

INCIDENCE AND SPATIAL PATTERN OF TREES WITH NECROTIC NEEDLE SYMPTOMS
IN Pinus strobus POPULATIONS OF
NINE NATIONAL PARKS IN 1987

By

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INTRODUCTION

The presence of conspicuous needle necrosis has been observed on a subset of Pinus strobus trees at Acadia National Park (ACAD) since the 1983 growing season (Bennett et al. 1986, Treshow 1985). The symptomatic trees are conspicuous because of the pinkish brown tipburn which appears on current year needles during the growing season (Bennett et al. 1986, Sanchini 1988b). The pinkish brown color contrasts sharply with the green asymptomatic portion of the new needles. The necrotic portion of the needles often exceeds 30% of the length of affected needles by late summer (Sanchini 1988). The causes of the injuries at Acadia are unclear; needle feeding insects, needle fungi, semi-mature needle tissue blight (SNB), sulfur dioxide and ozone have all been suggested (Bennett et al. 1986, Treshow 1985).

The necrotic needle syndrome observed at Acadia belongs to a complex of diseases called white pine needle blight. Outbreaks of white pine needle blight have been observed throughout the range of eastern white pine since the first published report in 1908 (Dana 1908, Hepting and Berry 1960). Needle blight is a symptom complex in which necrosis of needle tips, chlorosis of needles, production of short needles and premature shedding of fascicles are observed when no pathogen is evident at the time the symptoms appear (Hepting and Berry 1960). They pointed out that needle necrosis is a symptom caused by a very large number of pathogens in white pine (Boyce 1961, Hepting and Berry 1960, Hirt 1959) and must be associated with presence of the pathogen to be reliably distinguished. Costonis (1968, 1969, 1970) and Linzon (1968, 1971) have demonstrated that needle fungi, ozone, sulfur dioxide and physiological disorders can produce necrotic symptoms of white pine needles. While injury caused by needle fungi can be identified by the presence of fruiting bodies on the needles late in the growing season, the symptoms can be difficult to differentiate earlier. It is not clear whether injury caused by ozone, sulfur dioxide and semi-mature tissue needle blight can be differentiated once the course of symptom development is complete (Costonis 1969, 1970, Linzon 1970).

The first description of conspicuous necrotic injury on white pine at Acadia was made by Treshow (1985) in his report describing tree conditions on permanent plots. While the necrotic trees were not sampled on the permanent plots, the presence of symptomatic trees was noted, and some of the trees were cored for growth rate analysis. In 1985 trees on the permanent pine plots were resampled and foliage evaluated for presence of three symptoms of ozone injury: chlorotic mottle, tipburn and silver fleck (Sanchini 1986). None of the trees on the permanent plots showed the necrotic symptom in 1985. The symptom complex was observed on Pinus strobus trees within the Park however. A workshop was convened in August 1986 to examine symptom development and pattern of incidence within the crowns of affected trees (Bennett et al. 1986). The consensus reached by that group of pathologists was that ozone, needle fungi, needle feeding insects and semi-mature tissue needle blight could not be eliminated as possible causes of the injury observed on at least some trees. They agreed that details of symptom development were required to further elucidate causes of the symptom. This is consistent with the approach of Hepting and Berry (1960), who suggested that detailed observations during symptom development may be the only way to differentiate the multiple causes of the white pine blight symptom complex.

The first dataset to provide an estimate of incidence of syaptoaatic trees within pine stands at Acadia was a survey of chlorotic aottle and tipburn injuries of white pine conducted in 1986 (Sanchini 1988). The objectives of the survey were to obtain estimates of the frequencies of trees with visible foliar injuries caused by oxone (incidence) and trees with relatively high severity of ozone injuries based on a randoaly selected, large saaple of trees. A set of 757 trees was saapled froa 23 locations within Acadia National Park during Septeaber 1986 (Sanchini 1988). Forty-one trees, or 5.4%, exhibited necrotic needle syaptoas at the tiae of the survey. Fifteen of the 23 plots contained at least 1 necrotic type tree. Incidence of the necrotic type syaptoa ranged froa 2.5% to 19.6% in that saaple. While the study provided preliainary inforaation about the incidence of the necrotic needle syaptoa at Acadia, the overall distribution and spatial pattern of syaptoaatic trees could not be investigated due to the relatively saall nuaber of syaptoaatic trees in the saaple.

This study is the first of a set of research projects directed at deteraining the cause(s) of the syaptoa coaplex at Acadia National Park (Bennett 1987). Studies of injury developaent on syaptoaatic trees are of priaary importance in excluding potential pathogens froa the list under consideration. However studies of the spatial patterns of trees exhibiting the syaptoa will provide insight into the epideaiology of the problea which studies of relatively few trees cannot provide. This is particularly iaportant in this instance, due to the potential for multiple causes to exist. This study investigates pattern at three levels; aaong National Parks which contain Pinus strobus populations, aaong Pinus strobus stands at Acadia NP, and within stands in which the syaptoa coaplex was encountered.

At Acadia National Park, the goal of this study was to describe the spatial pattern of syaptoaatic trees both across and within stands. Since it was not possible to census all stands which contain Pinus strobus at Acadia, the study was based on a saaple of forest stands identified froa a vegetation aap and froa previous field studies of eastern white pine. Patterns across stands will be identified by coaparison of relative frequency of syaptoaatic trees within randoa saaples drawn froa separate stands in the Park. If syaptoaatic trees have a randoa distribution within the Park, no differences in transect aeans will be found. A segregated, or patchy, pattern would result in soae saaples having significantly higher proportions of syaptoaatic trees. Since the priaary data in this study consist of proportions, the saaple size required froa each stand could be estiaated froa the equation for the 95% confidence liaits of a proportion (Kachigan 1986, Sokal and Rohlf 1981). The saaple size required for a test varies with both the precision desired of the test and the expected value of the proportion. An estimate of the expected value of the proportion was based on the saaple of 757 trees obtained in 1986 (Sanchini 1988b). Syaptoaatic trees coaprised 5% of the saaple, and ranged froa 0% to 20% on individual plots. The required sample sizes for 2 levels of precision and 1986 Acadia plot data are presented in Table 1. The results indicate that a saaple of 73 trees is sufficiently large to distinguish a proportion of .05 froa 0. A saaple of 81 trees will be required to distinguish a proportion of .20 froa .10 and .30. This indicates that a ainiaal saaple size of 80 trees should be obtained froa each location saapled, so that stands with low incidences of syaptoaatic trees can be distinguished with .05 precision and stands with higher incidences can be distinguished with .10 precision.

The relationships between stand characteristics such as elevation, aspect, slope, size and age of trees, and incidence of syaptoa expression will be investigated by correlation. Correlation analysis used in this context is a descriptive technique, providing an estimate of the degree of association among variables. The results may suggest hypotheses about functional relationships among the variables, or codependence of incidence of syaptoaatic trees and other measured variables. For example, incidence of injury may be associated with site conditions which enhance syaptoa expression of susceptible trees. One hypothesis stated in previous reports (Bennett et al. 1986, Treshow 1985), that trees at higher elevations show higher incidence of injury, can be tested with these data as well.

Patterns within stands will be identified from runs tests based on the sequences of syaptoaatic and asyaptoaatic trees within narrow belt transects. A segregated pattern, in which clumps of syaptoaatic trees occur within a matrix of healthy trees, would indicate that the cause of the necrotic needle syaptoa is associated with an infectious disease (Pielou 1963, 1964, or that genetic differences in susceptibility exist within stands. The length of the runs of affected trees would then represent the areal extent of either a pathogenic agent or a susceptible allele within the pine populations.

Another goal of the study is to determine whether the necrotic-needle type syaptoa occurs in other National Parks which contain white pine populations, and to obtain a sample on which a general comparison of Park means can be based. For Saratoga National Historical Park (SARA), Delaware Water Gap National Recreation Area (DEWA), Sleeping Bear Dunes National Lakeshore (SLBR), Pictured Rocks National Lakeshore (PIRO), Apostle Islands National Park (APIS), Saint Croix National Scenic Riverway (SACR), Grand Portage National Monument (GRPO), and Voyageurs National Park (VOYA), this study represents the first information on incidence of necrotic needle syaptoas within white pine stands. The objective of this part of the study was to assess spatial pattern of necrotic needle injury across Parks. The sample size required for significance testing of the proportion of syaptoaatic trees can be estimated based on the desired precision and the expected value of the proportion. The proportion of syaptoaatic trees may be expected to vary from 0 to 20%, based on the 1986 surveys at Acadia. Table 1 shows that a sample of 250 trees is sufficiently large to distinguish a 5% difference around an expected value of 20%. The 80 tree sample size requirement set for stand samples was not applied at these Parks since differentiating patterns within the Parks was not an objective of the study.

A second set of studies was undertaken in these Parks to evaluate the incidence and severity of chlorotic needle injury on Eastern white pine trees. Evaluation of chlorotic needle injury was based on evaluations of foliage obtained from 100 trees which could be pruned with a pole pruner.

This report describes the results of three sets of analyses of pattern in the incidence of necrotic needle type syaptoas within Pinus strobus populations. While the research was designed and carried out in the order described in the introduction above, it is presented in order of scale, from the largest, across Parks, through to the smallest, within stands. First, comparison of incidence of necrotic type injury among 9 National Parks will be based on surveys of trees conducted at each Park. Then comparison of stands at ACAD, based on a systematic survey of incidence of syaptoaatic trees in white pine stands on Mt Desert Island

will be presented. Finally patterns within stands which contain syaptoaatic trees will be investigated.

Asyaptoaatc Trees: Trees not exhibiting the necrotic-needle type syaptoas described above. Trees in this category had varying aamounts of other types of biotic and abiotic injuries on their needles.

Diaaeter Clama: Class intervals in ca as follows

3	10.0-14.99	4	15.0-19.99	5	20.0-24.99	6	25.0-29.99
7	30.0-34.99	8	35.0-39.99	9	40.0-44.99	10	45.0-49.99
11	50.0-54.99	12	55.0-59.99	13	60.0-64.99	14	65.0-69.99
15	70.0-74.99	16	75.0-79.99	17	80.0-84.99	18	85.0-89.99
19	90.0-94.99	20	95.0-99.99.				

Two locations, the old growth stand near Salisbury Cove, and a younger stand on Seal Cove Road, were chosen for the coring study. At each location, trees were selected by the transect aethod described above, scored for necrotic needle type syaptoas, and aeasured for diaaeter at breast height. Each tree was flagged and nuabered. A diaaeter distribution was constructed for each site, and a randoa saaple of trees in each diaaeter class was chosen for coring. One core was obtained froa each tree. Each tree was treated with a wound sealer and the flags were reaoeved. Cores were mounted on pine boards, sanded and the nuabers of annual rings were counted.

FIELD SURVEYS AT OTHER NATIONAL PARK UNITS

Two types of saaples were obtained at each Park. Estiaate of the incidence of necrotic-needle type injury in natural stands of white pine was based on cruise surveys of selected pine stands. The stands were chosen with the help of resource aanageaent personnel at each Park. Relatively little tiaa, usually less than 1 day, was devoted to finding new stands for the surveys. The transect aethod developed at Acadia and described above was used to saaple trees within selected stands at each Park. Saapling within each stands continued until 50 trees were observed whenever stand density and size allowed.

Trees were saapled in state parks and national forests along the travel route. The purpose of saapling these stands was to provide better coverage of the habitat area studied and to fill in gaps between the National Parks. I routed ay travel through state parks and preserves and national forests whenever travel tiaa allowed. At each location, trees were saapled along a belt transect laid out as described in the Acadia field aethods. The data recorded consisted of two totals, necrotic needle-type trees were recorded on one tally meter, and asyaptoaatc trees on another. The saaple size attained reflects the nuaber of trees saapled in one belt transect at each location.

A saaple of approxiaately 100 trees froa each Park was pruned to provide foliage for evaluation of visible ozone injury. The trees were selected froa one or aore locations within each Park and consist of a subset of transect trees with foliage that was within the range of a 38 ft pole pruner. Five branchlets were pruned froa each tree. The foliage saaples were obtained froa branches that were between 5 ft and 40 ft of the ground. No atteapt was aade to stratify saapling with respect to height or aspect. Foliage saaples were stored in ziploc plastic bags and were refrigerated until they were scored. Saaples froa Saratoga National Historical Park, Delaware Water Gap National Recreation Area, Saint Croix National Scenic Riverway, Grand Portage National Monument, and Voyageurs National Park

were scored within 48 hours of collection. Foliage samples from 5 Parks were collected by Dr. Ronald Hiebert as part of another study and were ailed to be for evaluation. Samples were obtained in this way for Sleeping Bear Dunes National Lakeshore, Pictured Rocks National Lakeshore, Apostle Islands National Park, Indiana Dunes National Lakeshore, and Hofsater State Park, Michigan. These samples usually contained foliage from 96 trees and were evaluated within 3 weeks of collection. All foliage was examined indoors under adequate lighting and against a gray background, optimal conditions for distinguishing chlorotic aottle from healthy leaf tissue. Patches of pale yellow aottle which retained a translucent appearance and which exhibited indistinct boundaries with healthy tissue were attributed to ozone (Costonis 1968, 1970, Jacobsen and Hill 1970, Malhotra and Blauel 1980). The severity of injury was estimated for each twig based on average percent area of needle tissue showing symptoms of chlorotic aottle. The following 8-class scale was applied to the observations of each twig:

Class 0	no evidence of chlorotic aottle on any needles examined
Class 1	0.1- 0.9% of needle length with chlorotic aottle on average
Class 2	1.0- 5.0% of needle length with chlorotic aottle on average
Class 3	5.1-24.9% of needle length with chlorotic aottle on average
Class 4	25.0-74.9% of needle length with chlorotic aottle on average
Class 5	75.0-94.9% of needle length with chlorotic aottle on average
Class 6	95.0-98.9% of needle length with chlorotic aottle on average
Class 7	99.0-99.9% of needle length with chlorotic aottle on average

STATISTICAL METHODS.

Data were entered on computer files for data summary and analysis. All procedures were performed by subroutines of SPSS/PC+ for the IBM PC/XT/AT (1986) on an XT-compatible personal computer running MS-DOS 3.3.

Data on necrotic needle injury were summarized as a set of proportions, representing incidence of the symptom for each Park or stand sampled. The size of the samples drawn from each Park, 250 trees, was designed to distinguish a 5% difference in incidence of trees with necrotic needle symptoms at $P \leq 0.05$, based on the assumption that the observed values would fall between 1% and 20% of trees examined (Kachigan 1986, Sokal and Rohlf 1981). If the incidences observed fall within this range, Park comparisons can be interpreted directly from tabulation of incidence of trees with necrotic needles. Similarly the sample size to be obtained from each stand at Acadia was set at 80 trees, so that 5% differences could be distinguished among stands with low observed incidences (5% or less) and 10% differences could be distinguished at higher incidences (10-30%) (Kachigan 1986, Sokal and Rohlf 1981). If the observed incidences fall within this range, comparison of stand means may proceed directly from tables of percent of trees injured. Incidence of chlorotic aottle injury across Parks can be analyzed by comparing observed incidences with the values in Table 1.

Diameter distributions of necrotic needle-type trees and asymptomatic trees are compared with the Kolmogorov-Smirnov Two Sample Test. This procedure is based on differences in location and dispersion of the relative cumulative distributions observed in each sample (Sokal and Rohlf 1981, Siegel 1956).

Correlation analysis of incidence of necrotic trees with site characteristics of block location, elevation, slope and aspect is based on Pearson

product-moment coefficients (Kachigan 1986, Sokal and Rohlf 1981). This procedure measures the strength of association among values of pairs of variables, and can provide descriptive summaries of the relationship of pairs variables and an estimate of the degree to which they covary.

Runs tests are used to test the hypothesis that the sequence of injured and asymptomatic trees within a stand are random (Kachigan 1986, Sokal and Rohlf 1981, Siegel 1956). Significance testing is based on the value of the normal deviate calculated from the observed number of runs, the expected number of runs and the standard error of the expected value.

Chlorosis scores were calculated for each tree by averaging the scores recorded for 5 branches. The tree scores were the variates on which a Kruskal-Wallis one-way analysis of variance was performed. This technique tests the null hypothesis that the chlorosis scores from each Park represent populations with identical means. In this analysis, values for the observations are replaced by ranks (Siegel 1956, Sokal and Rohlf 1981). The value of the test statistic was corrected for ties before comparison with the critical values of the statistic (SPSS 1986). All possible pairs of means were compared using the Student-Newman-Keuls Procedure. This is a relatively conservative test which indexes the critical values to the range of the compared means while protecting the error rate applied to each comparison (Dowdy and Wearden 1983). The formulation used also applies correction factors for unequal sample sizes to the critical ranges (SPSS 1986).

RESULTS AND DISCUSSION

COMPARISONS OF TREE CONDITIONS AT 9 NATIONAL PARKS IN 1987.

Incidence of Necrotic Needle Syaptoas.

The primary goal of these surveys was to determine whether Pinus strobus trees with necrotic needle syaptoas were present in Parks with significant white pine populations and to obtain samples large enough to provide estimates of incidence of the syaptoa in those Parks. For this purpose 4691 white pine trees were sampled from 74 stands in 9 National Parks between June 8 and August 29 1987. The schedule of field work and field notes from selected state parks and preserves along the travel route are shown in Appendix A. Table 2 shows the percent of trees showing necrotic needle syaptoas and the sample sizes attained at each Park. The samples from GRPO and APIS did not meet the target size of 250 trees. At both Parks, there are significant blister rust infestations which lead to elimination of trees from the transects. At APIS, field work was performed at only 2 islands due to time constraints. However both samples are sufficiently large in the sense that they exceed the number of observations required for significance testing of the incidence values observed.

The percentages in Table 2 represent incidences of trees exhibiting the necrotic needle syaptoa within the random samples of trees from natural stands within each Park. Three percent of the trees sampled showed necrotic needle syaptoas. No trees with necrotic needle syaptoas were observed at 5 Parks, including Delaware Water Gap National Recreation Area, Sleeping Bear Dunes National Lakeshore, Pictured Rocks National Lakeshore, Saint Croix National Scenic Riverway and Voyageurs National Park. One tree showing necrotic type symptoms was sampled in the transects at Saratoga National Historical Park, and a few others were noted in roadside stands that were not sampled. The white pine populations at 3 Parks had incidence values that are significantly higher than 0 (see Table 1). Acadia National Park, Apostle Islands National Park, and Grand Portage National Monument comprise this subset. Differences in incidence within this group are not statistically significant. This analysis shows that while the symptom complex does occur in Parks other than Acadia, it has an uneven, or patchy, distribution and does not affect a high percentage of trees in any Park.

When description of these patterns of incidence across Parks is combined with information on syaptoa development at Acadia and the results of fumigation studies, they may be useful in eliminating some hypotheses about causes of the syaptoa at Acadia. At present however, the patterns themselves do not represent support for any hypotheses about the potential causes of the syaptoa.

There appears to be a weak latitudinal trend in incidence of trees with necrotic needle syaptoas (see Figure 1). The effect is a result of the low incidence of necrotic needle syaptoas in the 2 Parks south of Acadia (SARA and DEWA). All of the other Parks lie within the range of latitudes set by ACAD (44° north) and VOYA (49° north). The positions of APIS at 47° and GRPO at 48° north latitude are above the midpoint of the latitudinal belt in which the syaptoa was observed, but so are PIRO (47° north) and VOYA (49° north). The field notes of surveys in other white pine forest stands along the travel route show the same pattern. Trees with necrotic needle syaptoas were encountered in 3 of 10 surveys

in forests north of 44° north latitude; 2 of these were north of 46° latitude. None of the 5 surveys south of 44° north latitude contained any necrotic needle-type trees.

Another set of observations concerns the incidence of blister rust infestations in the midwestern Parks. Blister rust became evident as a significant influence within forest stands in the Michigan Parks. From SLBR and PIRO through GRPO and the National Forest stands in Minnesota, the incidence of blister rust increases by at least a power of 10. Whenever possible, stands with high levels of blister rust were not sampled, and trees with recognizable branch and trunk lesions were not included in the tallies. However, it may not be coincidence that the two Parks in which incidences of blister rust were the highest, GRPO and APIS, also showed high incidence of necrotic needle samples. The presence of the necrotic samples in these stands may be due to stress on trees in early stages of infection, when blisters may not be readily visible.

Chlorosis Scores.

The incidence and severity of chlorotic needle injury in Pinus strobus populations observed in 8 of the Parks in 1987 is shown in Table 3. Incidence and severity of chlorotic needle injury in 1985 is given for Acadia, since needle injury was not surveyed in that Park in 1987. Chlorotic needle is one sample of foliar injury that has been attributed to elevated ambient ozone levels (Costonis 1968, 1970, Jacobsen and Hill 1970, Malhotra and Blauel 1980). The chlorotic needle scores recorded for the Parks provide a rough index of the ambient ozone levels during the 1987 growing season. Both incidence and severity of the needle injury is low for all Parks sampled in 1987. Three groups of Parks can be delineated based on incidence of chlorotic needle injury (see Table 3). All of the incidence values shown are significantly different than 0. At 2 Parks, HOSP, and SLBR, incidence of needle is less than 10%, significantly less injury than at the other Parks. For 3 Parks, ACAD, SACR, and SARA, incidence of needle is greater than 35%, significantly more injury than at the other Parks. Between are the values for 6 Parks with intermediate incidences. Analysis of the injury scores is summarized in Table 3. The mean injury scores are all less than 1, reflecting the fact that less than half of the trees sampled at any Park had chlorotic needle injury. The values mean that the 'average' tree in these samples had no chlorotic needle injury. Trees that showed injury most often fell in class 1; injury affected less than 1% of the needle length. While the variation in chlorosis scores is statistically significant (Kruskal-Wallis Chi-square=41.3, $p=0.00$), only the sample from SACR was differentiated by the SNK procedure ($p \leq 0.05$). The positions of the Parks in Tables 2 and 3 appear to be different. The patterns of incidence of necrotic needle-type injury did not closely resemble the pattern of incidence of chlorotic needle in these Parks in 1987.

Diameter Distributions of Asymptomatic and Necrotic Type Trees.

Figure 2 shows the diameter distributions of asymptomatic trees and necrotic type trees sampled on the transects in 1987. The frequencies are tabulated in Table 4. Frequency tables and bar charts representing distributions for each Park comprise Appendix B. The diameter distribution for 4538 asymptomatic trees shows the inverse relationship between frequency and size

expected for forest trees (Harper 1977, Knowles and Grant 1983). The mode of the distribution is in the smallest size class, followed by rather even decreases in size class frequencies except at class 9 which is over-represented in the sample. The diameter distribution of the 138 necrotic needle-type tree sample is similar to the larger sample of asymptomatic trees in location. Mean size class of the necrotic needle-type tree sample is 6.9, and of the asymptomatic tree sample is 6.7. While the distribution of necrotic needle-type trees appears more uniform across the range of size class observed, the results of Kolmogorov-Smirnov Two Sample test indicate that the differences are not statistically significant.

Table 2. Incidence of necrotic needle-type trees in transects at 9 National Parks in 1987.

Park	Number of Necrotic-Type Trees	Number of Asymptomatic Trees	Incidence of Necrotic-Type Trees
GRPO	15	235	6.0
ACAD	120	2334	4.9
APIS	5	195	2.5
SARA	1	293	.3
DEWA	0	278	0.0
SLBR	0	276	0.0
PIRO	0	250	0.0
SACR	0	279	0.0
VOYA	0	400	0.0
TOTAL	141	4540	3.0

Table 3. Chlorosis Scores of trees in 11 National Parks in 1987.

Park	Incidence of Chlorotic Mottle % ¹	Chlorosis Score Mean	N
ACAD	55	(1.7% ²)	294
SACR	38	.2 ³	99
SARA	35	.1	57
DEWA	19	.1	100
APIS	17	.1	96
VOYA	15	.1	100
INDU	12	.1	96
GRPO	11	.1	100
PIRO	10	.1	96
HOSP	8	.1	48
SLBR	4	.0	92

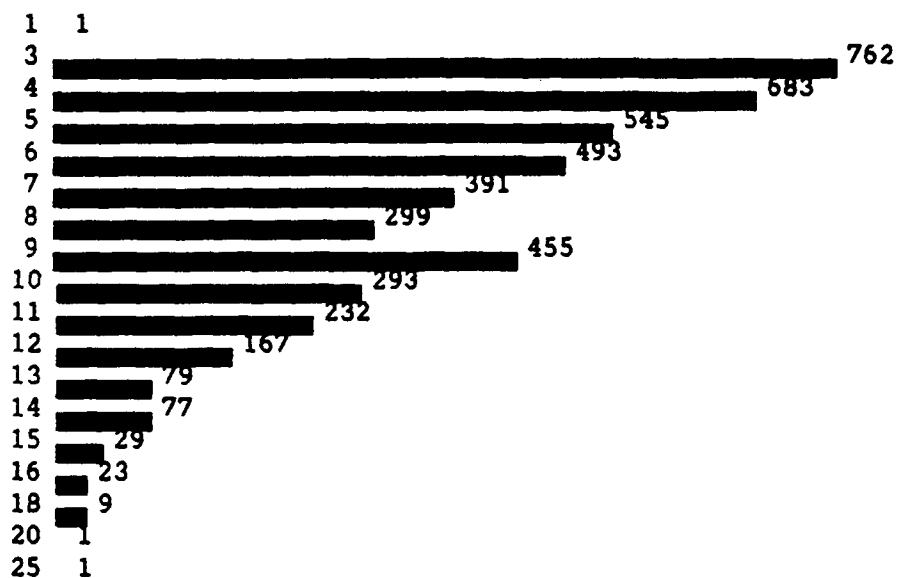
¹ All values are significantly different than 0 at $p \leq 0.05$.

² Based on analysis of permanent plot trees in 1985 (Sanchini 1986).
Chlorosis value is percent of needle area showing chlorotic mottle injury.

³ Mean chlorosis score is significantly higher than scores at 5 other Parks, SNK procedure, $p \leq 0.05$.

Figure 2. Diameter distributions of asyaptoaatc trees and necrotic needle type trees saapled at all Parks in 1987.

A. Asyaptoaatc Trees



B. Necrotic Needle-Type Trees

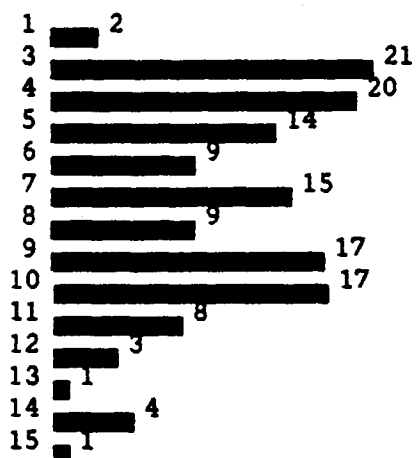


Table 4. Size class frequencies of asyaptoaatc trees and necrotic needle-type trees saapled at all Parks in 1987. The cuaulative distributions are not significantly different, Kolaogorov-Sairnov $Z=1.135$, $p=.152$.

A. Asyaptoaatc Trees

Size Class	Frequency	Percent	Cuaulative Percent
1	1	.0	.0
3	762	16.8	16.8
4	683	15.0	31.9
5	545	12.0	43.9
6	493	10.9	54.7
7	391	8.6	63.3
8	299	6.6	69.9
9	455	10.0	79.9
10	293	6.5	86.4
11	232	5.1	91.5
12	167	3.7	95.2
13	79	1.7	96.9
14	77	1.7	98.6
15	29	.6	99.3
16	23	.5	99.8
18	9	.2	100.0
20	1	.0	100.0
25	1	.0	100.0

B. Necrotic Needle-Type Trees

Size Class	Frequency	Percent	Cuaulative Percent
1	2	1.4	1.4
3	21	14.9	16.3
4	20	14.2	30.5
5	14	9.9	40.4
6	9	6.4	46.8
7	15	10.6	57.4
8	9	6.4	63.8
9	17	12.1	75.9
10	17	12.1	87.9
11	8	5.7	93.6
12	3	2.1	95.7
13	1	.7	96.5
14	4	2.8	99.3
15	1	.7	100.0

SUMMARY

Transects saapling 4691 trees in 74 stands at 9 National Parks were observed between June 8 and August 29 1987. Of this saaple, 141 or 3% exhibited necrotic needle syaptoas. Trees with necrotic needle syaptoas are not randomly distributed across Parks in this study. None of the trees exaained at DEWA, SLBR, PIRO, SACR, and VOYA exhibited the syaptoa. One tree showing necrotic type syaptoas was saapled in the transects at Saratoga National Historical Park, and a few others were noted in roadside stands that were not saapled. Incidence of necrotic needle-type trees was significantly different than 0 at GRPO, ACAD and APIS. The sample froa GRPO showed the highest incidence of injury, 6%. At ACAD incidence was 4.9% and at APIS 2.5% of the trees saapled.

Both incidence and severity of chlorotic aottle injury in the populations sampled at 11 Parks in 1987 was very low. Three groups of Parks can be delimited based on incidence of chlorotic mottle injury. All of the incidence values recorded are significantly different than 0. At HOSP and SLBR incidence of mottle is less than 10%, significantly less injury than at the other Parks. At ACAD (in 1985), SACR, and SARA, incidence of mottle is greater than 35%, significantly more injury than at the other Parks. The pattern of incidence of chlorotic aottle injury across Parks does not resemble the pattern of the necrotic needle symptom across the same Parks. Very low mean chlorosis scores were recorded at all Parks sampled in 1987; the range of values was 0 to .2. This reflects the observation that less than half of the trees saapled at any Park showed chlorotic aottle injury. Trees that showed injury had syaptoa developaent on less than 1% of the needle length. The saaple of trees from SACR had significantly higher aean chlorosis scores than saaples froa the other 10 Parks.

Five percent of the 2454 trees saapled at ACAD had severe necrotic foliar injuries. Trees with necrotic needle symptoms were not randomly distributed across stands at Acadia National Park. Twenty-five of 32 stands contained at least one symptomatic tree. In 7 stands incidence of the syaptom was not significantly different than 0. Incidences greater than 5% were significantly differently than 0 and were found in 18 stands. Only block location showed significant correlation with incidence in this study. It appears that this is due to the low level of syaptom expression in blocks 8 and 9, from the Cadillac massif east, and the higher level of syaptom expression in block 3, the southwest portion of Mt Desert island. Stands in blocks 5, 6 and 7 most often fell in the high incidence group. This corresponds to the area between the Park Visitors' Center and Jordon Pond. Elevation, slope and aspect of the stand were not associated with patterns of incidence in this study.

Runs tests were performed for 20 stands in which more than 2 necrotic needle-type trees were encountered. Two distribution patterns exist in the samples. In 15 stands necrotic needle-type trees and asyaptoaatic trees were arranged in a randoa pattern. In 5 stands, and for the ACAD saaple as a whole, significant departures froa randoaness existed in the data. In all stands in which nonrandom spatial patterns were observed, trees with necrotic needles exhibited a clumped or segregated pattern and the observed series contained significantly fewer runs than expected for the nuaber of symptomatic trees observed.

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Schedule of Field Work and Survey Notes
1987 Field Season

June 5 - July 4 ACAD field surveys completed.

July 12 -15 SARA field surveys completed.

Site	Location
1	Loop Stop 3
2	Loop Stop 5
3	avenue of pines
4	Loop Stop 4
5	southeast boundary
6	British Woods
7	Monument lane

July 17-21 DEWA field surveys completed.

Site	Location
1	Dingman's Ferry
2	Old Mine Rd
3	Rt 521 spur
4	Conashaugh Rd
5	Emory Rd
6	Raymondskill Falls Rd
7	Tom's Creek picnic area

July 22 Ohio survey sites:

Rt 22 leaving Steubenville	no NNTs in 20 roadside trees
city park in Steubenville	no NNTs in 25 trees
Beaver Creek SP	no NNTs in 250 trees
picnic area and wind row along entrance road	

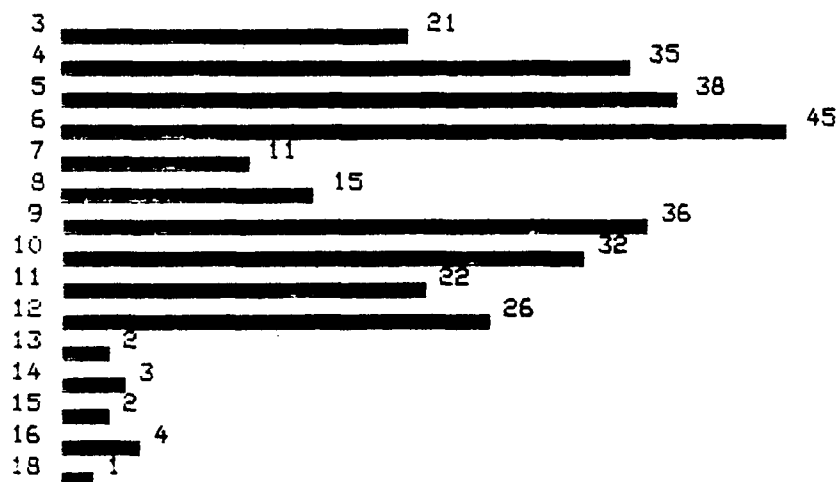
July 23 Michigan survey sites:

Rt 131 s of Big Rapids	no NNTs in 50 roadside trees
Newaygo SP	no NNTs in 100 trees
yg white pines (30yrs) in mixed hardwoods	
Rt 31 near Elk Rapids	no NNTs in 15 roadside trees
county rds around Pellston	3 NNTs in 20 roadside trees

July 24-28 SLBR field surveys completed

Table 1. Diameter Distribution of Asymptomatic Trees Sampled on Transects at SARA in 1987.

Size Class	Frequency	Percent	Cum Percent
3	21	7.2	7.2
4	35	11.9	19.1
5	38	13.0	32.1
6	45	15.4	47.4
7	11	3.8	51.2
8	15	5.1	56.3
9	36	12.3	68.6
10	32	10.9	79.5
11	22	7.5	87.0
12	26	8.9	95.9
13	2	.7	96.6
14	3	1.0	97.6
15	2	.7	98.3
16	4	1.4	99.7
18	1	.3	100.0
TOTAL	294	100.0	100.0



Mean	7.638	Std Dev	3.189	Minimum	3.000
Maximum	18.000				