.32	0.0004	0.307309	121.5310
ERROR	42	92.66666667	2.20634921		ROOT MSE		FC MEAN
CORRECTED TOTAL	44	133.77777778			1.48537847		1.22222222

SOURCE	DF	ANOVA SS	F VALUE	PR > F
PT	2	41.11111111	9.32	0.0004

SAS

COEFFICIENTS OF EXPECTED MEAN SQUARES

SOURCE	PT ERROR	TN	BN
PT	367.34694 1.00000	24.64569	5.00000
TN	0.0 1.00000	24.48909	5.00000
BN	0.0 1.00000	0.0	5.00000
ERROR	0.0 1.00000	0.0	0.0

ANALYSIS OF VARIABLE NL

VARIANCE SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	VARIANCE COMPONENT	PERCENT
TOTAL	734	640.40566	0.87249	0.91054	100.00
PT	1	28.81910	28.81910	0.06332	6.95
TN	28	154.95882	5.53424	0.15953	17.52
BN	117	190.41973	1.62752	0.23496	25.80
ERROR	588	266.20800	0.45273	0.45273	49.72
MEAN			4.085986		
STANDARD DEVIATION			0.672856		
COEFFICIENT OF VARIATION			16.467398		

SAS

ANALYSIS OF VARIABLE INJ

VARIANCE SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	VARIANCE COMPONENT	PERCENT
TOTAL	734	11.81284	0.01609	0.02359	100.00
PT	1	5.52242	5.52242	0.01490	63.15
TN	28	1.38169	0.04935	0.00146	6.20
BN	117	1.58475	0.01354	0.00158	6.69
ERROR	588	3.32398	0.00565	0.00565	23.96
MEAN			0.901840		
STANDARD DEVIATION			0.075187		
COEFFICIENT OF VARIATION			8.337025		

SAS

VARIABLE	N	MEAN	STD DEV	SUM	MINIMUM	MAXIMUM
TCHL	30	0.70711	0	21.2132	0.70711	0.70711
TNEC	30	0.70711	0	21.2132	0.70711	0.70711
TNL	30	4.09649	0.509122	122.8947	3.08000	4.96800
TINJ	30	0.89973	0.098740	26.9919	0.76088	1.12492
BI	30	1.26667	1.484014	38.0000	0	6.00000
FC	30	0	0	0	0	0
CD	30	7.43333	1.851064	223.0000	4.00000	12.00000
DBH	30	11.26000	2.530722	337.8000	7.60000	16.00000
HT	30	12.35667	3.604851	370.7000	6.10000	19.50000

SAS

ANALYSIS OF VARIANCE PROCEDURE

CLASS LEVEL INFORMATION

CLASS	LEVELS	VALUES
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PT	2	1 2
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NUMBER OF OBSERVATIONS IN DATA SET = 30

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SAS

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: CD

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	1	0.83333333	0.83333333	0.24	0.6303	0.008386	25.2365
ERROR	28	98.53333333	3.51904762		ROOT MSE		CD MEAN
CORRECTED TOTAL	29	99.36666667			1.87591248		7.43333333

SOURCE	DF	ANCVA SS	F VALUE	PR > F
PT	1	0.83333333	0.24	0.6303

DEPENDENT VARIABLE: FC

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	1	0	0	99999.99	0.0000	0.000000	99999.9999
ERROR	28	0	0		ROOT MSE		FC MEAN
CORRECTED TOTAL	29	0			0		0

SOURCE	DF	ANCVA SS	F VALUE	PR > F
PT	1	0	.	.

DEPENDENT VARIABLE: BI

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	1	22.53333333	22.53333333	15.26	0.0005	0.352818	95.9199
ERROR	28	41.33333333	1.47619048		ROOT MSE		BI MEAN
CORRECTED TOTAL	29	63.86666667			1.21498579		1.26666667

SOURCE	DF	ANCVA SS	F VALUE	PR > F
PT	1	22.53333333	15.26	0.0005

SAS

COEFFICIENTS OF EXPECTED MEAN SQUARES

SOURCE	PT ERROR	TN	BN
PT	375.00000 1.00000	25.00000	5.00000
TN	0.0 1.00000	25.00000	5.00000
BN	0.0 1.00000	0.0	5.00000
ERROR	0.0 1.00000	0.0	0.0

ANALYSIS OF VARIABLE INJ

VARIANCE SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	VARIANCE COMPONENT	PERCENT
TOTAL	749	12.07239	0.01612	0.01696	100.00
PT	1	0.64835	0.64835	0.00153	9.04
TN	28	2.05983	0.07357	0.00203	12.00
BN	120	2.72349	0.02270	0.00233	13.71
ERROR	600	6.64071	0.01107	0.01107	65.25
MEAN			0.942074		
STANDARD DEVIATION			0.105204		
COEFFICIENT OF VARIATION			11.167263		

ANALYSIS OF VARIABLE NL

VARIANCE SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	VARIANCE COMPONENT	PERCENT
TOTAL	749	16767.86667	22.38700	22.82097	100.00
PT	1	51.22133	51.22133	-0.39552	0.0
TN	28	5587.12533	199.54019	6.37470	27.93
BN	120	4820.72000	40.17267	5.93160	25.99
ERROR	600	6308.80000	10.51467	10.51467	46.07
MEAN			13.386667		
STANDARD DEVIATION			3.242633		
COEFFICIENT OF VARIATION			24.222854		

SAS						
VARIABLE	N	MEAN	STD DEV	SUM	MINIMUM	MAXIMUM
TCHL	30	0.70711	0	21.2132	0.70711	0.70711
TNEC	30	0.70711	0	21.2132	0.70711	0.70711
TNL	30	13.38667	2.78873	401.6000	8.24000	18.20000
TINJ	30	0.94207	0.06112	28.2622	0.84602	1.07861
BI	30	2.50000	2.12943	75.0000	0	8.00000
FC	30	3.76667	2.76285	113.0000	0	9.00000
CD	30	10.10000	3.10006	303.0000	6.00000	20.00000
DBH	30	30.56000	19.62819	916.8000	7.10000	92.40000
HT	30	10.28000	2.85843	308.4000	3.90000	15.20000

SAS
ANALYSIS OF VARIANCE PROCEDURE
CLASS LEVEL INFORMATION
CLASS LEVELS VALUES
PT 2 1 2

NUMBER OF OBSERVATIONS IN DATA SET = 30

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SAS

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: B1

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	1	12.03333333	12.03333333	2.82	0.1042	0.091508	82.6236
ERROR	28	119.4666667	4.26666667		ROOT MSE		81 MEAN
CORRECTED TOTAL	29	131.5000000			2.06559112		2.50000000

SOURCE	DF	ANCVA SS	F VALUE	PR > F
PT	1	12.03333333	2.82	0.1042

DEPENDENT VARIABLE: FC

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	1	32.03333333	32.03333333	4.74	0.0381	0.144707	69.0363
ERROR	28	189.3333333	6.76190476		ROOT MSE		FC MEAN
CORRECTED TOTAL	29	221.3666667			2.60036627		3.76666667

SOURCE	DF	ANCVA SS	F VALUE	PR > F
PT	1	32.03333333	4.74	0.0381

DEPENDENT VARIABLE: CD

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	1	4.03333333	4.03333333	0.41	0.5266	0.014472	31.0101
ERROR	28	274.6666667	9.80952381		ROOT MSE		CD MEAN
CORRECTED TOTAL	29	278.7000000			3.13201593		10.10000000

SOURCE	DF	ANCVA SS	F VALUE	PR > F
PT	1	4.03333333	0.41	0.5266

SAS

COEFFICIENTS OF EXPECTED MEAN SQUARES

SOURCE	PT ERROR	TN	BN
PT	0.0 0.0	0.0	0.0
TN	0.0 1.00000	25.00000	5.00000
BN	0.0 1.00000	0.0	5.00000
ERROR	0.0 1.00000	0.0	0.0

SAS

ANALYSIS OF VARIABLE INJ

VARIANCE SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	VARIANCE COMPONENT	PERCENT
TOTAL	374	1.29473	0.00346	0.00348	100.00
PT	0 0.0	0.0	0.0		0.0
TN	14	0.16009	0.01143	0.00031	8.81
BN	60	0.22601	0.00377	0.00015	4.24
ERROR	300	0.90863	0.00303	0.00303	86.96
MEAN			0.779924		
STANDARD DEVIATION			0.055034		
COEFFICIENT OF VARIATION			7.056360		

SAS

ANALYSIS OF VARIABLE CHL

VARIANCE SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	VARIANCE COMPONENT	PERCENT
TOTAL	374	0.93363	0.00250	0.00251	100.00
PT	0 0.0	0.0	0.0		0.0
TN	14	0.11112	0.00794	0.00013	5.14
BN	60	0.28262	0.00471	0.00058	23.19
ERROR	300	0.53989	0.00180	0.00180	71.67
MEAN			0.739489		
STANDARD DEVIATION			0.042422		
COEFFICIENT OF VARIATION			5.736666		

ANALYSIS OF VARIABLE NEC

VARIANCE SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	VARIANCE COMPONENT	PERCENT
TOTAL	374	0.93363	0.00250	0.00251	100.00
PT	0 0.0	0.0	0.0		0.0
TN	14	0.11112	0.00794	0.00013	5.14
BN	60	0.28262	0.00471	0.00058	23.19
ERROR	300	0.53989	0.00180	0.00180	71.67
MEAN			0.739489		
STANDARD DEVIATION			0.042422		
COEFFICIENT OF VARIATION			5.736666		

ANALYSIS OF VARIABLE NL

VARIANCE SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	VARIANCE COMPONENT	PERCENT
TOTAL	374	1263.90933	3.37944	3.42315	100.00
PT	0 0.0	0.0	0.0		0.0
TN	14	276.78933	19.77067	0.53541	15.64
BN	60	383.12000	6.38533	0.87440	25.54
ERROR	300	604.00000	2.01333	2.01333	58.82
MEAN			8.074667		
STANDARD DEVIATION			1.418920		
COEFFICIENT OF VARIATION			17.572487		

APPENDIX C

**STUDENT-NEWMAN-KEULS TESTS
OF MEANS BY PLOT AND BY WHORL NUMBER**

GENERAL LINEAR MODELS PROCEDURE

STUDENT-NEWMAN-KEULS TEST FOR VARIABLE: CHL

NOTE: THIS TEST CONTROLS THE TYPE I EXPERIMENTWISE ERROR RATE
UNDER THE COMPLETE NULL HYPOTHESIS BUT NOT UNDER PARTIAL
NULL HYPOTHESES.

ALPHA=0.05 DF=4138 MSE=.0086059

WARNING: CELL SIZES ARE NOT EQUAL.

HARMONIC MEAN OF CELL SIZES=272.556

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

				MEAN PERCENT	
SNK	GROUPING	MEAN	N	PT	OZONE CHLOROSIS
	A	0.82912	314	5	18.7
	B	0.80958	289	6	15.5
	B				
C	B	0.80577	231	4	14.9
C	B				
C	B	0.80327	222	2	14.5
C	B				
C	B	0.78941	265	3	12.3
C	D				
C	D	0.78690	289	15	11.9
	D				
	D	0.77998	220	7	10.8
	D				
	D	0.77480	287	10	10.0
	D				
	D	0.77250	250	9	9.7
	D				
	D	0.77109	350	1	9.5
	D				
	D	0.76631	237	12	8.7
	D				
	D	0.75599	308	8	7.1
	D				
	D	0.75477	280	11	7.0
	D				
	D	0.75242	286	13	6.6
	D				
	D	0.74321	275	14	5.2

GENERAL LINEAR MODELS PROCEDURE

STUDENT-NEWMAN-KEULS TEST FOR VARIABLE: NEC

NOTE: THIS TEST CONTROLS THE TYPE I EXPERIMENTWISE ERROR RATE
UNDER THE COMPLETE NULL HYPOTHESIS BUT NOT UNDER PARTIAL
NULL HYPOTHESES.

ALPHA=0.05 DF=4138 MSE=.0010309

WARNING: CELL SIZES ARE NOT EQUAL.

HARMONIC MEAN OF CELL SIZES=272.556

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

SNK	GROUPING	MEAN	N	PT	MEAN PERCENT OZONE NECROSIS
	A	0.73018	314	5	3.3
	B	0.71714	231	4	1.4
	B	0.71709	222	2	1.4
	B	0.71660	239	15	1.4
C	B	0.71435	289	6	1.0
C	B	0.71309	275	14	0.8
C	B	0.71077	250	9	0.4
C	B	0.71011	265	3	0.4
C	B	0.70910	220	7	0.3
C	B	0.70902	350	1	0.3
C	D	0.70828	287	10	0.2
	D	0.70781	287	12	0.1
	D	0.70758	286	13	0.1
	D	0.70733	308	8	0.03
	D	0.70711	280	11	0

SAS

18:10 SATURDAY, MARCH 9, 1985

GENERAL LINEAR MODELS PROCEDURE

STUDENT-NEWMAN-KEULS TEST FOR VARIABLE: NL

NOTE: THIS TEST CONTROLS THE TYPE I EXPERIMENTWISE ERROR RATE
UNDER THE COMPLETE NULL HYPOTHESIS BUT NOT UNDER PARTIAL
NULL HYPOTHESES.

ALPHA=0.05 DF=4138 MSE=7.17735

WARNING: CELL SIZES ARE NOT EQUAL.

HARMONIC MEAN OF CELL SIZES=272.556

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

SNK	GROUPING	MEAN NEEDLE LENGTH (cm)	N	PT
	A	18.218	275	14
	B	15.880	250	9
	B			
	B	15.829	287	12
	B			
	B	15.746	280	11
	B			
	B	15.707	287	10
	B			
C	B	15.393	308	8
C				
C		15.100	350	1
	D	14.325	236	13
	D			
E	D	14.145	220	7
E				
E	F	13.752	314	5
	F			
G	F	13.370	289	15
G				
G	H	13.072	265	3
	H			
I	H	12.647	289	6
I				
I		12.365	222	2
	J	11.732	231	4

SAS

18:10 SATURDAY, MARCH 9, 1985

GENERAL LINEAR MODELS PROCEDURE

STUDENT-NEWMAN-KEULS TEST FOR VARIABLE: INJ

NOTE: THIS TEST CONTROLS THE TYPE I EXPERIMENTWISE ERROR RATE
UNDER THE COMPLETE NULL HYPOTHESIS BUT NOT UNDER PARTIAL
NULL HYPOTHESES.

ALPHA=0.05 DF=4138 MSE=.0041302

WARNING: CELL SIZES ARE NOT EQUAL.

HARMONIC MEAN OF CELL SIZES=272.556

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

SNK	GROUPING	MEAN	N	PT	MEAN PERCENT OTHER INJURY
	A	0.83367	287	12	19.5
	A				
	A	0.83268	314	5	19.3
	B	0.81906	350	1	17.1
	B				
	B	0.81725	286	13	16.8
	B				
C	B	0.81385	220	7	16.2
C	B				
C	B	0.81239	231	4	16.0
C	B				
C	B	0.81037	275	14	15.7
C	B				
C	B	0.80908	289	15	15.5
C	B				
C	B	0.80726	287	10	15.2
C	B				
C		0.79903	250	9	13.8
C					
C	D	0.79783	289	6	13.7
C	D				
C	D	0.79773	265	3	13.6
C	D				
C	D	0.79678	280	11	13.5
C	D				
C	D	0.79665	308	8	13.5
C	D				
	D	0.78302	222	2	11.3

SAS

18:10 SATURDAY, MARCH 9, 1985

GENERAL LINEAR MODELS PROCEDURE

STUDENT-NEWMAN-KEULS TEST FOR VARIABLE: RET

NOTE: THIS TEST CONTROLS THE TYPE I EXPERIMENTWISE ERROR RATE
UNDER THE COMPLETE NULL HYPOTHESIS BUT NOT UNDER PARTIAL
NULL HYPOTHESES.

ALPHA=0.05 DF=4138 MSE=.0259013

WARNING: CELL SIZES ARE NOT EQUAL.

HARMONIC MEAN OF CELL SIZES=272.556

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

SNK	GROUPING	MEAN	N	PT	MEAN PERCENT NEEDLE RETENTION
	A	0.86360	350	1	75.4
	A				
B	A	0.85305	308	8	77.2
B	A				
B	A	0.84731	314	5	78.2
B	A				
B	A	0.84697	289	6	78.3
B	A				
B	A	0.83288	231	4	80.6
B	A				
B	A	0.83281	250	9	80.6
B	A				
B	A	0.83061	230	11	81.0
B	A				
B	A	0.82771	287	10	81.5
B	A				
B	A	0.82555	220	7	81.8
B	A				
B	A	0.82171	222	2	82.5
B	A				
B	A	0.82065	286	13	82.7
B	A				
B	A	0.81945	275	14	82.9
B					
B		0.81730	287	12	83.1
B					
B		0.81445	289	15	83.7
B					
B		0.81384	265	3	83.8

SAS

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GENERAL LINEAR MODELS PROCEDURE

STUDENT-NEWMAN-KEULS TEST FOR VARIABLE: CC

NOTE: THIS TEST CONTROLS THE TYPE I EXPERIMENTWISE ERROR RATE
UNDER THE COMPLETE NULL HYPOTHESIS BUT NOT UNDER PARTIAL
NULL HYPOTHESES.

ALPHA=0.05 DF=4138 MSE=1.71401

WARNING: CELL SIZES ARE NOT EQUAL.

HARMONIC MEAN OF CELL SIZES=272.556

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

SNK	GROUPING	MEAN CONE CROP	N	PT
	A	2.2892	287	12
	B	1.4343	350	1
	B			
C	B	1.3287	286	13
C				
C		1.1107	280	11
	D	0.7600	275	14
	D			
	D	0.6644	289	15
	E	0.3693	287	10
	E			
	E	0.3312	308	8
	E			
F	E	0.2561	289	6
F	E			
F	E	0.1358	265	3
F	E			
F	E	0.1306	314	5
F	E			
F	E	0.0823	231	4
F				
F		0.0000	222	2
F				
F		0.0000	220	7
F				
F		0.0000	250	9

SAS

18:10 SATURDAY, MARCH 9, 1985

GENERAL LINEAR MODELS PROCEDURE

STUDENT-NEWMAN-KEULS TEST FOR VARIABLE: BI

NOTE: THIS TEST CONTROLS THE TYPE I EXPERIMENTWISE ERROR RATE
UNDER THE COMPLETE NULL HYPOTHESIS BUT NOT UNDER PARTIAL
NULL HYPOTHESES.

ALPHA=0.05 DF=4138 MSE=2.27066

WARNING: CELL SIZES ARE NOT EQUAL.

HARMONIC MEAN OF CELL SIZES=272.556

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

SNK	GROUPING	BOLEINJURY		
		MEAN	N	PT
	A	4.4026	231	4
	B	3.2249	289	6
	B			
	B	3.0991	222	2
	C	2.7019	265	3
	D	1.0279	287	12
	D			
	D	0.8500	220	7
	D			
	D	0.8464	280	11
	D			
	D	0.8286	350	1
	D			
	D	0.7673	275	14
	D			
	D	0.6440	250	9
	D			
	D	0.5649	308	8
	D			
	D	0.5331	287	10
	D			
	D	0.4406	286	13
	D			
	G	0.1453	289	15
	G			
	G	0.1274	314	5

SAS

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GENERAL LINEAR MODELS PROCEDURE

STUDENT-NEWMAN-KEULS TEST FOR VARIABLE: CD

NOTE: THIS TEST CONTROLS THE TYPE I EXPERIMENTWISE ERROR RATE
UNDER THE COMPLETE NULL HYPOTHESIS BUT NOT UNDER PARTIAL
NULL HYPOTHESES.

ALPHA=0.05 DF=4138 MSE=6.38797

WARNING: CELL SIZES ARE NOT EQUAL.

HARMONIC MEAN OF CELL SIZES=272.556

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

SNK	GROUPING	CROWN DENSITY		N	PT
		MEAN			
	A	11.525	314	5	
	B	10.965	289	15	
	C	9.991	350	1	
	D	9.566	286	13	
	E	8.599	287	12	
	E				
F	E	8.349	289	6	
F					
F	G	8.025	280	11	
F	G				
F	G	H	7.887	222	2
	G	H			
	G	H	7.771	275	14
		H			
		H	7.453	287	10
	I	7.023	265	3	
	J	6.532	308	8	
	J				
K	J	6.259	220	7	
K					
K		5.964	250	9	
K					
K		5.896	231	4	

SAS

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GENERAL LINEAR MODELS PROCEDURE

STUDENT-NEWMAN-KEULS TEST FOR VARIABLE: CHL

NOTE: THIS TEST CONTROLS THE TYPE I EXPERIMENTWISE ERROR RATE
UNDER THE COMPLETE NULL HYPOTHESIS BUT NOT UNDER PARTIAL
NULL HYPOTHESES.

ALPHA=0.05 DF=4146 MSE=0.0049

WARNING: CELL SIZES ARE NOT EQUAL.

HARMONIC MEAN OF CELL SIZES=36.9805

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

SNK	GROUPING	MEAN	N	WN	MEAN PERCENT OZONE CHLOROSIS
	A	0.87545	731	4	26.6
	A				
	A	0.87132	260	5	25.9
	B	0.82392	69	6	17.9
	B				
	B	0.80678	1017	3	15.1
	C	0.75862	6	7	7.6
	C				
D	C	0.72816	1039	2	3.0
D					
D		0.70911	1031	1	0.3

SAS

18:10 SATURDAY, MARCH 9, 1985

GENERAL LINEAR MODELS PROCEDURE

STUDENT-NEWMAN-KEULS TEST FOR VARIABLE: NEC

NOTE: THIS TEST CONTROLS THE TYPE I EXPERIMENTWISE ERROR RATE
UNDER THE COMPLETE NULL HYPOTHESIS BUT NOT UNDER PARTIAL
NULL HYPOTHESES.

ALPHA=0.05 DF=4146 MSE=9.9E-04

WARNING: CELL SIZES ARE NOT EQUAL.

HARMONIC MEAN OF CELL SIZES=36.9805

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

SNK	GROUPING	MEAN	N	WN	MEAN PERCENT OZONE NECROSIS
	A	0.84220	6	7	20.9
	B	0.74157	69	6	5.0
	B				
C	B	0.73067	260	5	3.4
C					
C	D	0.71886	731	4	1.7
	D				
	D	0.71063	1017	3	0.5
	D				
	D	0.70743	1039	2	0.05
	D				
	D	0.70711	1031	1	0

SAS

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GENERAL LINEAR MODELS PROCEDURE

STUDENT-NEWMAN-KEULS TEST FOR VARIABLE: NL

NOTE: THIS TEST CONTROLS THE TYPE I EXPERIMENTWISE ERROR RATE
UNDER THE COMPLETE NULL HYPOTHESIS BUT NOT UNDER PARTIAL
NULL HYPOTHESES.

ALPHA=0.05 DF=4146 MSE=9.29172

WARNING: CELL SIZES ARE NOT EQUAL.

HARMONIC MEAN OF CELL SIZES=36.9805.

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

SNK	GROUPING	MEAN NEEDLE LENGTH(cm)	N	WN
	A	15.870	69	6
	A			
B	A	15.542	1039	2
B	A			
B	A	14.977	260	5
B	A			
B	A	14.833	6	7
B	A			
B	A	14.655	731	4
B	A			
B	A	14.051	1031	1
B	A			
B		13.771	1017	3

SAS

18:10 SATURDAY, MARCH 9, 1985

GENERAL LINEAR MODELS PROCEDURE

STUDENT-NEWMAN-KEULS TEST FOR VARIABLE: RET

NOTE: THIS TEST CONTROLS THE TYPE I EXPERIMENTWISE ERROR RATE
UNDER THE COMPLETE NULL HYPOTHESIS BUT NOT UNDER PARTIAL
NULL HYPOTHESES.

ALPHA=0.05 DF=4146 MSE=.0092534

WARNING: CELL SIZES ARE NOT EQUAL.

HARMONIC MEAN OF CELL SIZES=36.9805

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

SNK	GROUPING	MEAN	N	WN	MEAN PERCENT NEEDLE RETENTION
	A	1.1542	6	7	16.8
	A				
B	A	1.1278	69	6	22.8
B					
B		1.0872	260	5	32.9
	C	1.0092	731	4	48.2
	D	0.8324	1017	3	80.7
	E	0.7404	1039	2	95.2
	E				
	E	0.7133	1031	1	99.1

SAS

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GENERAL LINEAR MODELS PROCEDURE

STUDENT-NEWMAN-KEULS TEST FOR VARIABLE: INJ

NOTE: THIS TEST CONTROLS THE TYPE I EXPERIMENTWISE ERROR RATE
UNDER THE COMPLETE NULL HYPOTHESIS BUT NOT UNDER PARTIAL
NULL HYPOTHESES.

ALPHA=0.05 DF=4146 MSE=.0025573

WARNING: CELL SIZES ARE NOT EQUAL.

HARMONIC MEAN OF CELL SIZES=36.9805

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

SNK	GROUPING	MEAN	N	WN	MEAN PERCENT OTHER INJURY
	A	0.86422	260	5	24.7
	A				
	A	0.85836	69	6	23.7
	A				
	A	0.85638	731	4	23.3
	A				
	A	0.83432	6	7	19.6
	A				
	A	0.83352	1017	3	19.5
	B	0.79528	1039	2	13.2
	C	0.74810	1031	1	6.0

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