AN ANALYSIS OF INTER- AND INTRA-TREE EFFECTS ON THE SIZE OF SPRUCE BUDWORM[1] EGG MASSES ON BALSAM FIR[2] AND WHITE SPRUCE[3]

by

Bruce Allen Montgomery

A THESIS

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[1] *Choristoneura fumiferana* (Lepidoptera: Tortricidae)

[2] *Abies balsamea* (L.) Mill.

[3] *Picea glauca* (Muench) Voss

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ABSTRACT

AN ANALYSIS OF INTER- AND INTRA-TREE EFFECTS ON THE SIZE OF SPRUCE BUDWORM[1] EGG MASSES ON BALSAM FIR[2] AND WHITE SPRUCE[3]

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Spruce budworm, *Choristoneura fumiferana* (Clemens), egg masses on balsam fir, *Abies balsamea* (L.) Mill., and white spruce, *Picea glauca* (Muench.) Voss, were examined to determine if populations oviposit larger or smaller sized egg masses at (a) particular site(s) on a host tree, within a stand, within a forest complex and between tree species within a stand. Five stands exhibiting negligible defoliation and low budworm numbers were studied in the Ottawa National Forest in Michigan's Upper Peninsula. The mean number of eggs per egg mass does not differ significantly from one directional quadrant to another within a host tree, from one height division to another within a host tree, and, in general, from one host tree to another of the same species within a spruce-fir stand. The mean number of eggs per egg mass did not differ significantly between the five stands for each tree species. Egg masses found on balsam fir averaged 1.1 to 5.6 more eggs per mass than eggs found on white spruce within each stand. However, in only two of the five stands were such differences statistically significant.

Dedicated to my parents,

Dr. Keith and Rosalind Montgomery

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PREFACE

This is the second thesis that I have written on the subject of spruce budworm egg mass size. The first, An Analysis of Intra- and Inter-Tree Effects on the Size of Spruce Budworm Egg Masses on Balsam Fir (Montgomery 1981), was based on data collected in the Ottawa National Forest of Michigan in the summer of 1979. In the first thesis, I analyzed the distribution of mean egg mass size within and between balsam fir trees in stands that were experiencing light-moderate to moderate-severe defoliation.

The second thesis is based on data collected in Michigan's Ottawa National Forest in the summer of 1980. Here, I investigate the intra- and inter-tree effects of balsam fir and white spruce on mean egg mass size. Unlike the first thesis, these stands were supporting endemic spruce budworm populations and were suffering very little defoliation damage.

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I. INTRODUCTION

The spruce budworm, Choristoneura fumiferana (Clemens) (Lepidoptera: Tortricidae) is native to the northern boreal forests of North America. Outbreaks occur in 30-40 year intervals, spaced by 20-90 years, and are considered a "phase in the natural cycle of events associated with the maturing of balsam fir" (Blais 1954, 1960). As the preferred hosts, balsam fir (Abies balsamea (L.) Mill.) and white spruce (Picea glauca (Muench) Voss), approach maturation age, the spruce budworm population rises from the endemic level. It reaches epidemic proportions when there are consecutive years of dry, sunny weather (Greenbank 1963a, b; Baskerville 1975) and extensive unbroken, mature spruce-fir stands (Mott 1963).

The present epidemic started in the 1960s and encompasses approximately 60 million hectares of spruce-fir forests in eastern North America with resulting timber losses as high as 283 million cubic meters (Witter et al. 1980). Pulp and paper industries are dependent on the spruce-fir forest for provision of a continual supply of usable balsam fir and white spruce fiber. Unfortunately, these industries are competing with a highly successful organism for the same resource. In the past, man has detained budworm damage through chemical spray programs, first aimed at killing the pest and more recently directed at short-term perpetuation of the tree's life. Blais (1958) postulated, "saving the fir by spraying possibly helps to perpetuate budworm epidemics that would otherwise die out in a short period with the change in forest composition." New studies have been initiated to find environmentally safe and economically feasible, long-term control methods that are effective alternatives to chemical spraying. Improving spruce budworm population sampling methods, particularly when population levels are low to moderate, is essential to this task. "Although at this time it is hard to imagine an alternative to chemical treatment in widespread outbreaks that cover millions of acres, the potential for such an alternative does exist. If it can be demonstrated that outbreaks arise from discrete centers, and if a monitoring system can be developed that will detect these centers early enough, it is possible that measures other than chemical may be applied, singly or in combination, to extinguish embryonic outbreaks" (Blais 1973).

Life History of the Spruce Budworm

The spruce budworm has one generation each year. Female moths lay egg masses on spruce and fir needles in July and early August. Each mass can contain from 1 to 60 eggs, and each female can lay around 200 total eggs. The preferred oviposition host is white spruce (Jaynes and Speers 1949; Wilson 1963, Kemp 1981), although oviposition occurs to a great extent on balsam fir and to a lesser extent on red spruce (*Picea rubens* Sarg.) and black spruce (*Picea mariana* Mill. (B.S.P.)) (Wilson 1963). Eclosion occurs within 8 to 12 days, and the small first instars, dropping from branches on silken threads, are often wind-borne and dispersed among trees in a stand. Feeding does not occur during this stage. The larvae find overwintering sites on branches, among bark scales, lichen mats, and staminate flower bracts, molt once and hibernate. In May the second instars emerge to mine older needles and flower buds. A second dispersal occurs in which many larvae may be redistributed over the entire forest. As the larvae grow older and larger, they become free feeders, preferring the succulent new foliage of balsam fir but also feeding on white, black and red spruce and occasionally on hemlock, pine, larch, and blue spruce. They form feeding shelters on branch tips, molt through a sixth instar, and pupate in the shelters in late June and early July. After about 12 days, the adult moths emerge and mate. Typical female moths lay two large egg masses at their eclosion and mating site, and are then wind-dispersed on an "exodus flight" for up to 80 km downwind per night (Harvey 1977). Egg depositon continues until the female expires.

Spruce Budworm Egg Mass Size

The egg mass is a logical stage to sample since it can be expressed in terms of a basic unit (e.g., branch surface) and an absolute unit (e.g., area) (Morris 1955) and is retained on the needle surface for several months. Also, the egg stage can be sampled in the early fall, providing ample lead time for planning the following summer's management program and for appropriating funds.

Current egg mass sampling methods are inconsistent. Sampling schemes developed by Morris (1949, 1954, 1955) and others since then disagree on the type, size and number of sampling units required. There are variable recommendations as to where to sample within a tree and how many trees to sample within a management unit. The vital relationship between egg mass density and defoliation has not been clarified.

Since female spruce budworm moths lay different size egg masses, it is

imperative that this distribution be assessed to optimize sampling accuracy and precision. Studies on egg mass size have neglected investigating the number of eggs per egg mass in different parts of trees, on different trees on host species or in different stands. It has been cited that the average number of eggs per egg mass is about 20 (Morris 1963; Neilson 1963; Eidt and Cameron 1970; Harvey 1977) or about 18 (Morris 1954) or variations between 11 and 25 (Blais 1958; Harvey 1977; Otvos 1977). It has been suggested that certain interrelated factors, such as severity of infestation, food quality and quantity, and population vigor may be responsible for observed differences in egg mass size.

Blais (1952) reported that in a year when some sample plots were heavily infested with the spruce budworm and some plots were lightly to moderately infested, the average number of eggs per cluster was 20.3. The following year, when all plots were heavily infested, the average number of eggs per cluster was 17.8. Blais (1953) found that "adults from fifth- and sixth-instar larvae reared on old foliage produced fewer eggs than insects reared on the current year's growth." He noted that as populations increase to the point where the current year's growth is destroyed prior to completion of the larval stage, fecundity decreases. Fecundity increases again as populations decline to the point where there is incomplete destruction of the current year's growth.

Miller (1957) reported an average of 15.7 eggs per egg mass in sample plots with severe infestation and an average of 18.5 eggs per egg mass in sample plots with light infestations. He postulated that "if a population is subject to larval starvation, the resultant small adults tend to lay smaller masses." Thus, "mean eggs per mass is dependent on the degree of infestation."

In a severe spruce budworm infestation in the Shickshock Mountains of New Brunswick, Blais (1958) reported an average of 326 egg masses per 100 square feet of foliage in 75% of 52 sampled plots. From this egg mass pool, 100 clusters were examined and were found to have an average of 11.0 eggs per cluster.

Harris (1963) observed the identical relationship in the two-year cycle spruce budworm. He observed a drastically reduced number of eggs per mass after two years of severe defoliation. In one study area, the average number of eggs per mass on alpine fir (Abies lasiocarpa (Hook.) Nutt.), was estimated to be 51.9 in 1958 but dropped to 20.2 in 1959. He suggested "that moths which developed from larvae starved because of severe defoliation were incapable of laying as large a number of eggs as those that developed from a healthier 1958 population, or that only the weaker individuals with lower egg-laying capacities remained in the area."

McKnight (1969) observed certain trends in egg mass size of the western spruce budworm, C. occidentalis Freeman. He reported that "in the Rocky Mountain region, 1959-1965 . . . egg-mass size fluctuated widely: the average number of eggs per mass declined from 25.3 in 1959 to 23.6 in 1961 when egg mass densities were increasing; rose sharply to 31.9 in 1962 when egg mass densities were low; and fluctuated between 24.0 and 29.7 in 1963, 1964, and 1965, when egg mass densities were generally low but variable." Washburn and Brickell (1973) feel that McKnight's (1969, 1971) observation "suggests that egg mass size could be a good indicator of the place of a given infestation in the epidemic cycle."

Outram (1971) studied spruce budworm specimens that "were one generation removed from field-collected stock originally taken from an epidemic population." Twenty fertilized females, reared in a laboratory, produced egg masses with a low average of about 16.7 eggs.

Otvos (1977) reported an average of 25 eggs per egg mass for 170 masses collected from 50 cm long branch tips taken from the mid-crown of dominant balsam fir trees. He explained that the relatively large number of eggs per mass was possibly a result of a small sample size.

Harvey (1977) found that size and mean weight of eggs in successive clusters drops gradually during the oviposition of most female spruce budworm moths. He also found that "dietary limitations during (larval) development substantially reduce fecundity and steepen the curve of decreasing egg weight." He reported that the typical moth lays an average of slightly more than two clusters at the site of her eclosion and mating. These are the first clusters she lays and comprise the heaviest eggs.

Recently, Kemp (1981) reported an average of 17.3 and 19.1 eggs per egg mass from laboratory-reared and mated female spruce budworm moths on balsam fir in two separate experiments in Maine. In what I believe is the first reported test of egg mass size on white spruce foliage, Kemp (1981) found an average of 14.6 and 14.3 eggs per egg mass produced by laboratory-reared budworm moths in two separate experiments. However, his detailed study of the capabilities of budworm and forest variables as predicting agents of budworm population size yielded no information on mean egg mass from balsam fir or white spruce in the field.

Montgomery (1981) conducted an analysis of mean egg mass size within and between balsam fir trees in four spruce-fir stands in Michigan's Upper Peninsula. He found that the mean number of eggs per egg mass did not significantly differ from one height division to another within a host tree, from one directional quadrant to another within a host tree, from one of thirteen predesignated compartments to another within a host tree, or from one balsam fir tree to another within a spruce-fir stand. Mean egg mass size was significantly different between the four spruce-fir stands. Balsam fir trees in two light-moderately defoliated stands had averages of 18.1 and 19.3 eggs per mass as opposed to an average of 17.1 eggs per egg mass on balsam fir trees in each of two moderate-severely defoliated stands.

Objectives of the Study

The overall objective of this study was to analyze differences in egg mass size in spruce-fir stands that had very low spruce budworm population and defoliation levels. Specifically, I wanted to determine if egg mass size on white spruce and balsam fir trees was related to particular sites within a host tree, within a stand, or within a forest complex.

For egg masses collected from balsam fir trees, I analyzed:

1. intra-tree quadrant effects;
2. intra-tree stratum effects;
3. intra-tree compartment (cell) effects;
4. inter-tree effects within a stand; and
5. inter-stand effects within a forest complex.

For egg masses collected from white spruce trees, I also analyzed:

1. intra-tree quadrant effects;
2. intra-tree stratum effects;
3. intra-tree compartment (cell) effects;
4. inter-tree effect within a stand; and
5. inter-stand effects within a forest complex.

I was particularly interested in the differences in egg mass size between the balsam fir and white spruce tree species. Researchers have consistently avoided studying spruce budworm population dynamics on host species other than balsam fir. At this time, it is not known what effects this oversight has had on the accuracy or precision of sampling predictions. Since white spruce is the preferred oviposition host (Jaynes and Speers 1949, Wilson 1963, Kemp 1981), it is imperative that we investigate this tree species as an alternate and/or complement to the one traditionally sampled tree species. Kemp (1978, 1981) and Kemp and Simmons (1978, 1979) seem to have taken the initiative to quantify the effects of non-host and alternative host species on spruce budworm populations.

For all egg masses that had been collected in this study, I analyzed:

1. inter-species (tree) effects within a stand and
2. inter-species (tree) effects within a forest complex.

II. FIELD METHODS

The study was conducted in the summer of 1980 in Iron and Gogebic Counties of Michigan's Upper Peninsula. My objective was to select stands that had at least four balsam fir and four white spruce trees, 30 to 60 feet in height, with very low defoliation levels (no top kill and little or no new

Figure 1. Severely defoliated pockets of spruce and fir trees, photographed from the Tepee Lake fire tower, eight miles south of Kenton, Michigan.

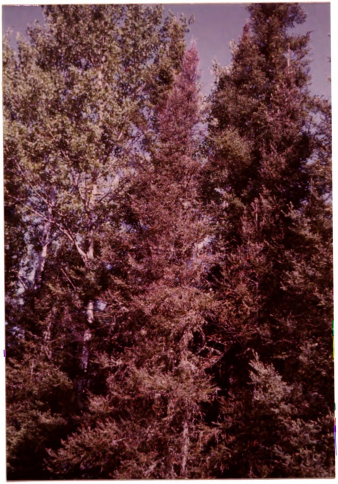


Figure 2. Severely defoliated balsam fir tree photographed in the Ottawa National Forest in 1980.

foliage consumed by larvae). However, the severity of the spruce budworm epidemic in the lake states limited my selection of stands to those which were isolated from other spruce-fir stands and were protected by hardwood cover. The pockets of dead and dying spruce and fir trees (Figure 1) and the dying balsam fir tree (Figure 2) illustrate the typical severe damage that exposed host trees were experiencing in the Ottawa National Forest in 1980.

After considerable time and effort, I located five stands that satisfied the study criteria. (Appendix A presents the locations of the four study sites within the Ottawa National Forest and the location of each study site within the respective township.) Each stand was primarily composed of mature hardwoods, with spruce and fir concentrated in one or two pockets along a ridge or on a bog's edge. Other spruce and fir trees were scattered around the pocket(s) and throughout the adjoining hardwoods. There was no definite border to the stands and the largest spruce-fir pocket served as the center of each stand. Within each stand four balsam fir and four white spruce trees were selected for study. Stand I included an additional six balsam fir trees for a total of ten balsam fir and four white spruce trees. Stand I could then be utilized as a replication of the 1979 study (Montgomery 1981).

Selection of individual trees from each stand was based on the following criteria, listed in order of priority:

1. Least attraction to ovipositing female moths
   - Trees that were overtopped by hardwoods
2. Lowest defoliation
   - Trees that had the healthiest tops and the least percent of new foliage missing

3. Closest proximity to the spruce-fir pocket

   - Trees that were within the pocket were considered first, followed by trees on the pocket's border

4. Within the height restriction

   - Trees that were thirty to sixty feet tall

5. Specific crown structure

   - One balsam fir and one white spruce with full crowns (these two trees would have every branch cut and examined and their feasible branches would be clipped in designated lengths and examined), i.e. "every branch--full sample" trees

   - One balsam fir and one white spruce with small crowns (these two trees would have every branch cut and examined but no sub-sampling would be conducted on their feasible branches), i.e., "every branch" trees.

   - Two balsam fir and two white spruce trees with crowns ranging from small to full (these four trees would have only their feasible branches cut and examined), i.e., "feasible branch" trees.

In summary, each stand had a pocket that contained more white spruce and balsam fir trees than the surrounding forest. I would first look for a tree within the pocket that was overtopped by hardwoods; that was experiencing little or no defoliation; that had a healthy single-stem top; and that was thirty to sixty feet tall. If the pocket's supply of trees that met these criteria was in excess of the required number then I would base my choice on crown structure. If it was less than this number, then I would select trees that met the other criteria and were closest to the pocket. Photographs of two typical sampled trees, White Spruce 2 in Stand 2 and Balsam Fir 1 in Stand 3, are presented in Figures 3 and 4, respectively.

Data collected from each sampled tree included height, diameter at breast height, and age at stump height. (Refer to Appendix B for a tabular presentation of the data from each sampled tree.) The ten trees that were closest to each sampled tree and had diameters at breast height of 12 centimeters or greater were recorded by species, height, diameter at breast height, direction from the sampled tree, and distance from the sampled tree. (Refer to Appendix C for a tabular presentation of this data base and Appendix D for stem maps.)

All foliage from each of the two "every branch--full sample" trees and each of the two "every branch" trees from each stand was examined for egg masses. This was accomplished by severing each branch at its base, clipping the branch into small segments, and thoroughly examining the foliage pieces. Data collected from the sampled branches consisted of height above ground, directional quadrant, total length, foliated width, total number of egg masses on current year's foliage (new), total number of egg masses (judged to be from the current population) on old foliage (old), total number of egg masses that could not be judged as definitely from the current or definitely from a previous year's population on old foliage (questionable), and foliated area. The apical 15 percent of the tree was classified as top and examined as a unit. However, branches longer than 70 centimeters that grew within the top were examined individually. (Details of the sampling procedure are graphically presented in Appendix E.)

Figure 3. Photograph of a sampled tree--White Spruce 2, Stand 2.

Figure 4. Photograph of a sampled tree--Balsam Fir I, Stand 3.

III. REGRESSION ESTIMATES FOR THE NUMBER OF EGGS PER EGG MASS LENGTH--BALSAM FIR AND WHITE SPRUCE

The tediousness and unreliability of directly counting the number of eggs in spruce budworm egg masses led to the development of estimating techniques by Miller (1957), Bean (1961), and Leonard et al. (1973). Their regression estimates were based on the relationship of mass length to number of eggs. Because of the spatial and temporal variability associated with spruce budworm population dynamics, I developed regression estimates from a subsample of the egg masses that had been collected for this study.

Methods

Egg masses were collected from balsam fir and white spruce trees in Michigan, beginning July 1980. They were placed in ½ dram vials and stored. The indistinctiveness of translucent egg chorions made counting of hatched eggs difficult and unreliable. Staining eclosed masses neither reduced the tediousness nor increased the counting accuracy. Therefore, only egg masses that were in such good condition that individual eggs were clearly distinguishable from each other were used in this portion of the study.

Spruce budworm moths in Michigan nearly always lay egg masses in rows of two (Figure 5), three (Figure 6), or two with a partial third (Figure 6). I have rarely observed four-row egg masses. Therefore six regression estimates were made--one for each of the three egg mass types from each of the two oviposition hosts. Six groups of approximately 100 egg masses were randomly selected from the egg mass pool. The masses were measured with an ocular micrometer to the nearest 0.5 millimeter, and the eggs were counted. Egg counts and corresponding egg mass lengths were entered into a file on Michigan State University's CDC 6500 computer.

Figure 5. Photograph of an eclosed 2-row egg mass.

Figure 6. Photograph of an eclosed 3-row egg mass.

Figure 7. Photograph of an eclosed 2-row egg mass with a partial third row.

Each group of 100 egg masses was tested to assure that the assumptions of normality and homogeneity were satisfied. The Statistical Package for the Social Sciences (SPSS) (Nie et al. 1975) was utilized for this and all subsequent analyses in the thesis. Appendix F presents a description of the statistical packages and computational formulae used to assess normality and homogeneity. Because the data in each group departed significantly from the desired normal distribution, the form of the data was changed in order to implement the desired parametric statistics. Morris (1955) reported that the frequency distribution for egg masses, as well as for eggs, follows the negative binomial pattern. Sokal and Rohlf (1969), on page 384 of their text, suggest that "when the data are counted, as of insects on a leaf or blood cells in a hemacytometer, we frequently find the square root transformation of value." I had used the square root transformation on data in the 1979 egg mass study (Montgomery 1981) and again found it to be the one method that would transform the egg counts so that they met the assumptions of normality and homogeneity. Tables F1 and F2 provide the test results, including statistics of skewness, kurtosis, and Bartlett-Box F, for egg counts used in the regression estimates of the number of eggs per egg mass from balsam fir and white spruce foliage, respectively.

Regression Estimates

Having met the assumptions of normality and homogeneity, the six groups of transformed egg counts were incorporated in SPSS's (Nie et al. 1975) "Subprogram Regression," pages 320-367. For each simple bivariate regression, the dependent variable was the square root of the number of eggs in each egg mass and the independent variable was the length of the corresponding egg mass to the nearest 0.5 millimeter. The regression estimates of the number of eggs per egg mass length for each of the three types of egg masses on balsam fir and on white spruce are presented in Tables 1 and 2, respectively. The estimates have been transformed back into the more familiar and relevant original scale and rounded to the nearest whole egg. Regression equations, 95 percent confidence intervals for the coefficients, correlation coefficients (r), and coefficients of determination (r^2) are presented below the regression estimates in Tables 1 and 2.

Figures 8, 9 and 10 present plots, comparing the white spruce and balsam fir estimated number of eggs per egg mass length for the 2-row, 2-row and a partial third row, and 3-row egg masses, respectively. The slight differences in the regression estimates for white spruce and balsam fir are probably related to the general shape of each species' needles. The flatter balsam fir needles could conceivably allow female moths more room to stretch fewer eggs over a longer horizontal distance. White spruce needles are often more curved and narrow which may force the ovipositing moths to "squeeze" more eggs together over a shorter distance. This trend becomes more noticeable as the length of the egg mass increases.

IV. LABORATORY METHODS

Egg masses had been collected from all foliated portions of 12 balsam fir and 10 white spruce trees. Egg masses from each branch on each tree were separately stored in labeled vials. A total of 286 masses from balsam fir and 907 masses from white spruce were available for analysis.

The 22 trees were initially treated as separate units. Each live crown

Table 1. Regression estimates for the number of eggs per egg mass length from balsam fir trees in Michigan.

	No. Eggs		
Length (mm)	2-row*	2-row with a partial third row**	3-row***
1.5	6		
2.0	7		
2.5	9	13	13
3.0	10	14	16
3.5	12	16	18
4.0	13	18	20
4.5	15	20	23
5.0	17	22	26
5.5	19	25	29
6.0	22	27	32
6.5	24	29	35
7.0	26	32	38
7.5	29	35	42
8.0	32	38	46
8.5	35	41	50
9.0	38		54
9.5			58
10.0			62

*$y = 1.7081 + 0.4913(x)$
95% Confidence Interval for A = 1.5163 to 1.9000
95% Confidence Interval for B = 0.4527 to 0.5299
$r = 0.927$; $r^2 = 0.860$; $n = 106$

**$y = 2.3676 + 0.4702(x)$
95% Confidence Interval for A = 2.1514 to 2.5839
95% Confidence Interval for B = 0.4304 to 0.5101
$r = 0.923$; $r^2 = 0.851$; $n = 98$

***$y = 2.2650 + 0.5623(x)$
95% Confidence Interval for A = 1.9634 to 2.5665
95% Confidence Interval for B = 0.5106 to 0.6140
$r = 0.906$; $r^2 = 0.820$; $n = 104$

Table I. Continued.

where:

$y = A + B(x)$
$y = (\text{No. Eggs per Mass})^{1/2}$
A = a coefficient (the slope)
B = coefficient for X
X = Mass length to the nearest 0.5 mm.

Table 2. Regression estimates for the number of eggs per egg mass length from white spruce trees in Michigan.

	No. Eggs		
Length (mm)	2-row*	2-row with a partial third row**	3-row***
2.0	6	11	
2.5	8	12	
3.0	9	14	17
3.5	11	16	19
4.0	13	18	22
4.5	15	20	24
5.0	18	22	27
5.5	20	25	30
6.0	23	27	33
6.5	25	30	36
7.0	28	32	39
7.5	31	35	43
8.0	34	38	46
8.5	38	41	
9.0	41	44	
9.5	45		

*$y = 1.3861 + 0.5602(x)$
95% Confidence Interval for A = 1.1429 to 1.6294
95% Confidence Interval for B = 0.5119 to 0.6085
$r = 0.897$; $r^2 = 0.804$; $n = 130$

**$y = 2.3084 + 0.4816(x)$
95% Confidence Interval for A = 2.0613 to 2.5554
95% Confidence Interval for B = 0.4354 to 0.5279
$r = 0.898$; $r^2 = 0.807$; $n = 104$

***$y = 2.4702 + 0.5424(x)$
95% Confidence Interval for A = 2.0885 to 2.8519
95% Confidence Interval for B = 0.4749 to 0.6100
$r = 0.847$; $r^2 = 0.717$; $n = 102$

Table 2. Continued.

where:

$y = A + B(x)$

$y = (\text{No. Eggs per Mass})^{1/2}$

A = a coefficient (the slope)

B = coefficient for X

X = Mass length to the nearest 0.5mm.

Figure 8. Plot of the estimated number of eggs per egg mass length, comparing 2-row egg masses from white spruce and balsam fir.

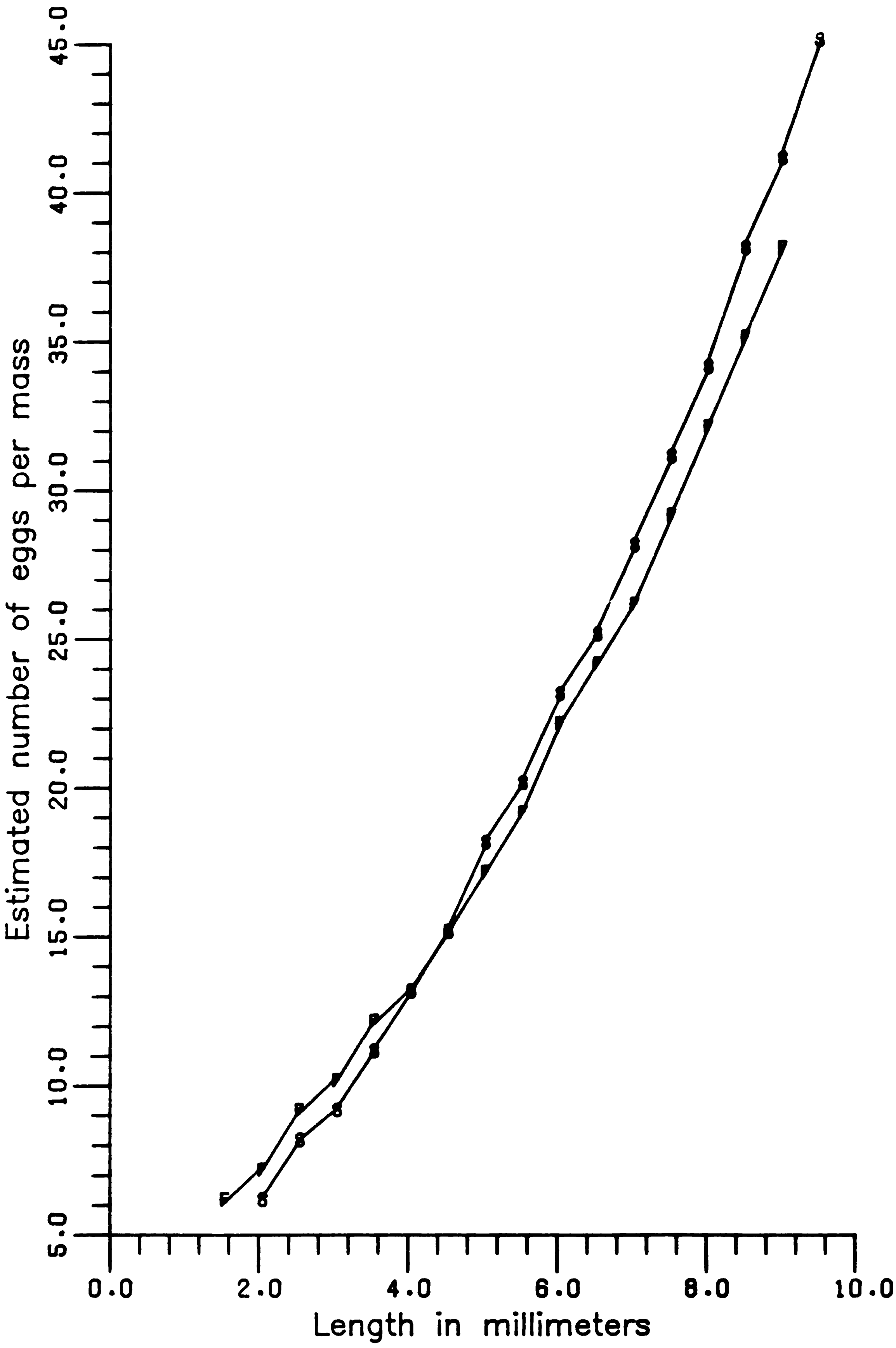

Estimated number of eggs per mass
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
2.0
4.0
6.0
8.0
10.0
Length in millimeters

Figure 9. Plot of the estimated number of eggs per egg mass length, comparing 2-row egg masses with a partial third row from white spruce and balsam fir.

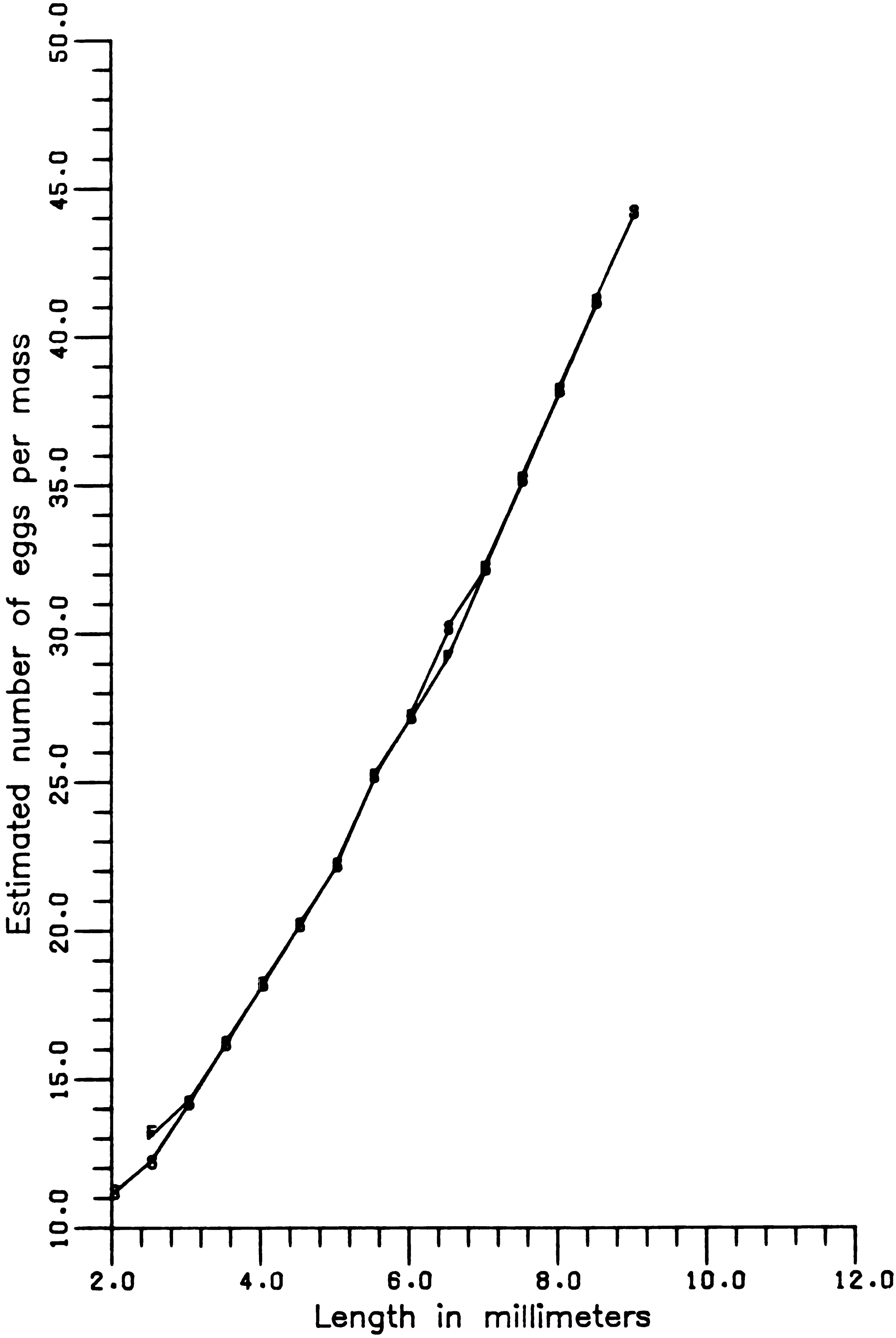
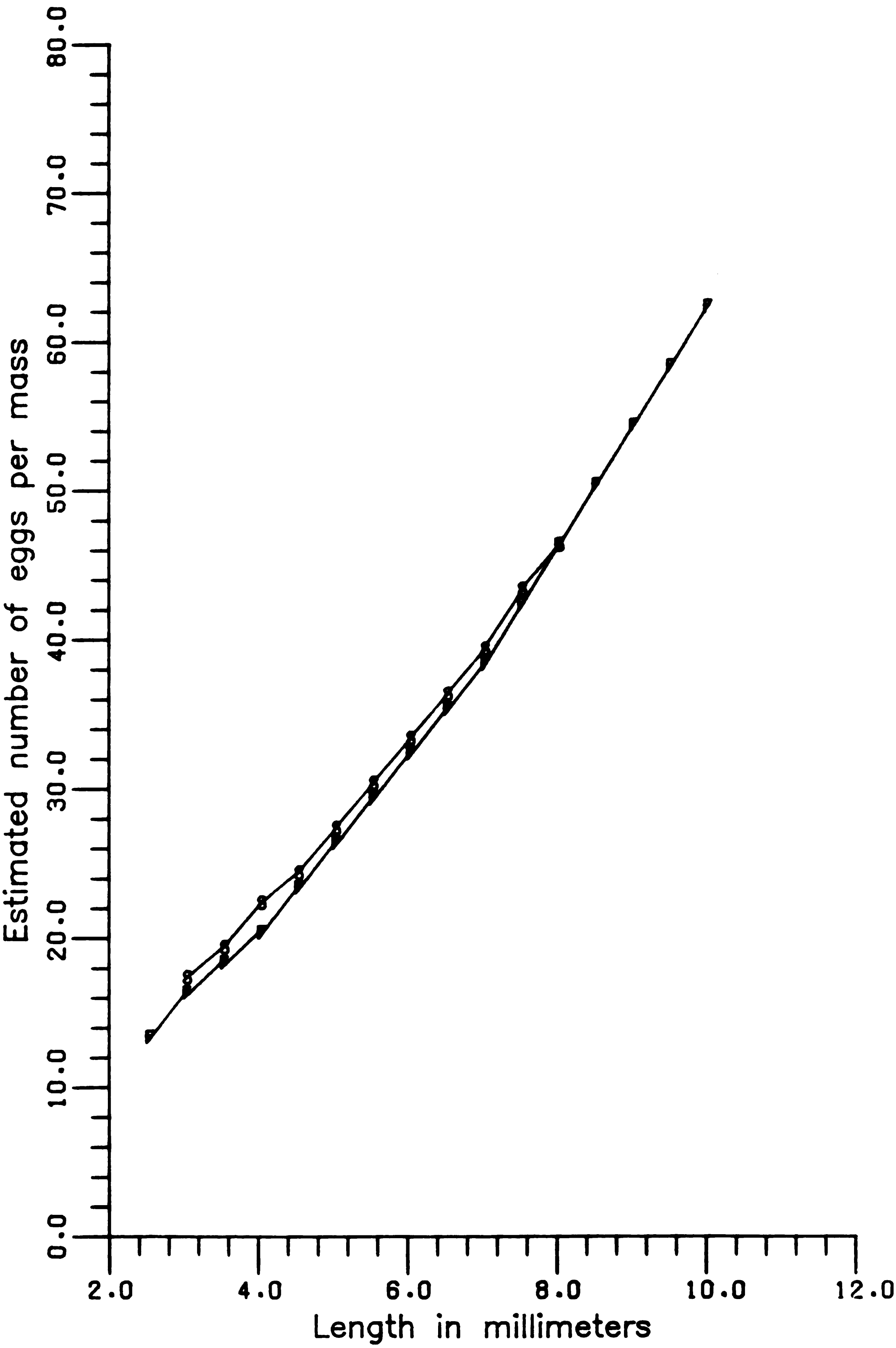

Estimated number of eggs per mass
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
2.0
4.0
6.0
8.0
10.0
12.0
Length in millimeters

Figure 10. Plot of the estimated number of eggs per egg mass length, comparing 3-row egg masses from white spruce and balsam fir.


Estimated number of eggs per mass
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
2.0
4.0
6.0
8.0
10.0
12.0
Length in millimeters

was divided into three strata and a top (Figure 11). Egg masses from branches that grew in a particular stratum were grouped into Stratum 1, Stratum 2, or Stratum 3.

Each branch had been recorded as residing in one of four quadrants--North, South, East or West (Figure 12). Egg masses from branches residing in a particular quadrant were reclassified into a corresponding quadrant within the predesignated stratum group. In this manner, each tree would have 12 quadrant/stratum divisions and a top, for a total of 13 cells.

Four branch numbers were randomly selected from each of the 12 quadrant/stratum divisions of each tree. The egg masses from the corresponding branch were obtained and arranged in a row. Parasitized and mutilated egg masses were disregarded. One egg mass was randomly chosen from each branch. The egg mass was measured with an ocular micrometer and the number of eggs in the mass was estimated with the appropriate regression table (1 or 2). Four egg masses were also randomly selected for measurement from each top. Frequently, cells had less than four measurable egg masses. In those cases I would measure as many masses (0, 1, 2 or 3) from each cell that I could. The data were tabulated and the number of eggs from a maximum of 52 egg masses per tree was used in the analysis of intra- and inter-tree effects. (Refer to Appendix G for a list of the cells and their corresponding egg counts.)

The subsequent tests of significance (one-way anova) in Sections 1-12 were performed on the transformed data, but estimates of means are given in the more familiar and relevant untransformed scale.

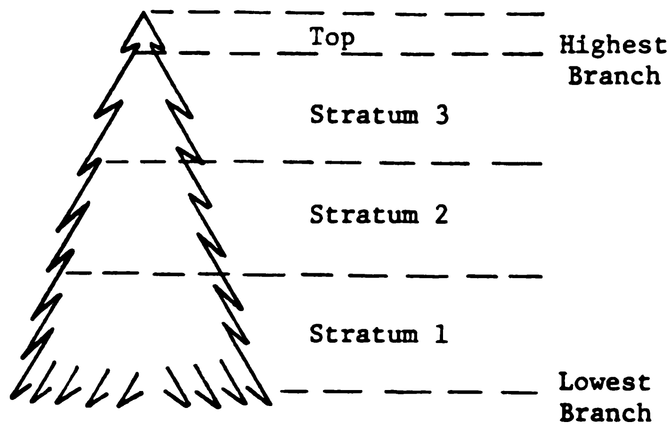


Figure 11. Diagram of a sampled tree--side view. Division of live crown into three strata and a top.

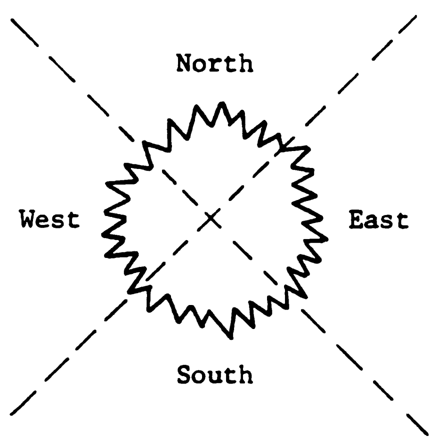


Figure 12. Diagram of a sampled tree--top view. Division of live crown into four quadrants.

V. RESULTS

Nine analyses were conducted to test for trends in egg mass size distribution within the sampled trees, between the sampled trees of each stand, and between the five stands. These analyses were conducted separately for egg masses from each tree species (balsam fir in Sections 1-5 and white spruce in Sections 11-12). Six analyses were made to test for trends in egg mass size distribution between the two tree species within each stand and between the tree species over all five stands (Sections 11-12).

Prior to each analysis, the assumptions of normality and homogeneity were tested with the appropriate data group. These tests were made with SPSS's (Nie et al. 1975) "Subprogram Condescriptive" (normality) and "Subprogram T-TEST" (homogeneity). These computer programs were incorporated earlier in the study and are described in Appendix F. The normality and homogeneity test results for each analysis are presented in separate tables in Appendix F and will be subsequently referred to in the corresponding sections.

"Subprogram Oneway," SPSS, (Nie et al. 1975), pages 422-433, was used to compute the mean numbers of eggs per mass, standard deviations, standard errors, and confidence intervals for the means of the specific groups of egg masses under investigation in Sections 1-12. These estimated values are reported in their more relevant and familiar untransformed scale.

One-way analysis of variance was also conducted with "Subprogram Oneway," SPSS, (Nie et al. 1975). The statistical package tested for significant differences between the groups of transformed egg counts in each section. In four cases the square root transformation did not yield

distributions that satisfied the assumptions of normality and/or homogeneity. With those groups of egg counts, a nonparametric rank test was incorporated to test for significant differences.

Section I. An Analysis of Quadrant Effects on the Size of Spruce Budworm Egg Masses on Balsam Fir

This analysis was designed to answer the question, "Do spruce budworm populations tend to lay significantly larger or smaller size egg masses on (a) particular side(s) of balsam fir trees?" The estimated numbers of eggs per mass from the data pool were transformed into square roots and the assumptions of normality and homogeneity were satisfied (Table F3) for each group of egg counts from the four quadrants--North, East, South and West--over all 12 sampled balsam fir trees.

"Subprogram Oneway," SPSS, (Nie et al. 1975), pages 422-433, calculates means, standard deviations, standard errors, and confidence intervals for the means. These results are presented in Table 3.

One-way analysis of variance was used to test if observed differences of egg mass size between the four designated quadrants were due to chance or whether they were indicative of actual differences between the four population means. The significance test was performed on the transformed data, again with "Subprogram Oneway," SPSS, (Nie et al. 1975). The results strongly indicate that the mean number of eggs per egg mass does not significantly differ from one side of a balsam fir tree to another ($p > 0.69$) (Table 4).

Table 3. The mean number of eggs per egg mass (transformed back into original form) from the north, east, south, and west quadrants of balsam fir trees.

Quadrant	Sample Size	Mean No. Eggs/Mass	Standard Deviation	Standard Error	95% Confidence Interval for the Mean
North	49	22.61	8.54	1.22	20.16 to 25.06
East	60	25.17	10.34	1.33	22.50 to 27.84
South	59	24.67	11.36	1.48	21.71 to 27.63
West	60	23.85	10.10	1.30	21.24 to 26.46
Total	228	24.14			

Table 4. Anova table for data in Table 3—Analysis of differences in the mean number of eggs per egg mass between four quadrants within balsam fir trees.

Source of Variation	Degrees of Freedom	Sum of Squares*	Mean Squares*	F Ratio*	F Probability*
Between Quadrants	3	1.611	0.537	0.483	0.695 (ns)
Within Quadrant	224	249.205	1.112		
Total	227	250.816			

*These statistics were computed with the data transformed into square root form. The statistics from the untransformed data were mean squares (between groups) = 66.399, mean squares (within groups) = 104.042, F ratio = 0.638, and F probability = 0.591.

Section 2. An Analysis of Stratum Effects on the Size of Spruce Budworm Egg Masses on Balsam Fir

This analysis was designed to answer the question, "Do spruce budworm populations tend to lay significantly larger or smaller size egg masses at (a) particular height(s) within balsam fir trees?" The assumptions of normality and homogeneity were met with the data groups transformed into square roots (Table F4). Means were computed (Table 5) and egg mass size between 3 height divisions within the 12 sampled balsam fir trees was tested to determine if observed differences were attributable to chance or whether they indicated actual differences between the three means. The result of the one-way analysis of variance test (transformed egg counts by strata) indicates that the mean number of eggs per egg mass does not significantly differ from one height division to another ($p > 0.40$) (Table 6) within balsam fir trees. However, there may be biological significance in the larger egg mass size found on the lower stratum.

Table 5. The mean number of eggs per egg mass (transformed back into original form) from the lower, middle, and upper strata of balsam fir trees.

Stratum	Sample Size	Mean No. Eggs/Mass	Standard Deviation	Standard Error	95% Confidence Interval for the Mean
Lower	21	26.74	11.65	2.54	21.43 to 32.04
Middle	91	24.52	10.62	1.11	22.31 to 26.73
Upper	116	23.38	9.52	0.88	21.63 to 25.13
Total	228	24.14			

Table 6. Anova table for data in Table 5--Analysis of differences in the mean number of eggs per egg mass between three strata within balsam fir trees.

Source of Variation	Degrees of Freedom	Sum of Squares*	Mean Squares*	F Ratio*	F Probability*
Between Strata	2	2.023	1.011	0.915	0.402 (ns)
Within Strata	225	248.794	1.106		
Total	227	250.816			

*These statistics were computed with the data transformed into square root form. The statistics from the untransformed data were mean squares (between groups) = 110.886, mean squares (within groups) = 103.479, F ratio = 1.072, and F probability = 0.344.

Section 3. An Analysis of the Effects of 13 Cells (Predesignated Compartments Within Balsam Fir Trees) on the Size of Spruce Budworm Egg Masses

This analysis incorporated egg counts from the tops of balsam fir trees and tested for effects between all cells within 12 sampled balsam fir trees (cells were described on page 28). It was designed to answer the question, "Do spruce budworm populations tend to lay significantly larger or smaller sized egg masses at one or more of the 13 cells within balsam fir trees?"

The assumptions of normality and homogeneity were satisfied with the egg counts from the cell groups transformed into square roots (Table F5). Mean number of eggs per egg mass were calculated for each cell over the 12 sampled balsam fir trees (Table 7). One-way analysis of variance was used to test for significance in observed differences in egg mass size between the 13 cells. The results clearly indicate that the mean number of eggs per egg mass does not significantly differ from one location to another within the sampled balsam fir trees ($p > 0.84$) (Table 8).

Table 7. The mean number of eggs per egg mass (transformed back into original form) from thirteen cells within balsam fir trees.

Cell	Sample Size	Mean No. Eggs/Mass	Standard Deviation	Standard Error	95% Confidence Interval for the Mean
Lower North	4	22.25	4.72	2.36	14.74 to 29.76
Lower East	7	27.86	12.05	4.55	16.72 to 39.00
Lower South	3	34.17	13.99	8.07	-0.57 to 68.91
Lower West	7	25.00	13.60	5.14	12.42 to 37.58
Middle North	18	22.56	8.71	2.05	18.23 to 26.88
Middle East	21	26.43	9.74	2.13	22.00 to 30.86
Middle South	26	25.08	12.35	2.42	20.09 to 30.07
Middle West	26	23.77	10.92	2.14	19.36 to 28.18
Upper North	27	22.70	9.08	1.75	19.11 to 26.29
Upper East	32	23.75	10.45	1.85	19.98 to 27.52
Upper South	30	23.37	10.08	1.84	19.60 to 27.13
Upper West	27	23.63	8.60	1.66	20.23 to 27.03
Top	22	21.36	11.02	2.35	16.48 to 26.25
Total	250	23.90			

Table 8. Anova table for data in Table 7—Analysis of differences in the mean number of eggs per egg mass between thirteen cells within balsam fir trees.

Source of Variation	Degrees of Freedom	Sum of Squares*	Mean Squares*	F Ratio*	F Probability*
Between Cells	12	8.183	0.682	0.601	0.840 (ns)
Within Cells	237	268.829	1.134		
Total	249	277.012			

*These statistics were computed with the data transformed into square root form. The statistics from the untransformed data were mean squares (between groups) = 69.987, mean Squares (within groups) = 107.050, F ratio = 0.654, and F probability = 0.794.

Section 4. Analysis of Inter-Tree Effects on Spruce Budworm Egg Mass Size on Balsam Fir Within Five Stands

Do spruce budworm populations exhibit a tendency to lay significantly larger or smaller sized egg masses on particular balsam fir trees within a stand? Data from the five isolated stands were analyzed to answer this question. Since intra-tree differences in egg mass size were not significant (Sections 1, 2 and 3), the egg mass measurements were pooled together for inter-tree study.

The assumptions of normality and homogeneity were met for the transformed data from each stand (Tables F6, F7, F8, F9 and F10). The mean number of eggs per egg mass from each balsam fir tree within stands 1, 2, 3, 4 and 5 are reported in Tables 9, 11, 13, 15 and 17, respectively. One-way analysis of variance was conducted to test if observed differences of egg mass size on the sampled trees within a stand were due to chance or whether they were indicative of actual differences between the population means. An anova table was computed for each stand (Tables 10, 12, 14, 16 and 18). The mean number of eggs per egg mass did not significantly differ from one tree to another within Stand 1 ($p > 0.77$) (Table 10), Stand 2 ($p > 0.13$) (Table 12), Stand 3 ($p > 0.52$) (Table 16). However, egg mass size was significantly different between the two sampled balsam fir trees in Stand 5 ($p > 0.01$) (Table 18). Egg masses from Balsam Fir 1 had approximately 7 eggs per egg mass less than egg masses from Balsam Fir 2 in absolute terms.

Table 9. The mean number of eggs per egg mass (transformed back into original form) from four balsam fir trees within Stand I.

Tree	Sample Size	Mean No. Eggs/Mass	Standard Deviation	Standard Error	95% Confidence Interval for the Mean
BF1	6	24.83	12.46	5.09	11.75 to 37.91
BF2	30	25.30	10.44	1.91	21.40 to 29.20
BF5	11	22.00	9.38	2.83	1.570 to 28.30
BF6	23	23.30	14.38	3.00	17.09 to 29.52
Total	70	24.09			

Table 10. Anova table for data in Table 9--Analysis of differences in the mean number of eggs per egg mass between four balsam fir trees within Stand I.

Source of Variation	Degrees of Freedom	Sum of Squares*	Mean Squares*	F Ratio*	F Probability*
Between Trees	3	1.569	0.523	0.365	0.778 (ns)
Within Trees	66	94.511	1.432		
Total	69	96.080			

*These statistics were computed with the data transformed into square root form. The statistics from the untransformed data were mean squares (between groups) = 36.494, mean squares (within groups) = 141.848, F ratio = 0.257, and F probability = 0.856.

Table 11. The mean number of eggs per egg mass (transformed back into original form) from two balsam fir trees within Stand 2.

Tree	Sample Size	Mean No. Eggs/Mass	Standard Deviation	Standard Error	95% Confidence Interval for the Mean
BF1	24	20.29	8.95	1.83	16.51 to 24.07
BF2	22	24.68	10.34	2.21	20.10 to 29.27
Total	46	22.39			

Table 12. Anova table for data in Table 11--Analysis of the difference in the mean number of eggs per egg mass between two balsam fir trees within Stand 2.

Source of Variation	Degrees of Freedom	Sum of Squares*	Mean Squares*	F Ratio*	F Probability*
Between Trees	1	2.311	2.311	2.278	0.138 (ns)
Within Trees	44	44.648	1.015		
Total	45	46.960			

*These statistics were computed with the data transformed into square root form. The statistics from the untransformed data were mean squares (between groups) = 221.226, mean squares (within groups) = 92.948, F ratio = 2.380, and F probability = 0.130.

Table 13. The mean number of eggs per egg mass (transformed back into original form) from two balsam fir trees within Stand 3.

Tree	Sample Size	Mean No. Eggs/Mass	Standard Deviation	Standard Error	95% Confidence Interval for the Mean
BF1	21	26.24	11.40	2.49	21.05 to 31.43
BF2	17	23.76	11.80	2.86	17.70 to 29.83
Total	38	25.13			

Table 14. Anova table for data in Table 13--Analysis of the difference in the mean number of eggs per egg mass between two balsam fir trees within Stand 3.

Source of Variation	Degrees of Freedom	Sum of Squares*	Mean Squares*	F Ratio*	F Probability*
Between Trees	1	0.561	0.561	0.412	0.525 (ns)
Within Trees	36	49.086	1.364		
Total	37	49.648			

*These statistics were computed with the data transformed into square root form. The statistics from the untransformed data were mean squares (between groups) = 57.474, mean squares (within groups) = 134.135, F ratio = 0.428, and F probability = 0.517.

Table 15. The mean number of eggs per egg mass (transformed back into original form) from two balsam fir trees within Stand 4.

Tree	Sample Size	Mean No. Eggs/Mass	Standard Deviation	Standard Error	95% Confidence Interval for the Mean
BF1	36	23.58	9.57	1.60	20.34 to 26.82
BF2	32	25.19	10.11	1.79	21.54 to 28.83
Total	68	24.34			

Table 16. Anova table for data in Table 15--Analysis of the difference in the mean number of eggs per egg mass between two balsam fir trees within Stand 4.

Source of Variation	Degrees of Freedom	Sum of Squares*	Mean Squares*	F Ratio*	F Probability*
Between Trees	1	0.418	0.418	0.417	0.521 (ns)
Within Trees	66	66.149	1.002		
Total	67	66.567			

*These statistics were computed with the data transformed into square root form. The statistics from the untransformed data were mean squares (between groups) = 43.596, mean squares (within groups) = 96.600, F ratio = 0.451, and F probability = 0.504.

Table 17. The mean number of eggs per egg mass (transformed back into original form) from two balsam fir trees within Stand 5.

Tree	Sample Size	Mean No. Eggs/Mass	Standard Deviation	Standard Error	95% Confidence Interval for the Mean
BF1	35	19.91	8.55	1.44	16.98 to 22.85
BF2	27	27.02	10.95	2.11	22.69 to 31.35
Total	62	23.01			

Table 18. Anova table for data in Table 17--Analysis of the difference in the mean number of eggs per egg mass between two balsam fir trees within Stand 5.

Source of Variation	Degrees of Freedom	Sum of Squares*	Mean Squares*	F Ratio*	F Probability*
Between Trees	1	8.159	8.159	7.905	0.007 (s)
Within Trees	60	61.933	1.003		
Total	61	70.092			

*These statistics were computed with the data transformed into square root form. The statistics from the untransformed data were mean squares (between groups) = 769.262, mean squares (within groups) = 93.350, F ratio = 8.241, and F probability = 0.006.

Section 5. An Analysis of Inter-Stand Effects on Spruce Budworm Egg Mass Size on Balsam Fir Within a Forest Complex

This analysis was designed to answer the question, "Do spruce budworm populations lay significantly larger or smaller sized egg masses on balsam fir in different stands?" The measured egg masses that had been pooled for each balsam fir tree (Section 4) were re-pooled over each stand. The transformed egg counts met the assumptions of normality and homogeneity (Table F11 in Appendix F).

"Subprogram Oneway," SPSS (Nie et al. 1975) was again implemented to calculate means (Table 19) and to test if observed differences of egg mass size were due to chance or whether they were indicative of actual differences in the five population means. The results of this one-way analysis of variance indicated that the mean number of eggs per egg mass from balsam fir trees did not significantly differ between five stands with similar levels of defoliation ($p > 0.62$) (Table 20).

Table 19. The mean number of eggs per egg mass (transformed back into original form) from ten balsam fir trees in five stands in the Ottawa National Forest.

Stand	Sample Size	Mean No. Eggs/Mass	Standard Deviation	Standard Error	95% Confidence Interval for the Mean
1	36	25.22	10.60	1.77	21.63 to 28.81
2	46	22.39	9.79	1.44	19.48 to 25.30
3	38	25.13	11.49	1.86	21.35 to 28.91
4	68	24.34	9.79	1.19	21.97 to 26.71
5	62	23.00	10.22	1.30	20.41 to 25.60
Total	250	23.90			

Table 20. Anova table for data in Table 19--Analysis of the difference in the mean number of eggs per egg mass between balsam fir trees in five spruce-fir stands.

Source of Variation	Degrees of Freedom	Sum of Squares*	Mean Squares*	F Ratio*	F Probability*
Between Stands	4	2.951	0.738	0.660	0.621 (ns)
Within Stands	245	274.061	1.119		
Total	249	277.012			

*These statistics were computed with the data transformed into square root form. The statistics from the untransformed data were mean squares (between groups) = 71.915, mean squares (within groups) = 105.808, F ratio = 0.680, and F probability = 0.607.

Section 6. An Analysis of Quadrant Effects on the Size of Spruce Budworm Egg Masses on White Spruce

With this section I begin analyzing various intra- and inter-tree effects on the size of egg masses from white spruce. This analysis was designed to answer the question, "Do spruce budworm populations tend to lay significantly larger or smaller size egg masses on (a) particular side(s) of white spruce trees?" The assumptions of normality and homogeneity were satisfied for the transformed egg counts from the four quadrants--North, East, South, and West--over all 10 sampled white spruce trees (Table F12). Table 21 presents the mean number of eggs per mass per quadrant. The one-way analysis of variance test revealed that the average number of eggs per mass is not significantly different between the four pre-designated sides of balsam fir trees ($p > 0.82$) (Table 22).

Table 21. The mean number of eggs per egg mass (transformed back into original form) from the north, east, south, and west quadrants of white spruce trees.

Quadrant	Sample Size	Mean No. Eggs/Mass	Standard Deviation	Standard Error	95% Confidence Interval for the Mean
North	71	20.27	7.78	0.92	18.43 to 22.11
East	97	20.45	8.16	0.83	18.81 to 22.10
South	100	21.22	8.80	0.88	19.47 to 22.96
West	79	21.54	9.50	1.07	19.42 to 23.67
Total	347	20.88			

Table 22. Anova table for data in Table 21—Analysis of the difference in the mean number of eggs per egg mass between four quadrants within white spruce trees.

Source of Variation	Degrees of Freedom	Sum of Squares*	Mean Squares*	F Ratio*	F Probability*
Between Quadrants	3	0.769	0.256	0.297	0.827 (ns)
Within Quadrants	343	295.996	0.863		
Total	346	296.765			

*These statistics were computed with the data transformed into square root form. The statistics from the untransformed data were mean squares (between groups) = 30.181, mean squares (within groups) = 73.921, F ratio = 0.408, and F probability = 0.747.

Section 7. An Analysis of Stratum Effects on the Size of Spruce Budworm Egg Masses on White Spruce

Do spruce budworm populations tend to lay significantly larger or smaller size egg masses at (a) particular height(s) within white spruce trees? Egg counts from the lower, middle and upper strata of live crowns from the ten sampled white spruce trees were aggregated to answer this question.

The assumptions of normality and homogeneity were met with the data transformed into square roots (Table F13). The mean number of eggs per mass per stratum are reported in Table 23. Statistically, the differences in egg mass size are not significant at the α-level of 0.05 ($p > 0.05$) (Table 24). However, as in Section 2--stratum effects on egg mass size on balsam fir--there may be biological significance to the smaller size of egg masses found in the upper stratum.

Table 23. The mean number of eggs per egg mass (transformed back into original form) from the lower, middle, and upper strata of white spruce trees.

Stratum	Sample Size	Mean No. Eggs/Mass	Standard Deviation	Standard Error	95% Confidence Interval for the Mean
Lower	73	21.74	9.16	1.07	19.60 to 23.88
Middle	136	21.76	8.62	0.74	20.30 to 23.23
Upper	138	19.56	8.10	0.69	18.20 to 20.93
Total	347	20.88			

Table 24. Anova table for data in Table 23—Analysis of the difference in the mean number of eggs per egg mass between three strata within white spruce trees.

Source of Variation	Degrees of Freedom	Sum of Squares*	Mean Squares*	F Ratio*	F Probability*
Between Strata	2	4.952	2.476	2.919	0.055 (ns)
Within Strata	344	291.813	0.848		
Total	346	296.765			

*These statistics were computed with the data transformed into square root form. The statistics from the untransformed data were mean squares (between groups) = 199.739, mean Squares (within groups) = 72.808, F ratio = 2.743, and F probability = 0.066.

Section 8. An Analysis of the Effects of Thirteen Cells (Predesignated Compartments Within White Spruce Trees) on the Size of Spruce Budworm Egg Masses

Egg counts from the tops of the 10 sampled white spruce trees were incorporated with the egg counts from the other portions of the 10 sampled trees to test for effects between all 13 cells. This analysis was designed to answer the question, "Do spruce budworm populations tend to lay larger or smaller sized egg masses at one or more of the 13 cells within white spruce trees?"

Table F14 shows that the assumptions of normality and homogeneity were satisfied with the groups of egg counts transformed into square roots. The mean number of eggs per egg mass per cell are reported in Table 25. The results of the one-way analysis of variance are presented in Table 26. The mean number of eggs per egg mass does not significantly differ from one location to another within the sampled white spruce trees ($p > 0.20$).

Table 25. The mean number of eggs per egg mass (transformed back into original form) from thirteen cells within white spruce trees.

Cell	Sample Size	Mean No. Eggs/Mass	Standard Deviation	Standard Error	95% Confidence Interval for the Mean
Lower North	10	22.50	10.10	3.19	15.27 to 29.73
Lower East	24	20.92	8.56	1.75	17.30 to 24.53
Lower South	29	23.59	9.76	1.81	19.88 to 27.30
Lower West	10	17.60	7.29	2.31	12.38 to 22.82
Middle North	28	20.32	6.77	1.28	17.70 to 22.95
Middle East	37	22.32	8.53	1.40	19.48 to 25.17
Middle South	36	19.94	8.09	1.35	17.21 to 22.68
Middle West	35	24.20	10.12	1.71	20.72 to 27.68
Upper North	33	19.55	7.93	1.38	16.73 to 22.36
Upper East	36	18.22	7.13	1.19	15.81 to 20.64
Upper South	35	20.57	8.54	1.44	17.63 to 23.50
Upper West	34	19.97	8.88	1.52	16.87 to 23.07
Top	25	21.48	10.06	2.01	17.33 to 25.63
Total	372	20.92			

Table 26. Anova table for data in Table 25--Analysis of the difference in the mean number of eggs per egg mass between thirteen cells within white spruce trees.

Source of Variation	Degrees of Freedom	Sum of Squares*	Mean Squares*	F Ratio*	F Probability*
Between Cells	12	13.605	1.134	1.315	0.208 (ns)
Within Cells	359	309.528	0.862		
Total	371	323.133			

*These statistics were computed with the data transformed into square root form. The statistics from the untransformed data were mean squares (between groups) = 100.198, mean Squares (within groups) = 74.316, F ratio = 1.3482.743, and F probability = 0.189.

Section 9. Analysis of Inter-Tree Effects on Spruce Budworm Egg Mass Size on White Spruce Within Five Stands

Data from the five isolated stands were analyzed to determine if spruce budworm populations exhibit a tendency to lay significantly larger or smaller size egg masses on particular white spruce trees within each stand. Since intra-tree differences in egg mass size were not statistically significant (Sections 6, 7 and 8), the egg counts were pooled together for inter-tree study.

Each data group did not depart significantly from the desired normal distribution and each group of variances was significantly homogeneous (Tables F15, F16, F17, F18 and F19). The mean number of eggs per egg mass per white spruce tree within Stands 1, 2, 3, 4 and 5 are reported in Tables 27, 29, 31, 33 and 35, respectively. The egg counts from each of the two white spruce trees within each stand were tested to see if the observed differences in average egg mass size were significant.

Five one-way analyses of variance tests were conducted and the results are reported in Tables 28, 30, 32, 34 and 36. The mean number of eggs per egg mass did not significantly differ between the two white spruce trees within Stand 1 ($p > 0.87$ (Table 28), Stand 3 ($p > 0.41$) (Table 32), Stand 4 ($p > 0.06$) (Table 34), or Stand 5 ($p > 0.45$) (Table 36). Statistically, egg mass size was significantly different between the two sampled white spruce trees in Stand 2 (pF 0.02) (Table 30). Egg masses from White Spruce 1 had an average of approximately 5 eggs per mass greater than egg masses from White Spruce 2 in absolute values.

Table 27. The mean number of eggs per egg mass (transformed back into original form) from two white spruce trees within Stand I.

Tree	Sample Size	Mean No. Eggs/Mass	Standard Deviation	Standard Error	95% Confidence Interval for the Mean
WS1	37	23.30	9.45	1.45	20.15 to 26.45
WS2	33	23.09	10.29	1.79	19.44 to 26.74
Total	70	23.20			

Table 28. Anova table for data in Table 27--Analysis of the difference in the mean number of eggs per egg mass between two white spruce trees within Stand I.

Source of Variation	Degrees of Freedom	Sum of Squares*	Mean Squares*	F Ratio*	F Probability*
Between Trees	1	0.027	0.027	0.025	0.874 (ns)
Within Trees	68	71.896	1.057		
Total	69	71.923			

*These statistics were computed with the data transformed into square root form. The statistics from the untransformed data were mean squares (between groups) = 0.7430, mean squares (within groups) = 97.066, F ratio = 0.008, and F probability = 0.930.

Table 29. The mean number of eggs per egg mass (transformed back into original form) from two white spruce trees within Stand 2.

Tree	Sample Size	Mean No. Eggs/Mass	Standard Deviation	Standard Error	95% Confidence Interval for the Mean
WS1	46	21.57	8.23	1.21	19.12 to 24.01
WS2	27	16.89	6.96	1.34	14.13 to 19.64
Total	73	19.84			

Table 30. Anova table for data in Table 29--Analysis of the difference in the mean number of eggs per egg mass between two white spruce trees within Stand 2.

Source of Variation	Degrees of Freedom	Sum of Squares*	Mean Squares*	F Ratio*	F Probability*
Between Trees	1	4.937	4.937	6.808	0.011 (s)
Within Trees	71	51.483	0.725		
Total	72	56.420			

*These statistics were computed with the data transformed into square root form. The statistics from the untransformed data were mean squares (between groups) = 372.056, mean Squares (within groups) = 60.648, F ratio = 6.135, and F probability = 0.016.

Table 31. The mean number of eggs per egg mass (transformed back into original form) from two white spruce trees within Stand 3.

Tree	Sample Size	Mean No. Eggs/Mass	Standard Deviation	Standard Error	95% Confidence Interval for the Mean
WS1	28	20.29	6.38	1.21	17.81 to 22.76
WS2	40	18.95	5.66	0.90	17.14 to 20.76
Total	68	19.50			

Table 32. Anova table for data in Table 31—Analysis of the difference in the mean number of eggs per egg mass between two white spruce trees within Stand 3.

Source of Variation	Degrees of Freedom	Sum of Squares*	Mean Squares*	F Ratio*	F Probability*
Between Trees	1	0.320	0.320	0.666	0.417 (ns)
Within Trees	66	31.768	0.481		
Total	67	32.089			

*These statistics were computed with the data transformed into square root form. The statistics from the untransformed data were mean squares (between groups) = 29.386, mean squares (within groups) = 35.600, F ratio = 0.825, and F probability = 0.367.

Table 33. The mean number of eggs per egg mass (transformed back into original form) from two white spruce trees within Stand 4.

Tree	Sample Size	Mean No. Eggs/Mass	Standard Deviation	Standard Error	95% Confidence Interval for the Mean
WS1	48	22.27	10.63	1.54	19.18 to 25.36
WS2	44	18.32	8.68	1.31	15.68 to 20.96
Total	92	20.38			

Table 34. Anova table for data in Table 33—Analysis of the difference in the mean number of eggs per egg mass between two white spruce trees within Stand 4.

Source of Variation	Degrees of Freedom	Sum of Squares*	Mean Squares*	F Ratio*	F Probability*
Between Trees	1	3.856	3.856	3.432	0.067 (ns)
Within Trees	90	101.096	1.123		
Total	91	104.951			

*These statistics were computed with the data transformed into square root form. The statistics from the untransformed data were mean squares (between groups) = 358.660, mean squares (within groups) = 95.078, F ratio = 3.772, and F probability = 0.055.

Table 35. The mean number of eggs per egg mass (transformed back into original form) from two white spruce trees within Stand 5.

Tree	Sample Size	Mean No. Eggs/Mass	Standard Deviation	Standard Error	95% Confidence Interval for the Mean
WS1	45	22.48	8.55	1.27	19.92 to 25.05
WS2	24	20.79	7.72	1.58	17.53 to 24.05
Total	69	21.90			

Table 36. Anova table for data in Table 35--Analysis of difference in the mean number of eggs per egg mass between two white spruce trees within Stand 5.

Source of Variation	Degrees of Freedom	Sum of Squares*	Mean Squares*	F Ratio*	F Probability*
Between Trees	1	0.426	0.426	0.571	0.453 (ns)
Within Trees	67	49.960	0.746		
Total	68	50.385			

*These statistics were computed with the data transformed into square root form. The statistics from the untransformed data were mean squares (between groups) = 44.851, mean squares (within groups) = 68.416, F ratio = 0.656, and F probability = 0.421.

Section 10. An Analysis of Inter-Stand Effects on Spruce Budworm Egg Mass Size From White Spruce Within a Forest Complex

The egg counts from the two sampled white spruce trees within each stand were combined for an average number of eggs per mass per stand. This analysis was designed to answer the question, "Do spruce budworm populations lay significantly larger or smaller size egg masses on white spruce in five stands?"

Table F20 shows that the assumption of normality was met but the variances were not homogeneous ($p = 0.003$). However, "Subprogram Oneway," SPSS (Nie et al. 1975) was again implemented to calculate the mean egg mass size per stand (Table 37) and to test if observed differences of egg mass size were due to chance or whether they were indicative of actual differences in the five population means. Results reported in Table 38 indicate that the average egg mass size did not significantly differ from stand to stand on the white spruce trees ($p > 0.07$).

Because heteroscedacity may have affected the outcome of the test, a nonparametric rank test, the Kruskal-Wallis Test, was used to reaffirm or nullify the original test results. Conover (1980) provides an excellent explanation and examples of this test on pages 229-237 of his text. Table 39 relates the sum of the ranks and sample sizes of the egg counts from each stand.

The Kruskal-Wallis Test is designed to determine if the null hypothesis, the k populations do all have identical means, should be rejected. Since there were many equal ranks (ties), tie decision rule was based on the chi-square distribution with 4 degrees of freedom at the α-level, 0.05. since the test statistic, $T = 7.394$, was less than the 0.95 quantile, $\chi^2 = 9.488$, the null hypothesis was again accepted and the mean number of eggs per mass per stand on white spruce are not significantly different ($p > 0.10$).

Table 37. The mean number of eggs per egg mass (transformed back into original form) from ten white spruce trees in five stands in the Ottawa National Forest.

Stand	Sample Size	Mean No. Eggs/Mass	Standard Deviation	Standard Error	95% Confidence Interval for the Mean
1	70	23.20	9.78	1.17	20.87 to 25.53
2	73	19.84	8.06	0.94	17.95 to 21.72
3	68	19.50	5.96	0.72	18.06 to 20.94
4	92	20.38	9.90	1.03	18.33 to 22.43
5	69	21.90	8.25	0.99	19.91 to 23.88
Total	372	20.92			

Table 38. Anova table for data in Table 37—Analysis of the difference in the mean number of eggs per egg mass between white spruce trees in five stands in the Ottawa National Forest.**

Source of Variation	Degrees of Freedom	Sum of Squares*	Mean Squares*	F Ratio*	F Probability*
Between Stands	4	7.366	1.841	2.140	0.075 (ns)
Within Stands	367	315.768	0.860		
Total	371	323.133			

*These statistics were computed with the data transformed into square root form. The statistics from the untransformed data were mean squares (between groups) = 169.825, mean squares (within groups) = 74.121, F ratio = 2.291, and F probability = 0.059.

**NOTE:The assumption of homogeneity of variances was not satisfied with this data set. Refer to the alternative test (Kruskal-Wallis) on page 64.

Table 39. Results of the Kruskal-Wallis test, comparing mean egg mass sizes on white spruce between all 5 stands.

Stand(i)	n_i	R_i
1	70	14,789
2	73	12,645
3	68	12,042
4	92	16,001
5	69	13,883

$$T = \frac{1}{S^2}\left(\sum_{i=1}^{K} \frac{Ri^2}{ni} - \frac{N(N+1)^2}{4}\right)$$

= the test statistic

where:

$$S^2 = \frac{1}{N-1}\left(\sum_{\substack{\text{all} \\ \text{ranks}}} R\left(X_{ij}\right)^2 - N\frac{(N+1)^2}{4}\right)$$

R_i = sum of ranks of egg masses for stand i

i = stand number

k = total number of stands
= 5

N = total number of ranks (egg masses)
= 372

n_i = number of ranks (egg masses) per stand

$\sum_{\substack{\text{all} \\ \text{ranks}}} R(X_{ij})^2$ = Σ (individual ranks)^2

= 17,183,967.5

S^2 = 11,441.969

T = 7.394(NS)

Section 11. Analysis of Inter-Species (Trees) Effects on Spruce Budworm Egg Mass Size Within Each Stand

Five analyses were conducted to answer the question, "Do spruce budworm populations tend to lay larger or smaller size egg masses on white spruce or balsam fir in a stand?" The egg counts from the two trees of the same species within each stand were aggregated for comparison of mean egg mass size.

The data were transformed into square roots to test the assumptions of normality and homogeneity (Tables F21-F25). In two cases, Stand 3 (Table F23) and Stand 5 (Table 25), the variances were significantly different from the desired homogeneous form ($p = 0.000$) and ($p = 0.080$), respectively. Each significance test was performed with the one-way analysis of variance method; however, data in Stands 3 and 5 were also analyzed with nonparametric statistics--the Mann-Whitney Test for two independent samples.

Tables 40, 42, 44, 47 and 49 present the mean number of eggs per mass per species per stand. Tables 41, 43, 45 and 46, 48, 50 and 51 present the results of the tests for significant differences between mean egg mass size per species in Stands 1, 2, 3, 4 and 5, respectively. Differences in the mean numbers of eggs per mass between the white spruce and balsam fir species was statistically significant in Stand 3 ($p < 0.01$) and Stand 4 ($p < 0.01$). Mean egg mass size was not significantly different between the two tree species in Stand 1 ($p > 0.35$), Stand 2 ($p > 0.14$) or Stand 5 ($p > 0.65$). However, there may be biological significance in the larger average number of eggs per mass from balsam fir as opposed to white spruce. This trend was evident in each stand, with egg masses on balsam fir containing an average of 1.1 to 5.6 more eggs per mass per stand than the egg masses on white spruce in absolute terms.

Heteroskedasticity may have affected the results of tests on data in Stands 3 and 5. Therefore, nonparametric statistics were utilized to re-analyze the observed differences in egg mass size. Conover (1980) describes the Mann-Whitney Test on pages 215-227 of his text. The Kruskal-Wallis Test, used in Section 10, is merely an extension of the Mann-Whitney Test. Again, the numbers of eggs per sampled egg mass were ranked in ascending order, with the rank 1 assigned as the value of the smallest number of eggs per mass in the data base. The individual ranks were summed for each species from each stand and these sums are reported in Table 46 (Stand 3) and Table 51 (Stand 5), along with the test statistic and computational formulae. Results of the two-tailed tests confirmed the original result that had been computed with parametric statistics. Balsam fir had significantly different size egg masses than white spruce in Stand 3 ($p < 0.01$) and balsam fir and white spruce egg masses were not significantly different in Stand 5 ($p > 0.65$).

Table 40. The mean number of eggs per egg mass (transformed back into original form) from white spruce and balsam fir trees in Stand 1.

Trees	Sample Size	Mean No. Eggs/Mass	Standard Deviation	Standard Error	95% Confidence Interval for the Mean
BF1 & BF2	36	25.22	10.60	1.77	21.63 to 28.81
WS1 & WS2	70	23.20	9.78	1.17	20.87 to 25.53
Total	106	23.89			

Table 41. Anova table for data in Table 39--Analysis of the difference in the mean number of eggs per egg mass between white spruce trees and balsam fir trees in Stand 1.

Source of Variation	Degrees of Freedom	Sum of Squares*	Mean Squares*	F Ratio*	F Probability*
Within Tree Species	1	0.944	0.944	0.871	0.353 (ns)
Between Tree Species	112.717	1.084			
Total	105	113.662			

*These statistics were computed with the data transformed into square root form. The statistics from the untransformed data were mean squares (between groups) = 97.219, mean squares (within groups) = 101.321, F ratio = 0.960, and F probability = 0.330.

Table 42. The mean number of eggs per egg mass (transformed back into original form) from white spruce and balsam fir trees in Stand 2.

Trees	Sample Size	Mean No. Eggs/Mass	Standard Deviation	Standard Error	95% Confidence Interval for the Mean
BF1 & BF2	46	22.39	9.79	1.44	19.48 to 25.30
WS1 & WS2	73	18.84	8.06	0.94	17.95 to 21.72
Total	119	20.82			

Table 43. Anova table for data in Table 41--Analysis of the difference in the mean number of eggs per egg mass between white spruce trees and balsam fir trees in Stand 2.

Source of Variation	Degrees of Freedom	Sum of Squares*	Mean Squares*	F Ratio*	F Probability*
Between Tree Species	1	1.860	1.860	2.105	0.150 (ns)
Within Tree Species	117	103.379	0.884		
Total	118	105.239			

*These statistics were computed with the data transformed into square root form. The statistics from the untransformed data were mean squares (between groups) = 184.310, mean Squares (within groups) = 76.829, F ratio = 2.399, and F probability = 0.124.

Table 44. The mean number of eggs per egg mass (transformed back into original form) from white spruce and balsam fir trees in Stand 3.

Trees	Sample Size	Mean No. Eggs/Mass	Standard Deviation	Standard Error	95% Confidence Interval for the Mean
BF1 & BF2	38	25.13	11.49	1.86	21.35 to 28.91
WS1 & WS2	68	19.50	5.96	0.72	18.06 to 20.94
Total	106	21.52			

Table 45. Anova table for data in Table 43—Analysis of the difference in the mean number of eggs per egg mass between white spruce trees and balsam fir trees in Stand 3.**

Source of Variation	Degrees of Freedom	Sum of Squares*	Mean Squares*	F Ratio*	F Probability*
Between Tree Species	1	6.566	6.566	8.354	0.005 (s)
Within Tree Species	104	81.737	0.786		
Total	105	88.302			

*These statistics were computed with the data transformed into square root form. The statistics from the untransformed data were mean squares (between groups) = 184.310, mean squares (within groups) = 76.829, F ratio = 2.399, and F probability = 0.124.

**NOTE: The assumption of homogeneity of variances was not satisfied with this data set. Refer to the alternative test (Mann-Whitney) on page 70.

Table 46. Results of the Mann-Whitney test, comparing mean egg mass size on white spruce with mean egg mass size on balsam fir in Stand 3.

Tree Species	Sample Size	$\sum_{i=1}^{n} R$
Balsam fir	38	2380
White spruce	68	3291

$$T_1 = \frac{T - n\frac{N+1}{2}}{\sqrt{\frac{nm}{N(N-1)}\sum_{i=1}^{N} R_i^2 - \frac{nm(N+1)^2}{4(N-1)}}}$$

= the test statistic when there are many tied ranks

where:

$T = \sum_{i=1}^{n} R$ (Balsam Fir)

= sum of the ranks assigned to the balsam fir egg counts
= 2380

$\sum_{i=1}^{n}$ = the sum of the squares of all N of the ranks
= 402,093.5

n = sample size from balsam fir

m = sample size from white spruce

N = n + m
= 106

T_1 = 2.292 (S)

Table 47. The mean number of eggs per egg mass (transformed back into original form) from white spruce and balsam fir trees in Stand 4.

Trees	Sample Size	Mean No. Eggs/Mass	Standard Deviation	Standard Error	95% Confidence Interval for the Mean
BF1 & BF2	68	24.34	9.79	1.19	21.97 to 26.71
WS1 & WS2	92	20.38	9.90	1.03	18.33 to 22.43
Total	160	22.06			

Table 48. Anova table for data in Table 45--Analysis of the difference in the mean number of eggs per egg mass between white spruce trees and balsam fir trees in Stand 4.

Source of Variation	Degrees of Freedom	Sum of Squares*	Mean Squares*	F Ratio*	F Probability*
Between Tree Species	1	7.807	7.807	7.192	0.008 (s)
Within Tree Species	158	171.518	1.086		
Total	159	179.325			

*These statistics were computed with the data transformed into square root form. The statistics from the untransformed data were mean squares (between groups) = 612.470, mean squares (within groups) = 97.056, F ratio = 6.310, and F probability = 0.013.

Table 49. The mean number of eggs per egg mass (transformed back into original form) from white spruce and balsam fir trees in Stand 5.

Trees	Sample Size	Mean No. Eggs/Mass	Standard Deviation	Standard Error	95% Confidence Interval for the Mean
BF1 & BF2	62	23.008	10.219	1.298	20.413 to 25.603
WS1 & WS2	69	21.896	8.250	0.993	19.914 to 23.878
Total	131	22.422			

Table 50. Anova table for data in Table 49--Analysis of the difference in the mean number of eggs per egg mass between white spruce trees and balsam fir trees in Stand 5.**

Source of Variation	Degrees of Freedom	Sum of Squares*	Mean Squares*	F Ratio*	F Probability*
Between Tree Species	1	0.192	0.192	0.206	0.651 (ns)
Within Tree Species	129	120.477	0.934		
Total	130	120.669			

*These statistics were computed with the data transformed into square root form. The statistics from the untransformed data were mean squares (between groups) = 40.411, mean squares (within groups) = 85.263, F ratio = 0.474, and F probability = 0.492.

**NOTE: The assumption of homogeneity of variances was not satisfied with this data set. Differences were tested for significance with the Mann-Whitney test on page 73.

Table 51. Results of the Mann-Whitney test, comparing mean egg mass size on white spruce with mean egg mass size on balsam fir in Stand 5.

Tree Species	Sample Size	$\sum_{i=1}^{n} R$
Balsam Fir	62	4202.5
White Spruce	69	4443.5

$$T_1 = \frac{T - n\frac{N+1}{2}}{\sqrt{\frac{nm}{N(N-1)} \sum_{i=1}^{N} R_i^2 - \frac{nm(N+1)^2}{4(N-1)}}}$$

= the test statistic when there are many tied ranks

where:

$T = \sum_{i=1}^{n} R$ (Balsam Fir)

= the sum of the ranks assigned to the balsam fir egg counts

= 4,202.5

$\sum_{i=1}^{n} R_i^2$ = the sum of the squares of all N of the ranks

= 757,309.5

n = sample size from balsam fir

m = sample size from white spruce

N = n + m
= 131

T_1 = 0.510 (NS)

Section 12. Analysis of Inter-Species (Trees) Effects on Spruce Budworm Egg Mass Size Within a Forest Complex

The final analysis was designed to answer the question, "Do spruce budworm populations lay larger or smaller size egg masses on balsam fir or white spruce trees?" All egg counts were aggregated into their respective host species group to test for significant difference between the two averages. Table 52 presents the average number of eggs per mass on the 10 sampled balsam fir trees (23.90) and the average number of eggs per mass on the 10 sampled white spruce trees (20.92) from all five stands.

The assumption of normality was confirmed, but variances were nonhomogeneous. Both parametric and nonparametric statistics were performed. Results of the one-way analysis of variance test strongly indicate that the mean number of eggs per mass is significantly different between egg masses on white spruce and egg masses on balsam fir (Table 53) ($p < 0.0001$). Results of the Mann-Whitney Test confirm the results of the parametric test (Table 54) ($p < 0.001$).

Table 52. The mean number of eggs per egg mass (transformed back into original form) from ten white spruce and ten balsam fir trees in five stands.

Species	Sample Size	Mean No. Eggs/Mass	Standard Deviation	Standard Error	95% Confidence Interval for the Mean
Balsam Fir	250	23.90	10.26	0.65	22.62 to 25.18
White Spruce	372	20.92	8.67	0.45	20.04 to 21.81
Total	622	22.12			

Table 53. Anova table for data in Table 52--Analysis of the difference in the mean number of eggs per egg mass between ten white spruce and ten balsam fir trees in five stands.

Source of Variation	Degrees of Freedom	Sum of Squares*	Mean Squares*	F Ratio*	F Probability*
Between Tree Species	1	13.059	13.059	13.491	0.000(s)
Within Tree Species	620	600.146	0.968		
Total	621	613.205			

*These statistics were computed with the data transformed into square root form. The statistics from the untransformed data were mean squares (between groups) = 1322.263, mean squares (within groups) = 87.246, F ratio = 15.156, and F probability = 0.000.

Table 54. Results of the Mann-Whitney test, comparing mean egg mass size on white spruce with mean egg mass size on balsam fir over all five stands.

Tree Species	Sample Size	$\sum_{i=1}^{n} R$
Balsam Fir	250	85,380
White Spruce	372	108,373

$$T_1 = \frac{T - n\frac{N+1}{2}}{\sqrt{\frac{nm}{N(N-1)}\sum_{i=1}^{N} R_i^2 - \frac{nm(N+1)^2}{4(N-1)}}}$$

= the test statistic when there are many tied ranks

where:

$T = \sum_{i=1}^{n} R$ (Balsam Fir)

= the sum of the ranks assigned to the balsam fir egg counts

= 85,380

$\sum_{i=1}^{n} R_i^2$ = the sum of the squares of all N of the ranks

= 80,350,396

n = sample size from balsam fir

m = sample size from white spruce

N = n + m
= 622

T = 3.420 (s)

VI. DISCUSSION

This thesis presents an analysis of the distribution of spruce budworm egg mass sizes within trees, between trees, between tree species, and between stands. A number of important trends were evident from the study results. These findings should improve the accuracy and precision of egg mass surveys, particularly when the sampled populations are at very low densities.

As I expressed in my first thesis (Montgomery 1981), spruce budworm investigators must refrain from incontestably applying quantitative results from one region to another. Regional and local diversity in stand structure, composition, and management activities span the boreal forest habitat of the spruce budworm. These factors and the year-to-year variability associated with the intricate effects of parasites, predators, rainfall, temperature, humidity, and available foliage nutrients and biomass play important and interrelated roles in determining population vigor, dynamics, and relevant egg mass size.

Therefore, I feel that it is important to restate the conditions of the five spruce fir stands that I studied and the conditions of the surrounding forest in general. The project was conducted in the summer of 1980 in the Ottawa National Forest, located in the western half of Michigan's Upper Penninsula. In the majority of spruce fir stands, the spruce budworms were in their fifth to tenth year at outbreak densities, as shown by severe defoliation, an abundance of top-kill, and tree mortality. Management in the Upper Peninsula has generally refrained from chemical control in spruce-fir stands and have rarely made a conscientious effort to implement silvicultural control or prevention measures. This stems from the spotty demand for spruce or fir in the market; however, higher demand will apparently come into effect in the near future.

The maximum size of spruce-fir stands in the Ottawa National Forest is about 80 hectares, with most in the range of 16 hectares or less. They grow in isolated pockets, are often intermixed with hardwoods, and generally consist of a variety of soil types, influenced by enormous variability in past ecological perturbations within each site (particularly glacial deposits and fires).

The five stands that I sampled for this study were all experiencing low spruce budworm defoliation and population levels. Defoliation of current foliage ranged from 0 to 30 percent, using Fettes (1950) method of estimating defoliation, as a tree average. Population levels were as low as seven egg masses on all foliated portions of a sampled tree. Sampled stands were high in hardwood content, with spruce and fir comprising only 10 to 40 percent of the overstory growth in each stand. Most sampled trees grew in the vicinity of a high density spruce-fir pocket; however, nearly all were overtopped by hardwood cover.

The objective of this study was to determine if egg mass size was related to particular sites within a host tree, within a stand, or within a forest complex. From my analyses, I wanted to determine if estimates of population size, computed solely from egg mass densities, would be significantly distorted by neglecting to account for differences in the numbers of eggs per masses. Another goal of the project was to analyze differences in egg mass size between the preferred ovipositional host, white spruce, and the preferred food source, balsam fir.

Twelve balsam fir and ten white spruce trees had every branch severed, measured, and thoroughly examined for spruce budworm egg masses. The position of each egg mass within a sampled tree and a stand was recorded. The number of eggs were estimated by measuring mass length and using regresion equations derived from a subsample of this study's egg mass pool. "Subprogram Oneway" in SPSS: Statistical Packages for the Social Sciences (Nie et al. 1975) was used to calculate the mean number of eggs per egg mass for the specific group of egg masses under investigation. The same subprogram was used to test for trends in egg mass size distribution, incorporating one-way analysis of variance to test for significant difference(s) between mean egg mass sizes within trees, between trees, between tree species, and between stands.

Regression estimates

Separate regression estimates were made for 2-row, 2-row with a partial third row, and 3-row egg masses from balsam fir foliage and from white spruce foliage, giving the number of whole eggs per egg mass length. Differences in the regression equations between the two hosts were small and possibly related to structural differences between the two species needles. Ovipositing moths may compress their eggs more tightly into masses, over shorter lengths on white spruce, than moths ovipositing eggs on flatter, wider balsam fir foliage.

Large differences are evident between my regression equations (1981) and Miller's (1957), Bean's (1961), and Leonard's et al. (1973). Although no specific statistical tests were performed that compare the four groups of equations, a simple visual comparison reveals significant biological differences between the numbers of eggs per mass length. It would be unacceptable for me to hypothesize on the specific reasons for these differences, without concrete data at my disposal. Suffice it to say that estimated numbers of eggs per mass length for each kind of mass will vary from location-to-location and from year-to-year.

These differences may be due to a multitude of factors, including nutritional composition of the larvae diet, weather conditions during oviposition, differences in sampling methods, stand structures, moth dispersal, or a combination of these factors and more.

Intra-tree distribution of egg mass size

Statistically, no significant differences were found in the mean number of eggs per mass between any loci within sampled trees--balsam fir or white spruce. Quadrant differences were minimal. However, there may be biological significance to the relatively large differences in egg mass sizes between the three stata within sampled balsam fir and white spruce trees. Mean number of eggs per mass in the lower, middle, and upper strata decreased from 26.74 to 24.52 to 23.38 in balsam fir and varied from 21.74 to 21.76 to 19.56 in white spruce, respectively. This anomaly may have resulted from the small sample size of eggs in the lower stratum. However, this trend might also indicate that female moths in stands with very low populations fly up toward the preferred oviposition sites to lay smaller egg clusters, after they have laid their first two largest egg clusters at their eclosion and mating sites. This vertical migration may be stimulated by the nutritous flower buds on tops of larger trees that would eventually provide their offspring with a better initial food source. Likewise, the moths may have been drawn from the lower branches in an attempt to disperse from the stand. Or gravid female moths may have immigrated to the stand and oviposited their smaller masses at or near the "attractive" spire tops of host trees.

This trend is different from the distribution of egg mass size between strata that I reported in my first thesis (1981). In that study a larger mean egg mass size (though not significant) was found in the middle stratum as opposed to the nearly equal sizes found in the upper and lower strata. The first thesis (1981) investigated spruce budworm populations with much higher densities and trees with heavier defoliation levels. Oviposition in those stands was possibly governed more by the quantity of foliage than by the quality.

In this study, the nonsignificant, yet highly visible differences in the mean number of eggs per mass between strata does not appear important enough to alter sampling methods on individual trees. In the first place, the differences would "balance" out in surveys that sample feasible branches from the mid-crown, since mass size there is intermediate between the sizes in upper and lower strata. Secondly, the differences are not excessive (approximately three eggs per mass and two eggs per mass mean differences between the largest and smallest sizes in balsam fir and white spruce strata, respectively). Thirdly, the difference could be related to the small sample size from the lower stratum.

<u>Inter-tree distribution of egg mass size</u>

Differences in mean egg mass size between trees of the same species within the same stand were for the most part variable and nonconclusive. In general, mean egg mass size was not significantly different. Statistically, tree pairs in eight of ten analyses had mean egg mass sizes that did not significantly differ at the 0.05 -level. Two groups of paired trees, the balsam fir (BF1 and BF2) in Stand 5 and the white spruce (WS1 and WS2) in Stand 2 had statistical and perhaps biological significance to the relatively large differences in egg mass size. These differences might be related to the trees' phenological and/or physiological characteristics.

BF1 and BF2 in Stand 5 had averages of 19.91 and 27.02 eggs per mass, respectively. BF1 was 33 years old and 10.1 meters tall, while BF2 was 43 years old and 12.0 meters tall. WS1 and WS2 in Stand 4 had averages of 21.57 and 16.89 eggs per egg mass, respectively. WS1 was 51 years old and 13.4 meters tall, while WS2 was 32 years old and 11.7 meters tall.

Kimmins (1971) found that higher concentrations of amino acids and a higher content of amino-nitrogen were in the foliage of flowering balsam fir as opposed to the foliage of non-flowering balsam fir. This effect was found to be small in white spruce foliage. However, it is not known "whether the changes in protein and amino acid metabolism result from flowering and fruiting, which in turn are induced by climatic factors, or whether the changes ar directly induced by climatic stress and are themselves important determinants of flowering and fruiting" (Kimmins 1971).

This could serve as the basis for an explanation of the significantly larger egg masses found on the much taller and older host trees, BF2 in Stand 5 and WS1 in Stand 2. If the relative abundance of available nitrogen was substantially greater in the foliage of the larger trees and if other factors had constant effects between the tree pairs, then larvae, feeding on the taller trees' foliage, would perhaps be more vigorous and would perhaps produce ovipositing adults that had proportionally higher fecundity rates and would be more apt to lay larger egg masses. I emphasize that it is certainly beyond the scope of this thesis to analyze the plant stress-plant response-herbivore response complex. Mattson (1980) reviews these relationships for general herbivores and plants in detail and other investigators are specifically studying spruce budworm population dynamics in relation to nutritional release.

There are many other factors that could also be responsible for larger or smaller egg masses being distributed on particular trees throughout a stand. Factors, such as larvae and/or moth dispersal within or between stands, microhabitat variation between trees, structural differences of trees and their foliage, variability of microclimate during oviposition, each could individually or in combination produce significant effects on egg mass sizes.

Whatever the cause(s), large differences in egg mass sizes can exist between trees within the same stand. These differences can have significant effects on population estimates derived from egg mass sampling surveys for a stand. The more diverse stands should have a larger number of trees sampled that are representative of the variety of host trees within these stands. This would improve the accuracy of estimated values of the number of eggs per egg mass per stand, particularly in the diverse forests of Michigan's Upper Peninsula.

Inter-stand differences in egg mass size

The mean number of eggs per egg mass was not significantly different between the five stands for each tree species. This relationship was expected since defoliation levels in all five stands were very similar. Slight differences in egg mass sizes between stands were possibly related to such interconnected factors as stand age, tree height, species composition, foliar nutrient content, soil type, topography, past ecological perturbations, larval and/or moth dispersal, and the local effects of population size and vigor, parasites, predators, diseases, rainfall, humidity, and temperature. However, any of these factors, singularly or in combination, could have had much more dramatic effects on egg mass size in any given stand, region or year. This can be best exemplified by comparing this study's results with the results in my first thesis (1981). Egg masses from sampled balsam fir trees had mean numbers of eggs of 17.12 in two moderate-severely defoliated stands (1981), 18.72 in two light-moderately defoliated stands (1981) and 23.90 in the five very lightly-defoliated stands from this project. The differences are obvious and the potential effects on the accuracy and precision of sampling programs should be observed. To recapitulate the suggestion that was made in my first thesis (1981)--as a rule, the mean number of eggs per egg mass should be calculated on a per stand basis to assure accuracy and precision in egg mass sampling surveys.

Inter-species distribution of egg mass size

Egg masses on sampled balsam fir in each stand contained an average of 1.1 to 5.6 more eggs per mass than egg masses on sampled white spruce. However, in only two stands were the differences in the averages statistically significant. Over all 20 sampled trees in the five stands, the 10 balsam fir trees had an average of 23.90 eggs per mass and the 10 white spruce trees had an average of 20.92 eggs per mass.

This trend is interesting since white spruce has been long noted as the preferred oviposition host for the spruce budworm (Jaynes and Speers 1949, Wilson 1963, Kemp 1981). It, therefore, might be expected that white spruce would also be the site of the largest egg masses. This is not the case for two possible reasons.

Structurally, white spruce foliage is generally not as conducive to receiving long or wide egg masses. White spruce needles are often curled and close together in a 3-dimensional whorl around each twig. Balsam fir needles are generally flatter and more 2-dimensionally oriented, particularly in our sampled stand that were heavily shaded. Female moths would have much less difficulty extending their ovipositors over a longer, wider balsam fir needle surface, than trying to squeeze their ovipositors between needles that are curled and narrow.

Kimmins (1971) found that balsam fir foliage had significantly greater levels of amino acids than white spruce foliage. If moths emerge, mate and oviposit most of their egg complement on the same trees that they had fed upon as larvae, then the protein content of the host species would be crucial to female development and fecundity.

Sampling programs should be cognizant of the consistently smaller egg mass size on white spruce foliage as opposed to balsam fir foliage. If white spruce is a relatively large component in sampled stands, then this tree species should also be incorporated in the survey and their average egg mass size should be estimated on a per stand basis.

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APPENDICES

APPENDIX A.

APPENDIX A.

Six maps denoting the location of the five sampled stands within the Ottawa National Forest and the location of each stand within the corresponding township.

Figure A1. Map of the Ottawa National Forest with locations of the five study sites.

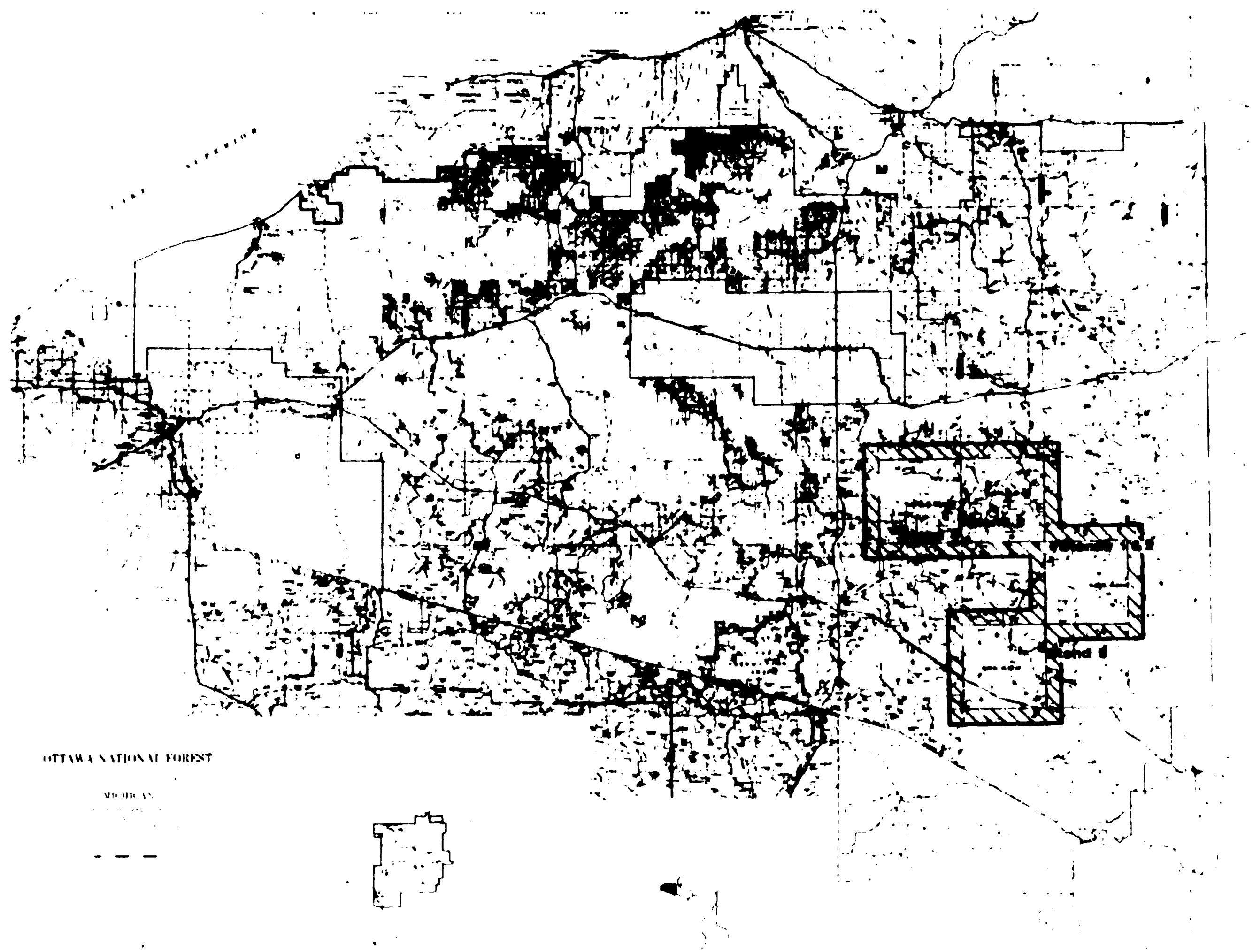
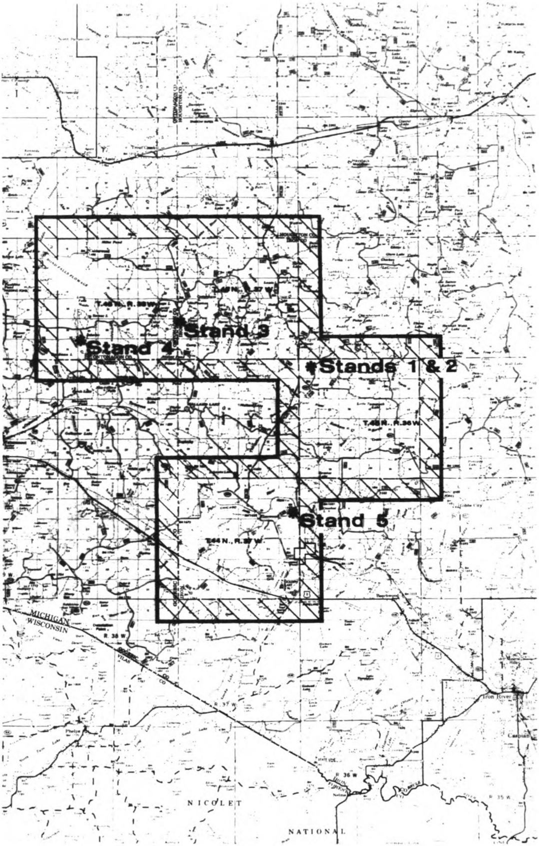


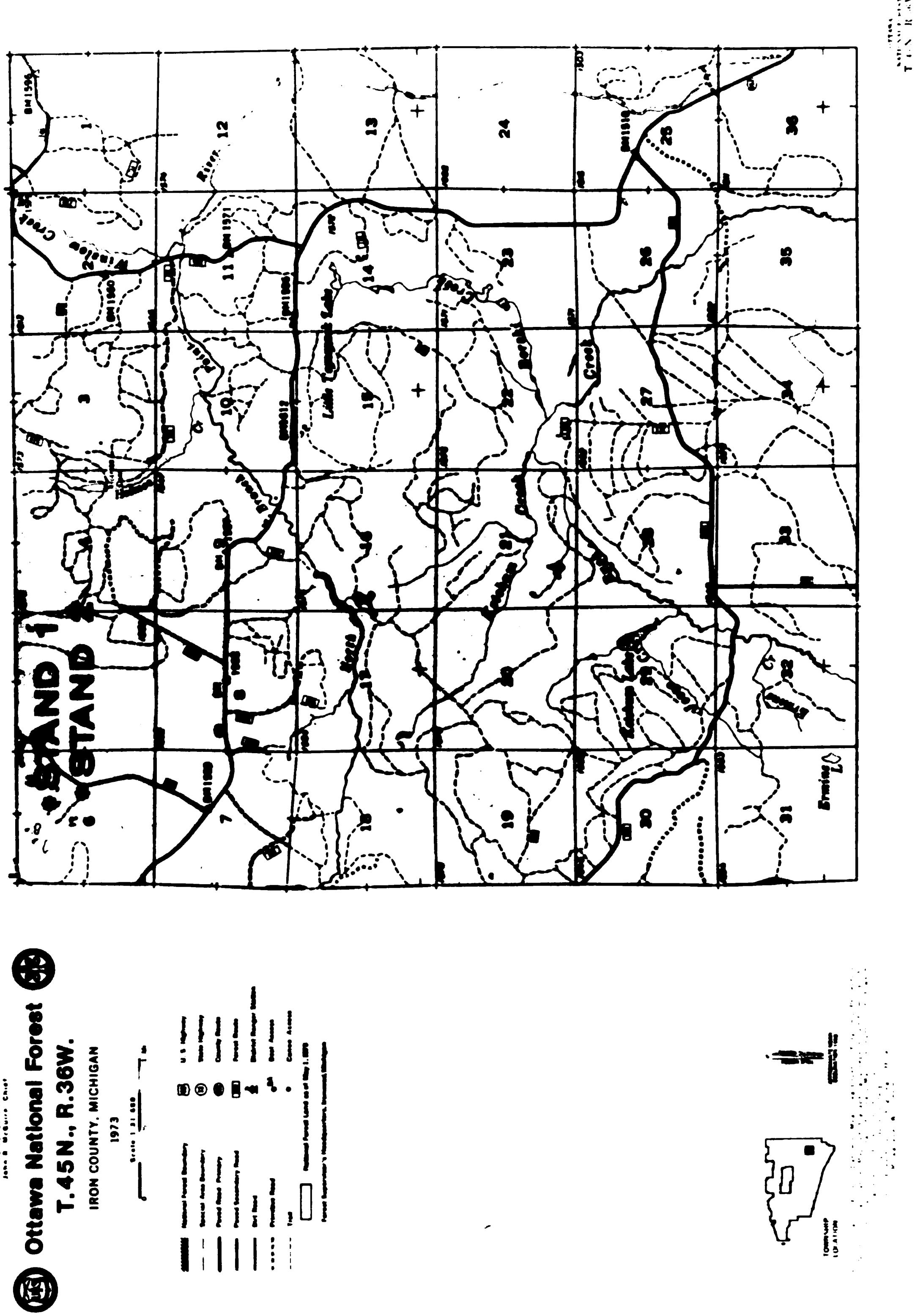
Figure A2. Map of the five study sites within the Iron River, Watersmeet and Kenton Districts of the Ottawa National Forest.


Stand 3
Stand 4
Stands 1 & 2
Stand 5
T.44 N., R.37 W.
MICHIGAN
WISCONSIN
R. 38 W
R. 37 W
R. 36 W
R. 35 W
Iron River
Caspian
Phelps
N I C O L E T
N A T I O N A L

Stand 1 was located in the NE 1/4, SW 1/4, Section 6, T45N, R36W, Iron River District, Ottawa National Forest, Iron County, Michigan. The stand was located on Forest Route 139, 1.25 miles north of the intersection of Forest Route 139 and County Route 657. The spruce-fir pocket was approximately 450 meters due east of the road through a white birch-aspen-maple type forest.

Stand 2 was located in the NE 1/4, SW 1/4, Section 6, T45N, R36W, Iron River District, Ottawa National Forest, Iron County, Michigan. The stand was located on Forest Route 139, 1.00 miles north of the intersection of Forest Route 139 and County Route 657. The spruce-fir pocket was approximately 100 meters due east of the road on an abandoned logging road.

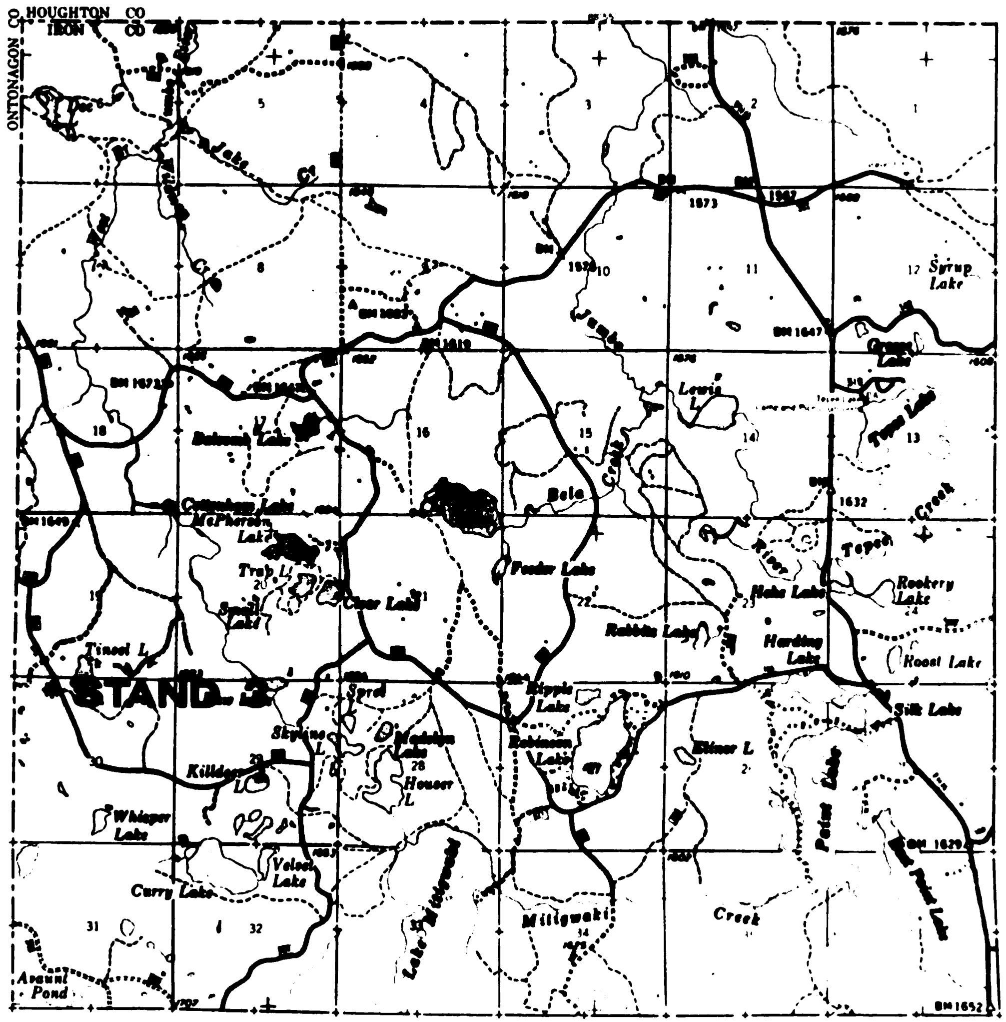
Figure A3. Map of the locations of Stand 1 and Stand 2 in Section 6 of Township T45N, R36W, Iron County, Michigan.

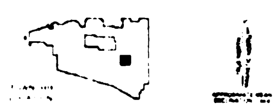

Ottawa National Forest
T.45N., R.36W.
IRON COUNTY, MICHIGAN
1973
STAND 1
STAND 2

Stand 3 was located in the NW 1/4, NE 1/4, Section 30, T46N, R37W, Iron River District, Ottawa National Forest, Iron County, Michigan. The stand was located on Forest Route 364, 1.8 miles west of the intersection of Forest Route 364 and Forest Route 164. Stand was on the opposite side of the road from Tinsel Lake. It was approximately 40 meters due west of road.

Figure A4. Map of the location of Stand 3 in Section 30 of Township T46N, R37W, Iron County, Michigan.

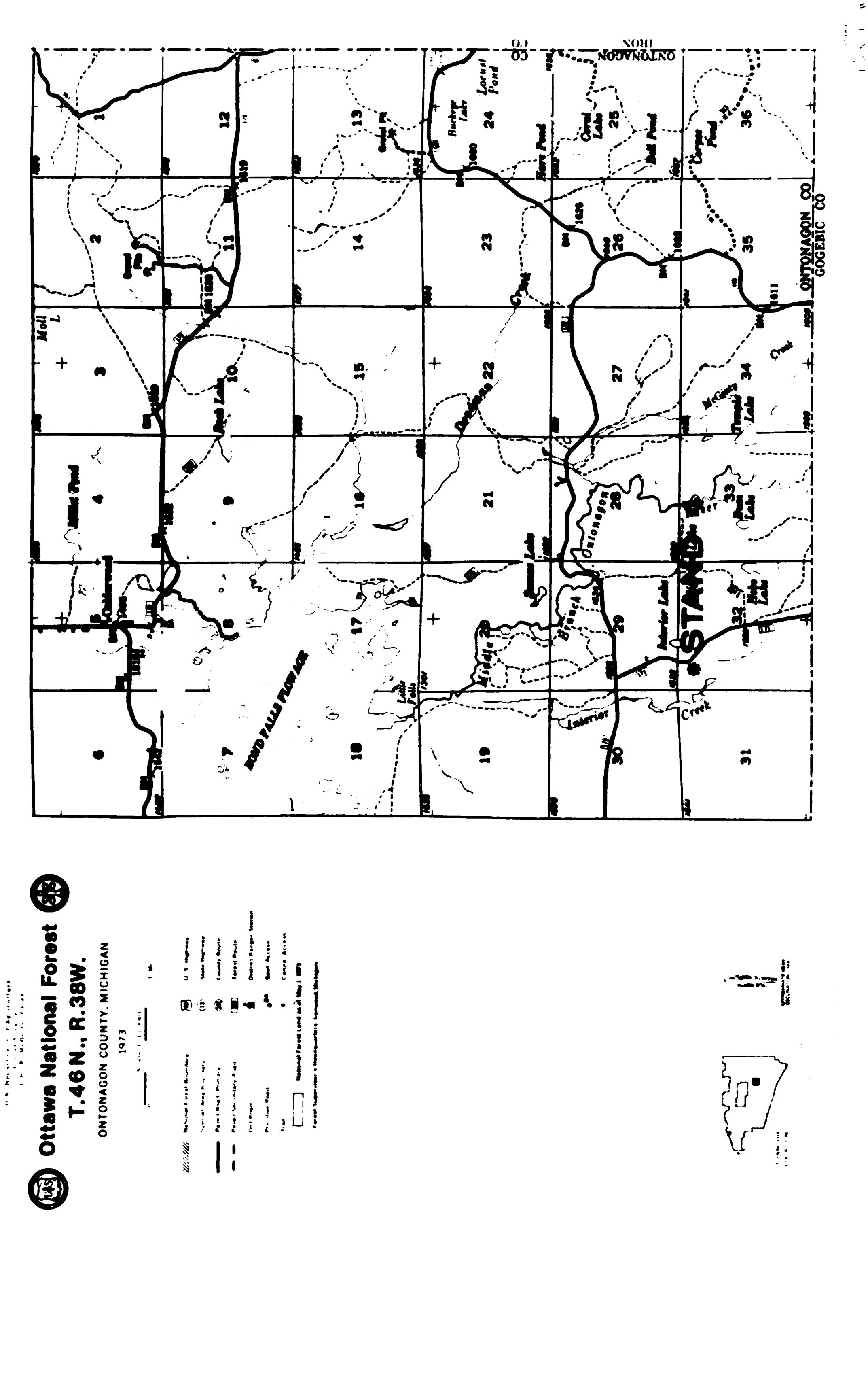
Ottawa National Forest
T. 46N., R.37W.
IRON COUNTY, MICHIGAN
1973





Stand 4 was in the NW 1/4, NW 1/4, Section 32, T46N, R38W, Ottawa National Forest, Ontonagon County, Michigan. The stand was located on Forest Route 171, 5.9 miles north of County Route 208 (Old U.S. 2) or 0.6 miles south of the intersection of Forest Routes 171 and 172. It was approximately 40 meters west of the road and on the opposite side of the road from Interior Lake.

Figure A5. Map of the location of Stand 4 in Section 32 of Township T46N, R38W, Ontonagon County, Michigan.


Ottawa National Forest
T.46 N., R.38W.
ONTONAGON COUNTY, MICHIGAN
1973
BOND FALLS FLOWAGE
ONTONAGON CO
GOGEBIC CO
STANARD

Stand 5 was located in the SE 1/4, NW 1/4, Section 12, Iron River District, Ottawa National Forest, Iron County, Michigan. It was located on Forest Route 149, approximately 0.3 miles ESE of the intersection of Forest Routes 149 and 342 (approximately 0.1 mile southeast of railroad tracks and the south branch of the Paint River). Stand is 100 meters southwest of Forest Route 149 on a two-track road.

Figure A6. Map of the location of Stand 5 in Section 12 of Township T44N, R37W, Iron County, Michigan.

U S Department of Agriculture
Forest Service
John R. McGuire, Chief

Ottawa National Forest

T.44 N., R.37W.

IRON COUNTY, MICHIGAN

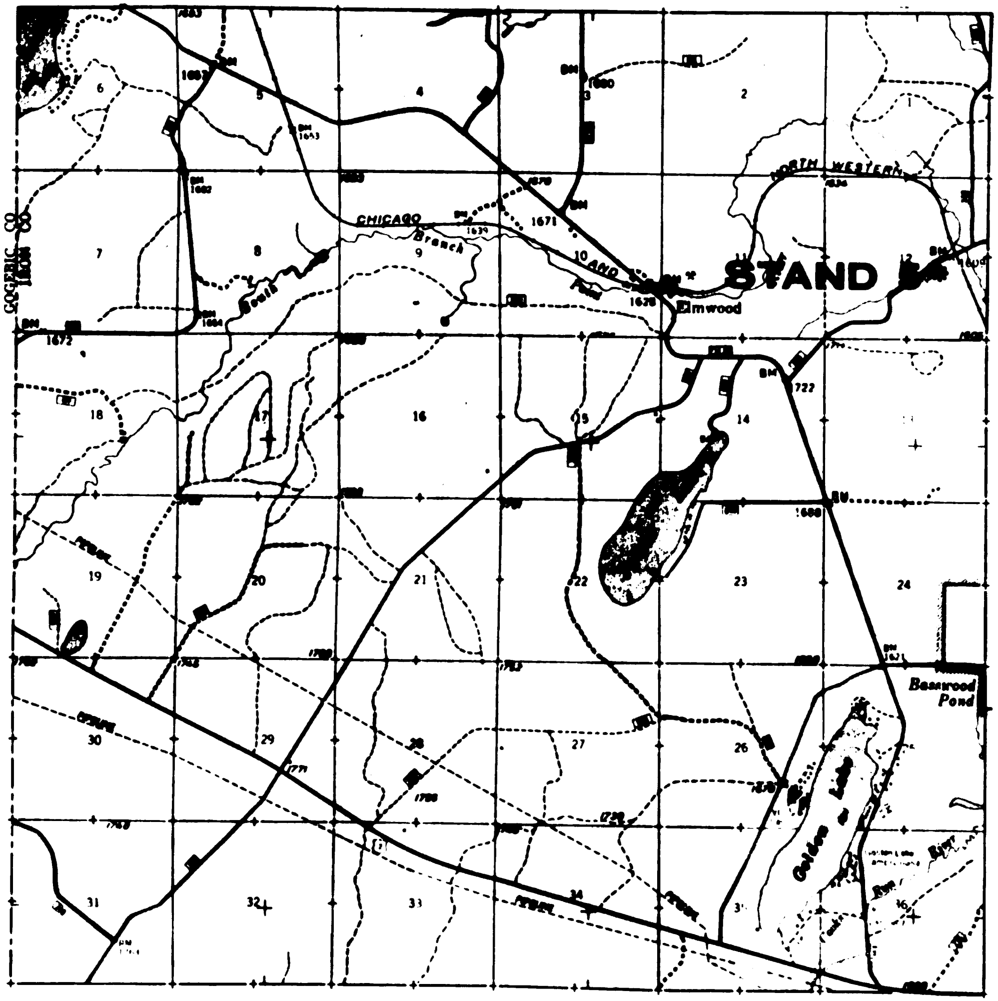
1973

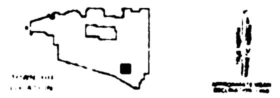
Scale 1:31,680

National Forest Boundary	U. S. Highway
Special Area Boundary	State Highway
Paved Road Primary	County Route
Paved Secondary Road	Forest Route
Dirt Road	District Ranger Station
Primitive Road	Boat Access
Trail	Canoe Access

National Forest Land as of May 1, 1973

Forest Supervisor's Headquarters, Ironwood, Michigan





APPENDIX B.

APPENDIX B.

Diameter, age, height and total number of egg masses for each sampled tree.

Table B1. Sampled trees' ages, heights, diameters, and total number of egg masses.*

STD	SPP	Tree	S-D	DBH	Age	HT	# EMS
1	BF	1	FS	21.0	41	17.8	
1	BF	2	EB	23.0	44	16.7	
1	BF	5	EB	16.1	43	15.9	
1	BF	6	FS	23.4	63	14.6	
1	WS	1	EB	27.9	60	14.2	
1	WS	2	FS	21.7	70	13.7	
2	BF	1	FS	19.3	40	14.8	
2	BF	2	EB	17.3	37	13.0	
2	WS	1	FS	23.9	51	13.4	
2	WS	2	EB	15.9	32	11.7	
3	BF	1	EB	15.7	63	11.8	
3	BF	2	FS	18.2	63	14.6	
3	WS	1	EB	16.2	72	12.5	
3	WS	2	FS	18.0	73	14.0	
4	BF	1	FS	17.1	45	15.5	
4	BF	2	EB	14.3	41	12.3	
4	WS	1	EB	16.2	42	12.1	
4	WS	2	FS	24.3	45	17.5	
5	BF	1	FS	13.2	33	10.1	
5	BF	2	EB	12.6	43	12.0	
5	WS	1	FS	12.3	42	9.5	
5	WS	2	EB	11.5	38	9.4	

*Refer to the following page for a key to the column headings and their units.

STD: Stand number

SPP: Tree species:

BF = Balsam fir
WS = White spruce

TREE: Tree number

S-D: Sampling design:

1 = Every branch full sample (feasible branches were disected into varying lengths)
2 = Every branch sample (but feasible branches were not disected)

DBH: Diameter of the tree at breast height (1.37 meters above ground), measured with a metric "D-tape" to the nearest 0.1 centimeter.

AGE: Age of the tree in years, taken at stump height (8" above ground) by counting rings.

HT: Total height of the tree measured with a metric tape after tree was felled. Units were taken to the nearest 0.1 meter.

EMS: Total number of egg masses found on all foliated surfaces of the tree by the research crew.

APPENDIX C.

APPENDIX C.

Distances, angles, diameters, and heights of the ten "nearest neighbors" (trees with diameters at breast height greater than 12.0 centimeters) of each sampled tree.

Table C1. Locations, heights and diameters of trees that were within 10 meters of each sampled tree.*

STD	TREE	SPP	STSP	DIST	DIR	HT	DBH
1	1	BF	PB	02.3	080	17.7	19.5
1	1	BF	PB	04.9	123	17.4	20.1
1	1	BF	PB	04.6	092	20.7	24.7
1	1	BF	PB	05.6	034	17.4	24.1
1	1	BF	PB	04.2	354	18.6	23.5
1	1	BF	PB	00.9	207	19.8	26.2
1	1	BF	PB	01.2	317	18.3	25.7
1	1	BF	PB	02.5	129	20.1	24.3
1	1	BF	PB	04.8	153	19.2	25.4
1	1	BF	PB	06.0	315	16.5	15.4
1	2	BF	PB	01.8	166	17.4	24.1
1	2	BF	PB	02.7	072	18.3	22.8
1	2	BF	PB	04.8	096	16.2	15.5
1	2	BF	PB	05.4	135	18.6	17.9
1	2	BF	PB	06.4	131	19.2	17.0
1	2	BF	PB	03.7	234	18.6	23.5
1	2	BF	PB	06.7	027	16.5	18.0
1	2	BF	PB	06.3	016	18.0	21.0
1	2	BF	PB	04.4	333	13.7	13.4
1	2	BF	PB	03.6	312	14.9	13.5
1	5	BF	PB	03.5	294	16.2	20.4
1	5	BF	PB	03.1	315	15.2	19.0
1	5	BF	RM	03.3	338	13.4	16.1
1	5	BF	PB	03.4	006	15.8	17.3
1	5	BF	PB	05.7	311	19.5	28.0
1	5	BF	RM	04.7	156	12.5	12.2
1	5	BF	PB	03.5	215	19.5	26.7
1	5	BF	PB	05.1	261	16.2	21.5
1	5	BF	PB	04.4	088	16.2	14.8
1	5	BF	PB	04.7	093	16.2	18.4
1	6	BF	PB	01.4	278	18.9	19.4
1	6	BF	PB	01.5	201	20.7	30.2
1	6	BF	PB	03.0	250	14.9	13.2
1	6	BF	A	05.7	262	24.4	16.0
1	6	BF	PB	03.6	337	14.6	16.0
1	6	BF	PB	03.7	356	20.7	26.4
1	6	BF	PB	04.8	039	17.1	18.2
1	6	BF	RM	06.3	173	11.0	12.4
1	6	BF	PB	05.5	221	14.3	21.7
1	6	BF	RM	06.2	164	11.0	13.2

*Refer to page after table for key to column headings and their units.

Table C1. Continued

STD	TREE	SPP	STSP	DIST	DIR	HT	DBH
1	1	WS	PB	01.5	331	19.2	17.0
1	1	WS	PB	02.4	309	18.6	17.9
1	1	WS	PB	03.9	252	20.7	24.7
1	1	WS	PB	05.6	228	17.4	20.1
1	1	WS	PB	06.1	183	18.3	19.8
1	1	WS	PB	02.9	065	22.6	34.6
1	1	WS	PB	05.5	053	16.2	13.6
1	1	WS	PB	05.2	355	15.5	15.5
1	1	WS	PB	06.1	262	17.7	19.5
1	1	WS	PB	06.3	306	17.4	24.1
1	2	WS	PB	00.7	182	14.9	15.1
1	2	WS	A	01.2	046	17.7	25.0
1	2	WS	A	02.2	340	17.4	22.5
1	2	WS	BF	04.4	172	12.8	22.6
1	2	WS	PB	02.7	073	15.5	18.2
1	2	WS	PB	04.9	194	17.1	25.4
1	2	WS	A	04.3	301	12.5	13.8
1	2	WS	PB	04.6	256	16.2	16.7
1	2	WS	A	04.0	351	13.7	20.6
1	2	WS	BF	04.8	364	07.0	13.5
2	1	BF	PB	05.1	132	18.3	23.2
2	1	BF	RM	03.9	159	19.8	12.2
2	1	BF	PB	01.9	235	12.8	13.9
2	1	BF	PB	00.9	031	15.2	21.5
2	1	BF	PB	03.0	003	16.5	19.3
2	1	BF	PB	03.3	043	16.8	15.9
2	1	BF	PB	04.3	016	20.4	22.4
2	1	BF	PB	03.9	255	18.3	20.9
2	1	BF	PB	05.2	081	22.3	23.5
2	1	BF	BF	05.2	210	15.5	17.0
2	2	BF	PB	01.5	250	15.5	28.8
2	2	BF	PB	02.4	218	14.6	22.2
2	2	BF	PB	03.2	098	09.1	15.7
2	2	BF	PB	03.0	047	12.8	16.3
2	2	BF	PB	06.3	145	14.9	22.7
2	2	BF	PB	06.5	251	15.8	21.8
2	2	BF	PB	06.1	227	15.5	20.7
2	2	BF	PB	04.5	337	16.2	25.4
2	2	BF	BF	04.4	351	15.5	17.8
2	2	BF	PB	06.3	313	17.7	26.2

Table C1. Continued

STD	TREE	SPP	STSP	DIST	DIR	HT	DBH
2	1	WS	PB	Ø2.5	176	14.6	18.9
2	1	WS	PB	Ø3.8	179	12.8	18.4
2	1	WS	PB	Ø4.1	Ø69	2Ø.4	19.9
2	1	WS	BF	Ø5.9	Ø75	14.6	15.2
2	1	WS	BF	Ø6.Ø	Ø73	13.4	14.1
2	1	WS	PB	ØØ.9	Ø27	15.8	13.8
2	1	WS	PB	Ø2.6	338	18.Ø	2Ø.3
2	1	WS	PB	Ø4.3	Ø2Ø	16.5	16.3
2	1	WS	PB	Ø5.4	335	12.5	12.1
2	1	WS	PB	Ø4.9	264	11.6	15.5
2	2	WS	PB	ØØ.3	211	2Ø.4	27.9
2	2	WS	PB	Ø2.1	304	15.8	25.8
2	2	WS	PB	Ø3.3	297	12.5	16.6
2	2	WS	RM	Ø4.1	265	14.Ø	13.2
2	2	WS	PB	Ø3.1	211	17.1	2Ø.Ø
2	2	WS	PB	Ø5.6	173	17.4	17.Ø
2	2	WS	PB	Ø4.8	13Ø	18.9	15.5
2	2	WS	PB	Ø5.4	Ø25	19.8	18.2
2	2	WS	PB	Ø6.5	Ø27	17.1	15.7
2	2	WS	PB	Ø6.1	Ø96	17.1	21.7
3	1	BF	RM	Ø3.3	Ø38	16.1	24.7
3	1	BF	BF	Ø4.9	2Ø4	Ø8.5	14.8
3	1	BF	PB	Ø6.2	198	19.8	29.7
3	1	BF	RM	Ø4.5	123	15.5	24.4
3	1	BF	BF	Ø5.2	Ø96	13.7	16.4
3	1	BF	RM	Ø5.6	335	17.7	28.9
3	1	BF	BF	Ø6.3	321	Ø6.7	13.6
3	1	BF	RM	Ø6.Ø	278	18.3	26.9
3	1	BF	BF	Ø6.2	Ø33	14.6	18.2
3	1	BF	BF	Ø6.7	146	14.3	19.8
3	2	BF	RM	Ø2.Ø	Ø83	13.4	19.4
3	2	BF	RM	Ø2.8	2Ø4	16.2	24.7
3	2	BF	RM	Ø1.6	327	21.6	27.Ø
3	2	BF	RM	Ø5.2	268	17.7	28.9
3	2	BF	RM	Ø3.5	296	Ø7.6	12.Ø
3	2	BF	RM	Ø5.3	36Ø	18.Ø	26.9
3	2	BF	WS	Ø5.3	ØØ6	Ø8.2	15.3
3	2	BF	BF	Ø4.8	Ø49	11.Ø	17.2
3	2	BF	WS	Ø4.9	Ø56	Ø7.9	13.5
3	2	BF	BF	Ø6.2	213	11.9	15.7

Table C1. Continued

STD	TREE	SPP	STSP	DIST	DIR	HT	DBH
3	1	WS	BF	05.8	003	15.2	19.6
3	1	WS	RM	02.0	055	17.7	30.9
3	1	WS	BF	02.3	277	12.8	23.6
3	1	WS	WS	01.8	091	08.5	12.8
3	1	WS	RM	04.7	086	20.7	32.7
3	1	WS	RM	03.8	149	12.2	20.0
3	1	WS	RM	07.3	147	11.9	23.0
3	1	WS	WS	07.2	129	14.6	24.8
3	1	WS	RM	07.9	173	12.2	18.4
3	1	WS	RM	05.8	040	11.6	16.2
3	2	WS	RM	02.8	280	18.3	33.2
3	2	WS	YB	07.9	283	20.7	46.3
3	2	WS	BF	07.1	274	12.8	21.7
3	2	WS	WS	07.4	247	07.6	12.2
3	2	WS	RM	05.4	179	15.5	14.1
3	2	WS	RM	03.6	141	15.8	23.1
3	2	WS	RM	06.9	122	15.5	25.0
3	2	WS	RM	02.5	051	14.9	19.9
3	2	WS	RM	08.3	045	18.0	50.9
3	2	WS	YB	06.3	006	13.7	13.3
4	1	BF	BS	03.6	150	10.4	13.3
4	1	BF	A	03.2	130	17.7	27.2
4	1	BF	RM	01.3	120	13.7	14.3
4	1	BF	A	03.6	020	22.6	33.5
4	1	BF	A	02.8	300	23.2	29.9
4	1	BF	RM	04.5	195	12.8	12.9
4	1	BF	RM	05.5	165	14.3	12.5
4	1	BF	RM	05.6	165	14.3	12.5
4	1	BF	BS	04.4	045	11.9	14.8
4	1	BF	BS	04.9	015	11.3	12.8
4	2	BF	A	01.7	175	14.6	25.8
4	2	BF	RP	03.9	107	16.8	22.2
4	2	BF	BF	03.8	358	12.2	16.2
4	2	BF	A	01.2	319	19.8	37.7
4	2	BF	BF	00.4	301	12.2	14.0
4	2	BF	BF	04.4	273	14.3	16.8
4	2	BF	BS	04.7	024	12.2	12.0
4	2	BF	RM	05.8	013	15.2	14.7
4	2	BF	RM	06.2	067	14.6	13.4
4	2	BF	RM	06.3	066	13.4	13.2

Table C1. Continued

STD	TREE	SPP	STSP	DIST	DIR	HT	DBH
4	1	WS	BF	03.4	270	12.5	14.4
4	1	WS	A	03.0	205	16.2	13.4
4	1	WS	A	03.3	181	15.8	17.3
4	1	WS	BF	03.3	175	12.5	13.7
4	1	WS	RM	01.8	051	13.4	13.2
4	1	WS	A	03.4	088	16.8	19.0
4	1	WS	A	03.9	259	14.6	17.2
4	1	WS	A	04.8	353	18.6	32.6
4	1	WS	A	06.1	113	18.3	20.2
4	1	WS	A	05.6	204	15.5	22.0
4	2	WS	RM	01.8	100	17.4	12.2
4	2	WS	RM	02.2	105	16.8	16.1
4	2	WS	RM	01.7	285	16.8	20.2
4	2	WS	RP	03.2	266	10.7	17.8
4	2	WS	PB	03.1	278	18.3	17.3
4	2	WS	RM	05.4	231	12.2	13.2
4	2	WS	BS	05.8	269	12.5	18.4
4	2	WS	RP	04.9	335	22.8	22.7
4	2	WS	BS	05.2	144	16.8	16.1
4	2	WS	A	05.7	111	18.9	29.2
5	1	BF	E	02.2	227	15.8	18.2
5	1	BF	E	02.3	221	14.3	13.9
5	1	BF	E	03.8	170	12.3	21.7
5	1	BF	RM	04.7	135	16.5	47.6
5	1	BF	E	07.0	120	12.5	13.8
5	1	BF	E	07.5	142	14.0	14.2
5	1	BF	C	07.7	161	14.0	15.9
5	1	BF	C	07.7	162	12.8	14.9
5	1	BF	WS	07.6	330	12.5	19.0
5	1	BF	E	08.9	228	12.5	13.5
5	2	BF	BF	02.8	266	14.9	17.5
5	2	BF	WS	03.6	308	13.1	16.9
5	2	BF	WS	02.6	182	13.4	27.6
5	2	BF	WS	02.2	102	11.0	13.4
5	2	BF	RM	06.0	008	12.8	14.9
5	2	BF	A	06.1	151	16.5	15.4
5	2	BF	A	06.7	215	15.4	19.8
5	2	BF	RM	06.1	283	13.4	13.2
5	2	BF	BF	05.7	066	10.4	14.9
5	2	BF	WS	03.1	064	11.0	16.0

Table C1. Continued

STD	TREE	SPP	STSP	DIST	DIR	HT	DBH
5	1	WS	A	Ø2.4	314	2Ø.4	23.4
5	1	WS	BF	Ø3.9	279	11.6	19.2
5	1	WS	A	Ø4.9	286	14.6	2Ø.9
5	1	WS	WS	Ø4.3	Ø14	1Ø.4	17.8
5	1	WS	A	Ø5.2	Ø13	17.1	13.7
5	1	WS	WS	Ø5.9	Ø12	Ø9.1	13.6
5	1	WS	WS	Ø6.Ø	Ø13	Ø9.1	15.Ø
5	1	WS	C	Ø5.5	Ø74	14.Ø	29.3
5	1	WS	E	Ø3.8	169	12.8	14.Ø
5	1	WS	WS	Ø6.2	197	12.5	19.Ø
5	2	WS	WS	Ø3.7	Ø64	13.4	26.8
5	2	WS	RM	Ø3.9	356	11.3	17.4
5	2	WS	RM	Ø3.9	351	14.Ø	16.6
5	2	WS	C	Ø4.2	345	12.5	17.3
5	2	WS	RM	Ø4.1	316	11.Ø	13.2
5	2	WS	RM	Ø5.6	292	15.5	16.5
5	2	WS	RM	Ø5.7	212	14.6	18.4
5	2	WS	A	Ø5.6	189	17.1	19.9
5	2	WS	C	Ø4.1	Ø14	12.8	12.8
5	2	WS	RM	Ø5.8	142	13.7	14.9

FINAL EXECUTION

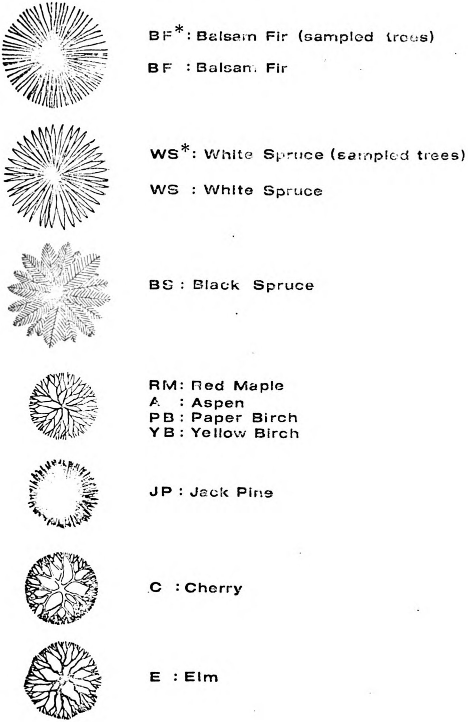
STD:	Stand number
TREE:	Tree number
SPP:	Sampled tree species: BF = Balsam fir WS = White spruce
STSP:	Surrounding tree species: BF = Balsam fir WS = White Spruce A = Aspen (*Populas tremuloides* Michx.) PB = Paper birch RM = Red maple (*Acer rubrum* L.) BS = Black spruce RP = Red pine (*Pinus resinosa* Ait.) YB = Yellow birch (*Betula lutea* Michx. f.) C = Cherry (*Prunus* sp.) E = Elm (*Ulmus* sp.)
DIST:	Distance from sampled trees outside bark at breast height to surrounding tree's outside bark at breast height to the nearest 0.1 meter
ANGLE:	Direction of surrounding tree, taken from the sampled tree with a Sylva "Type 15 T" compass, declinated at 4° east of true magnetic north
DBH:	Diameter at breast height of the surrounding tree to the nearest 0.1 centimeter
HEIGHT:	Height to the nearest 0.1 meter taken with a Suunto clinometer in feet and later converted to metric units

APPENDIX D.

APPENDIX D.

Stem maps

Figure D1. Key to symbols used in Figures D2-D23.*



*The tree symbols on all maps are not representative of actual crown sizes or shapes. They represent relative stem sizes and positions of those stems around the sampled trees. For exact sizes and locations of the sampled trees and the trees that surrounded them, refer to Appendices B and C. Numbers that are next to the symbols and the species abbreviations are the trees' diameters in centimeters.

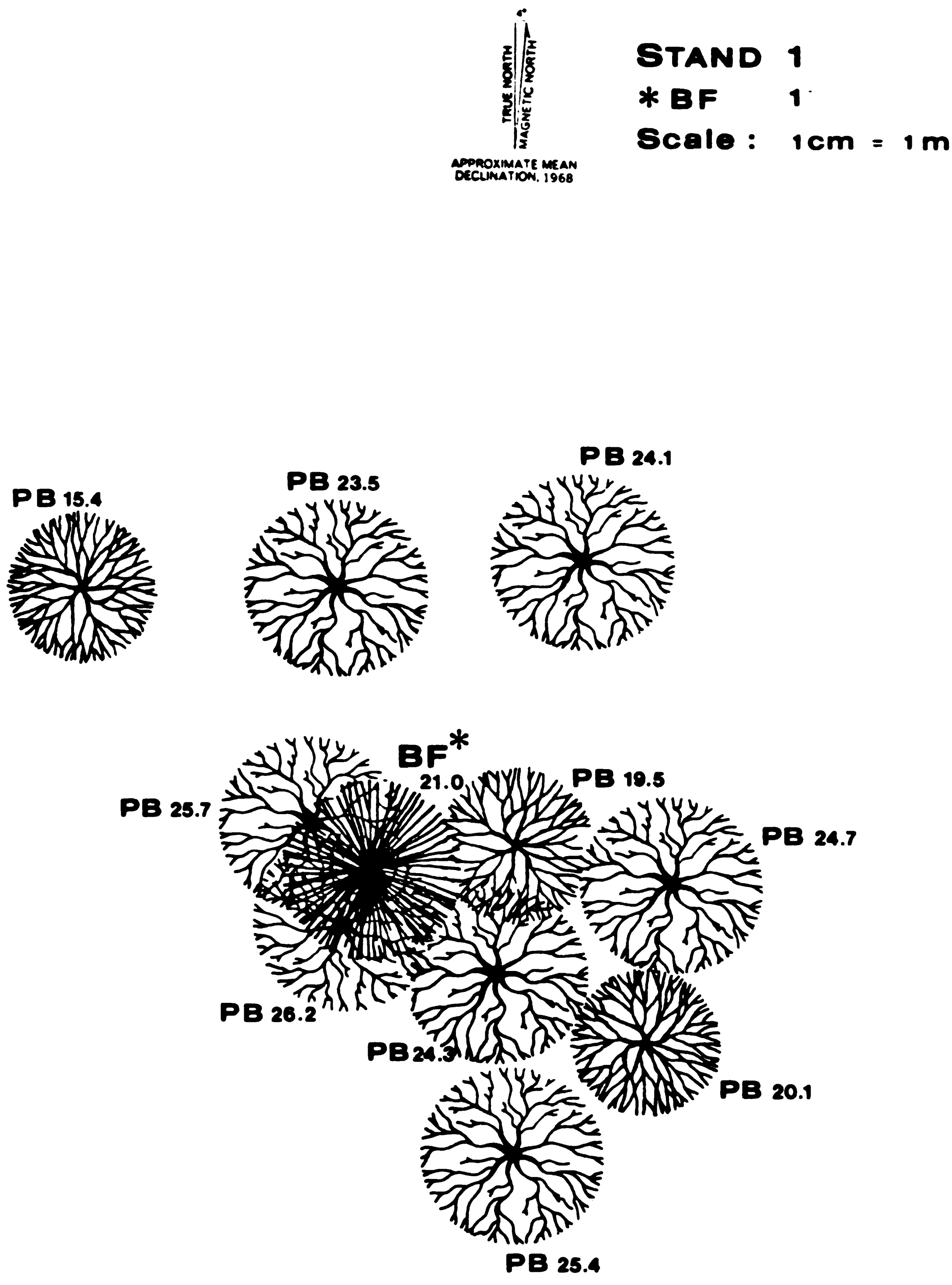


Figure D2. Stem map of the ten nearest trees that encompassed sampled tree BF 1 in Stand 1.

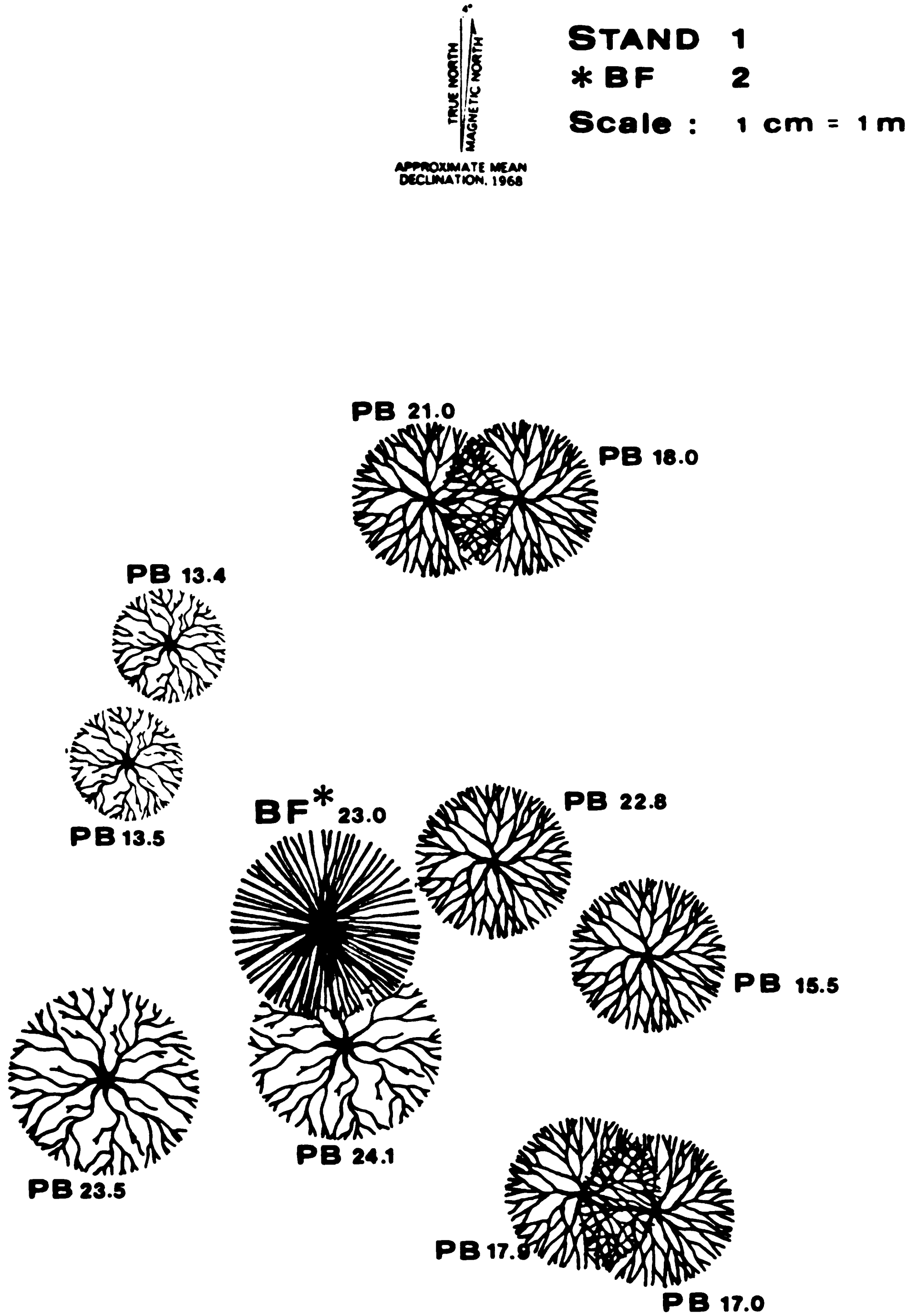


Figure D3. Stem map of the ten nearest trees that encompassed sampled tree BF 2 in Stand 1.

STAND 1
*BF 5
Scale : 1 cm = 1 m

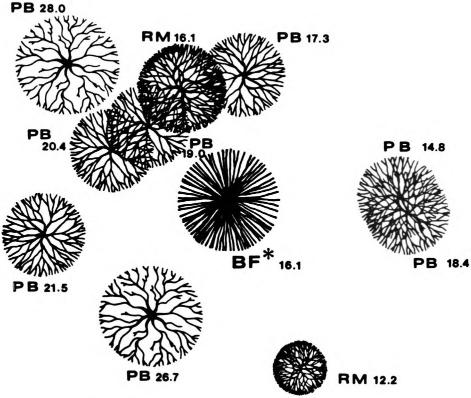


Figure D4. Stem map of the ten nearest trees that encompassed sampled tree BF 5 in Stand 1.

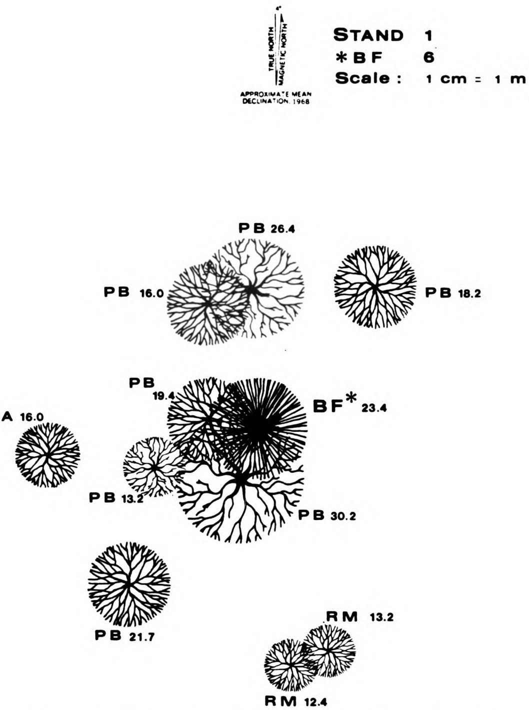


Figure D5. Stem map of the ten nearest trees that encompassed sampled tree BF 6 in Stand 1.

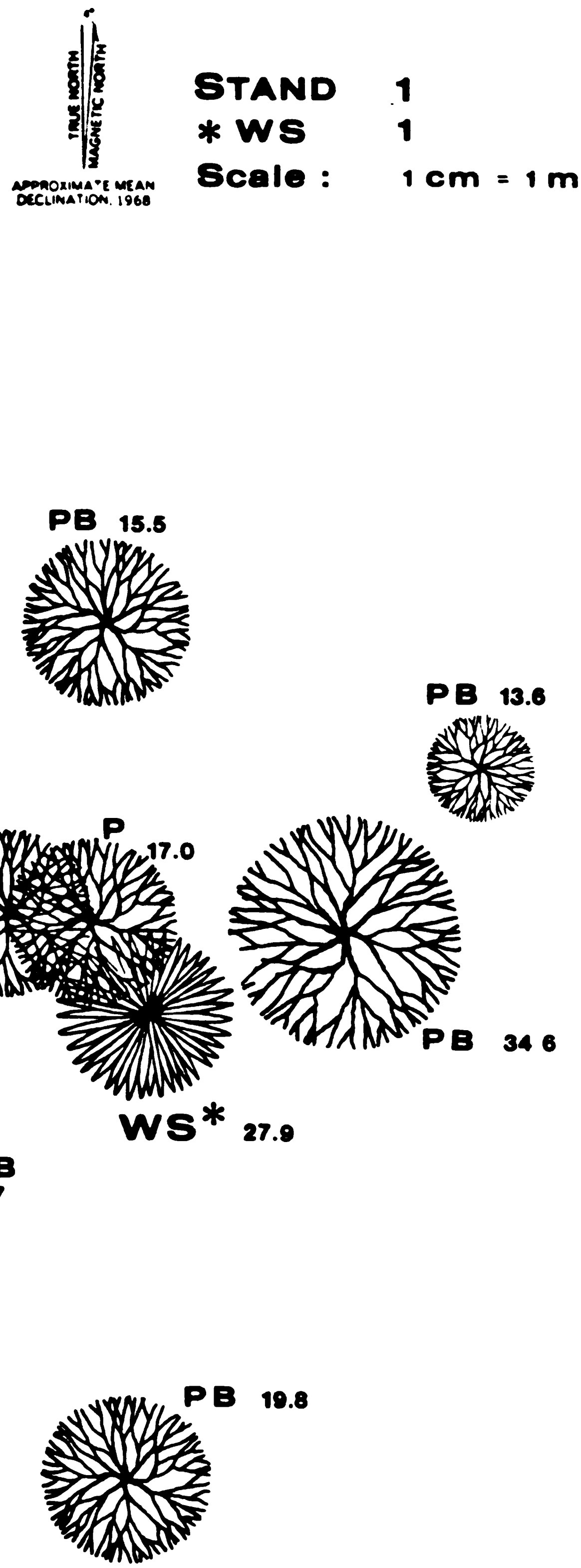


Figure D6. Stem map of the ten nearest trees that encompassed sampled tree WS 1 in Stand 1.

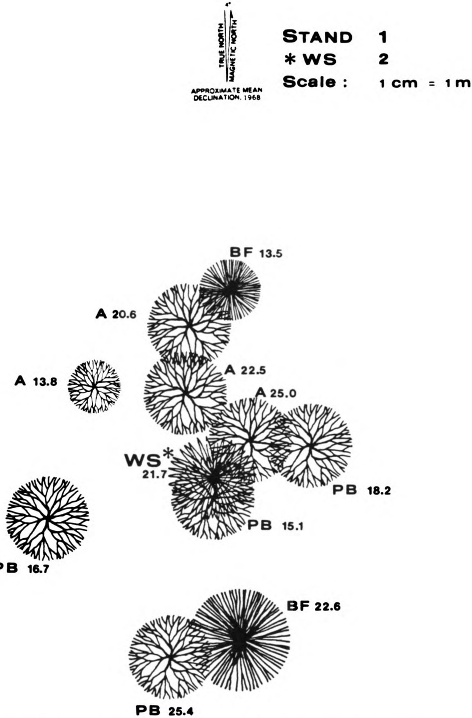


Figure D7. Stem map of the ten nearest trees that encompassed sampled tree WS 2 in Stand 1.

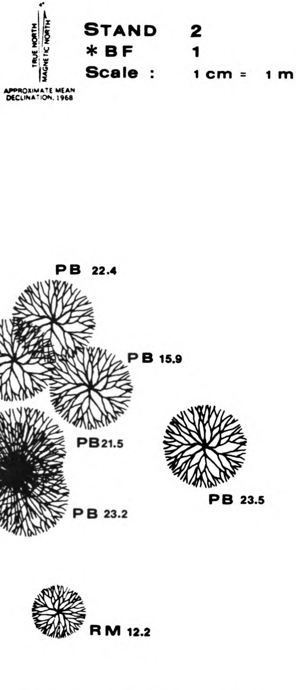


Figure D8. Stem map of the ten nearest trees that encompassed sampled tree BF 1 in Stand 2.

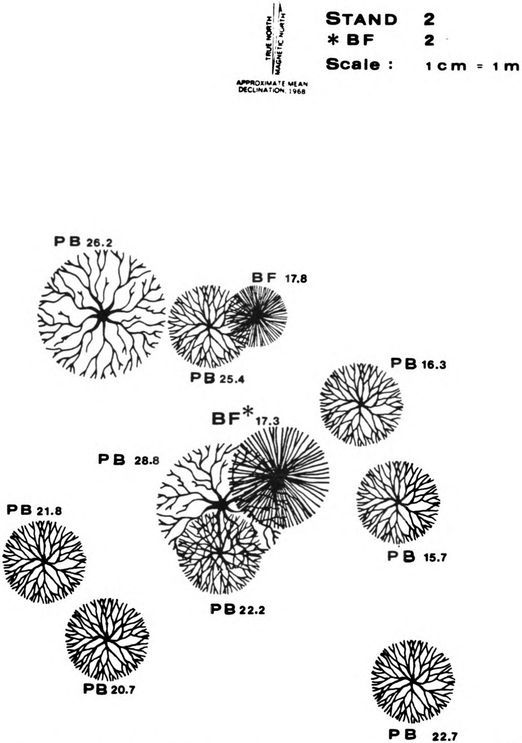


Figure D9. Stem map of the ten nearest trees that encompassed sampled tree BF 2 in Stand 2.

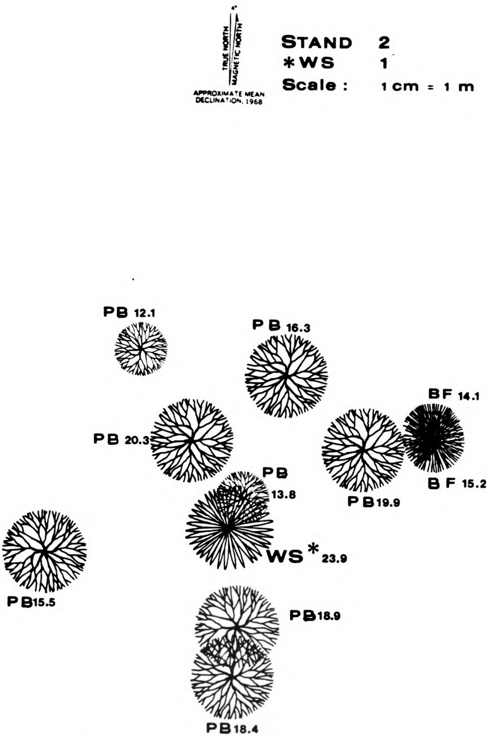


Figure D10. Stem map of the ten nearest trees that encompassed sampled tree WS 1 in Stand 2.

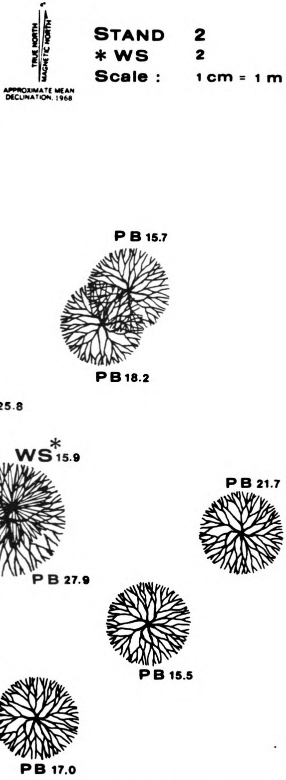


Figure D11. Stem map of the ten nearest trees that encompassed sampled tree WS 2 in Stand 2.

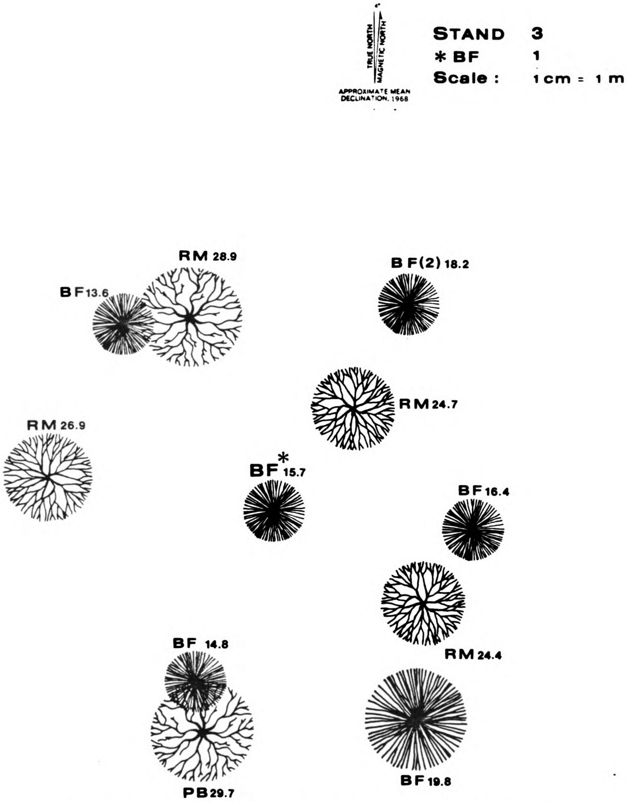


Figure D12. Stem map of the ten nearest trees that encompassed sampled tree BF 1 in Stand 3.

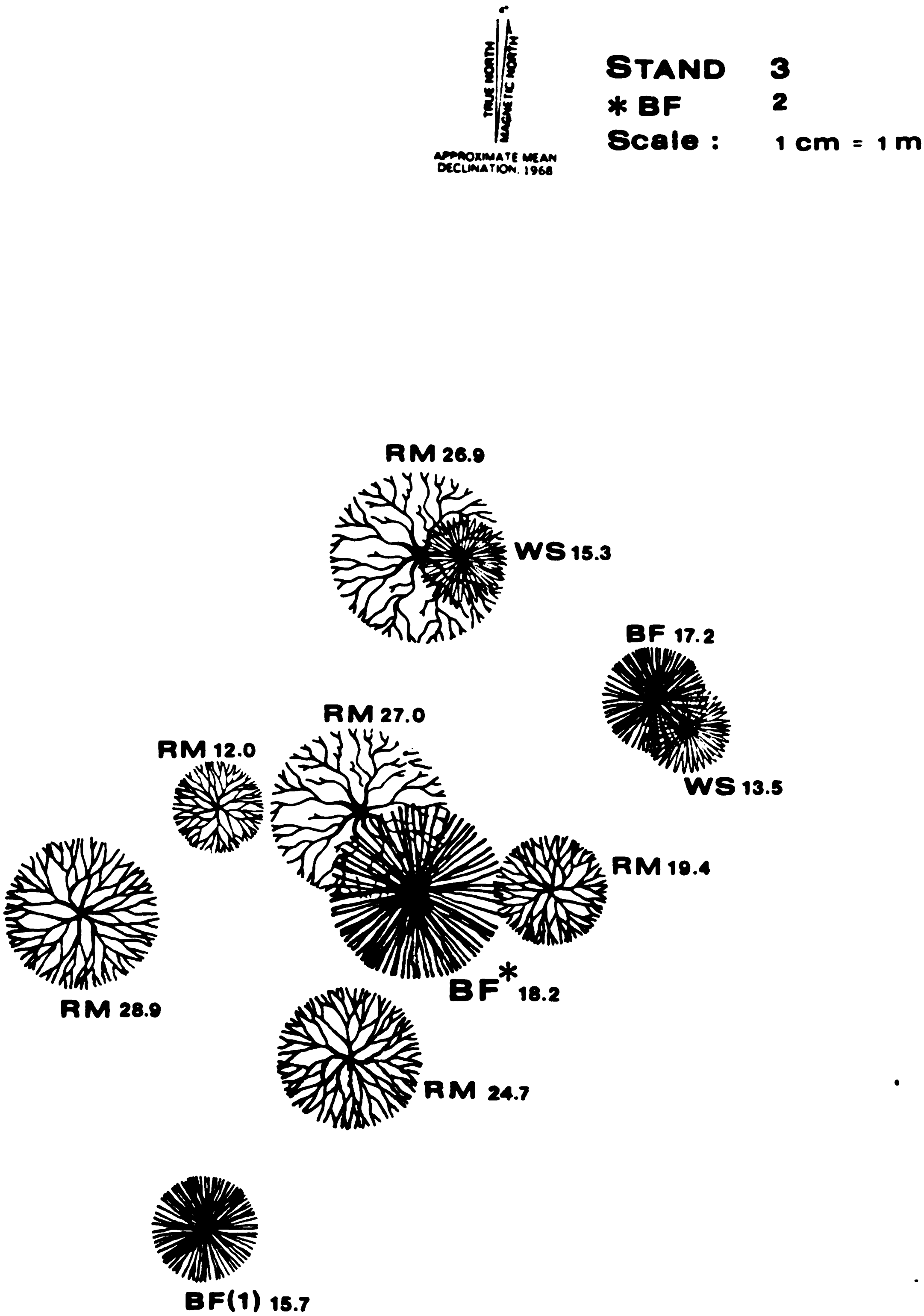


Figure D13. Stem map of the ten nearest trees that encompassed sampled tree BF 2 in Stand 3.

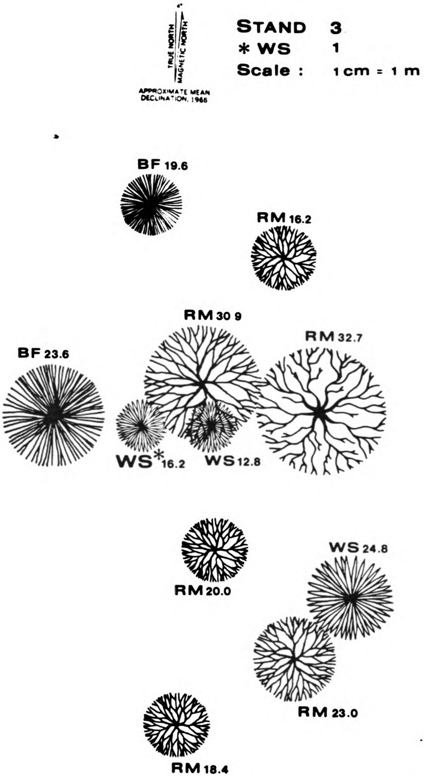


Figure D14. Stem map of the ten nearest trees that encompassed sampled tree WS 1 in Stand 3.

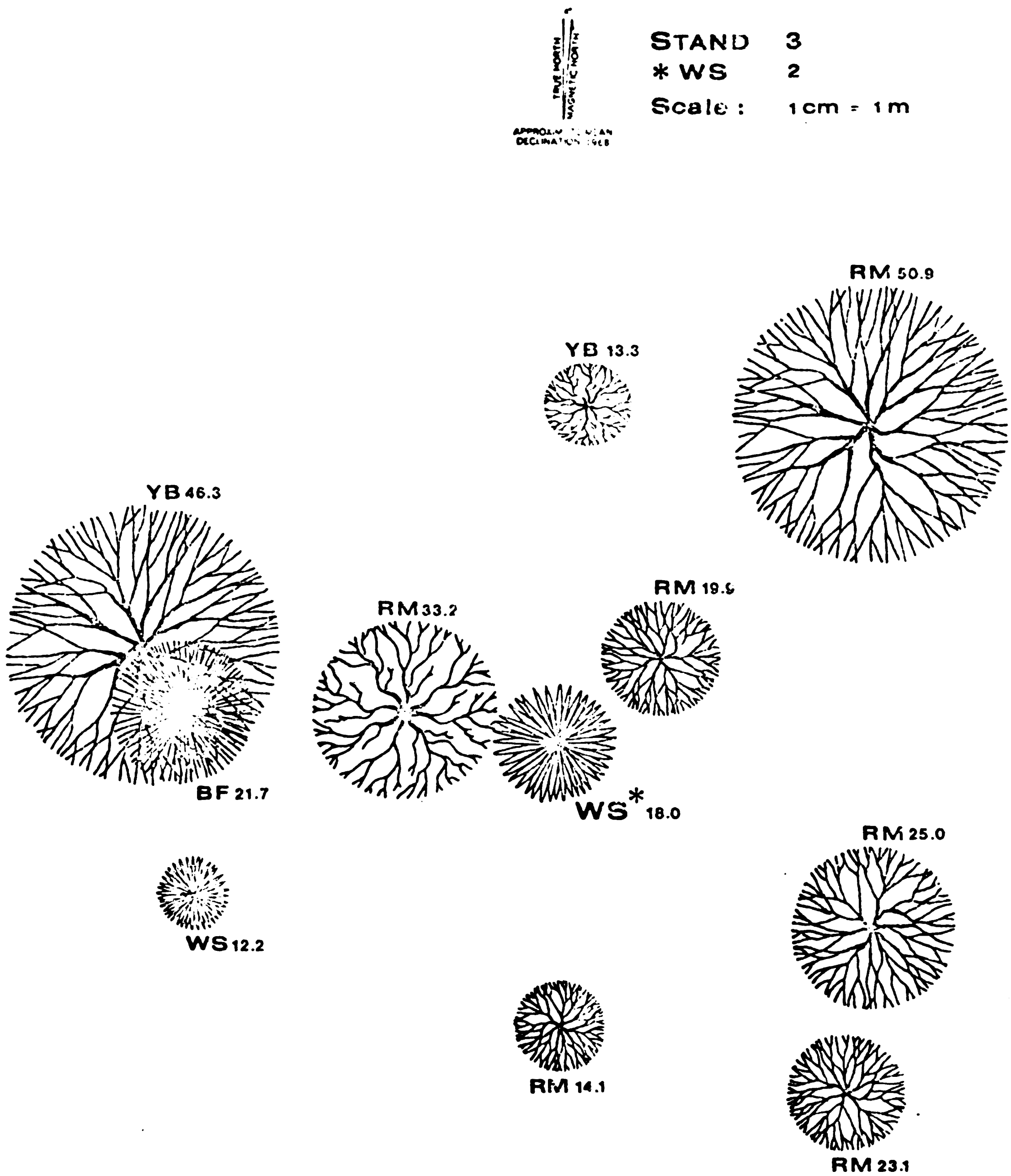


Figure D15. Stem map of the ten nearest trees that encompassed sampled tree WS 2 in Stand 3.

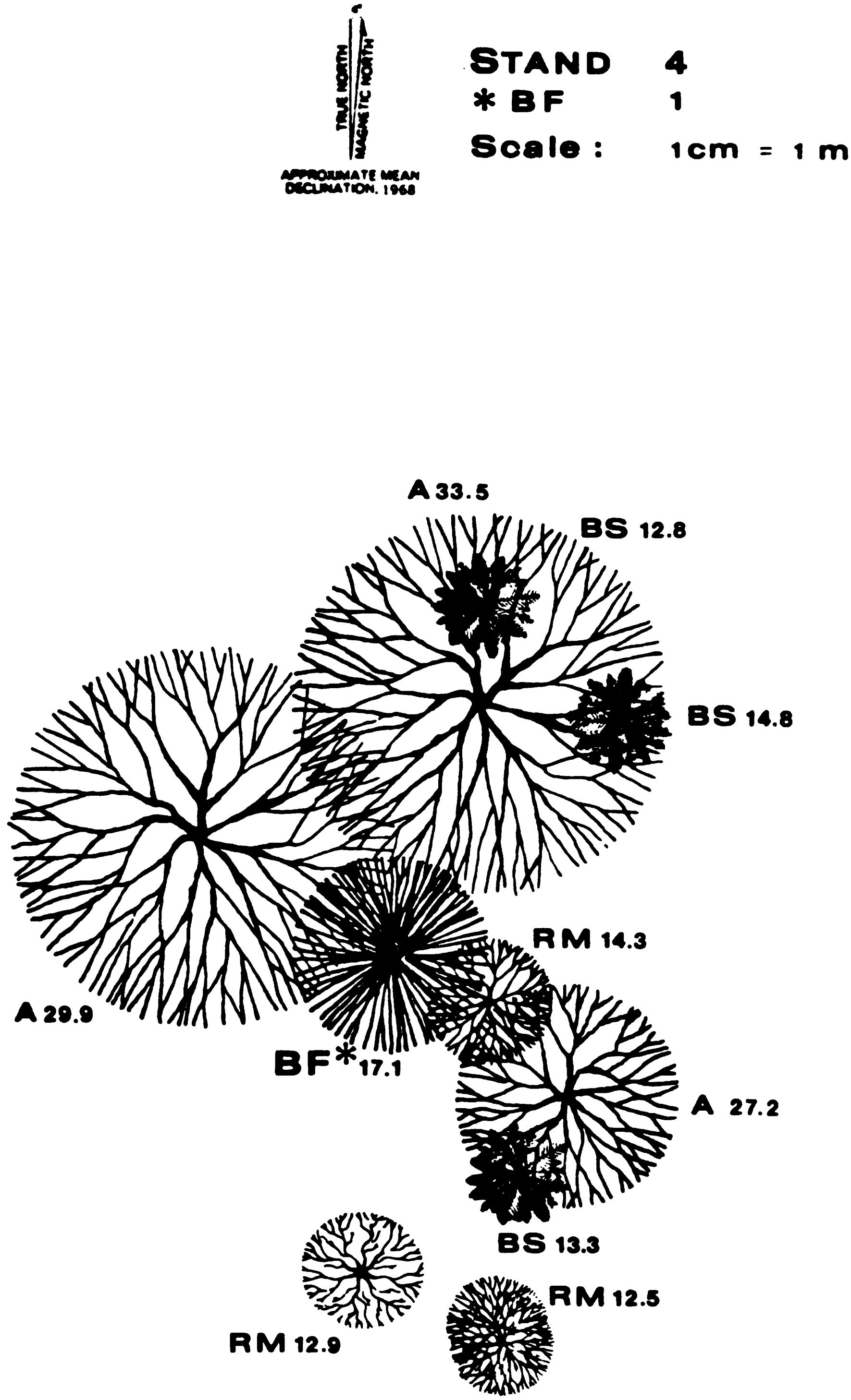


Figure D16. Stem map of the ten nearest trees that encompassed sampled tree BF 1 in Stand 4.

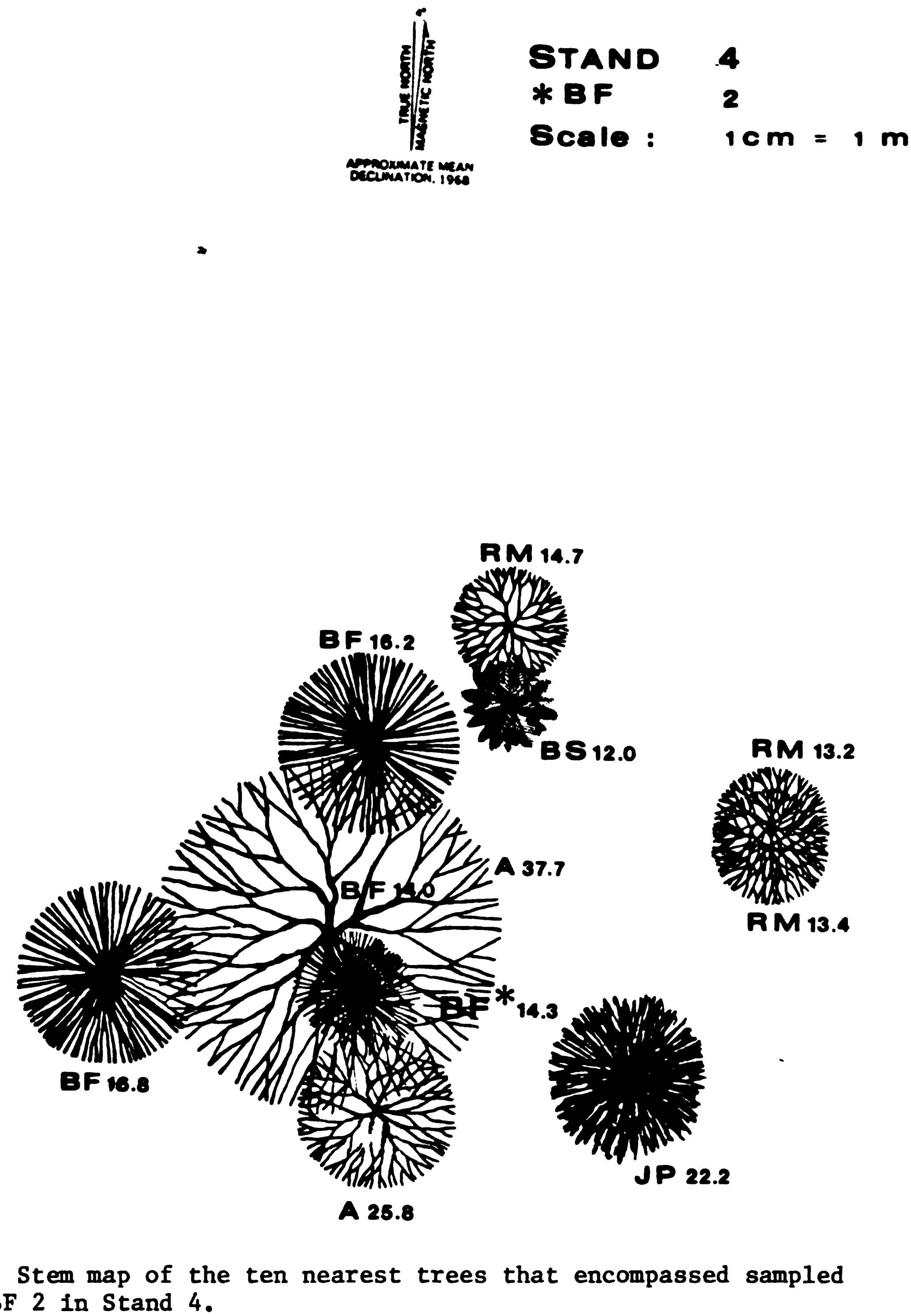


Figure D17. Stem map of the ten nearest trees that encompassed sampled tree BF 2 in Stand 4.

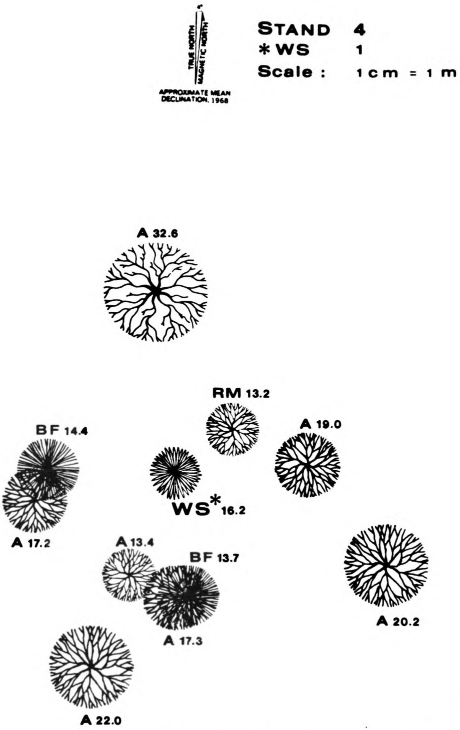


Figure D18. Stem map of the ten nearest trees that encompassed sampled tree WS 1 in Stand 4.

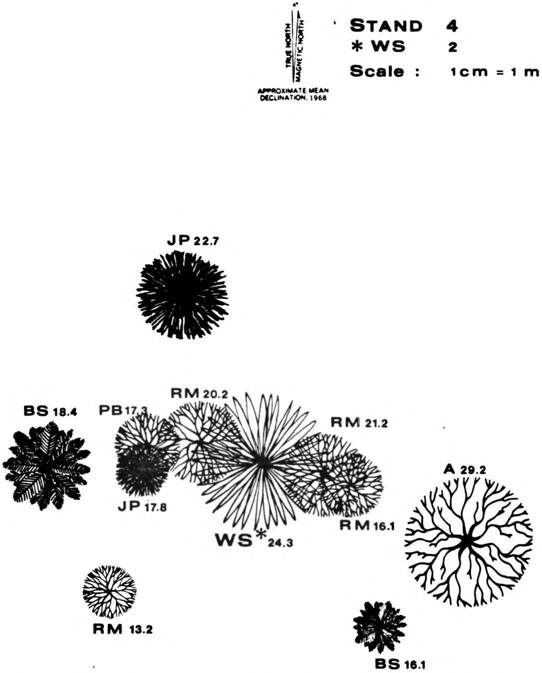
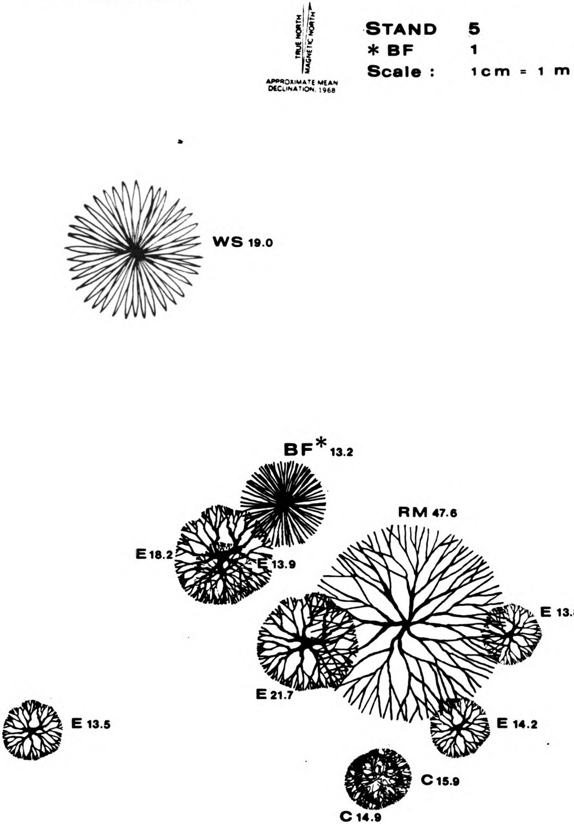


Figure D19. Stem map of the ten nearest trees that encompassed sampled tree WS 2 in Stand 4.

Figure D20. Stem map of the ten nearest trees that encompassed sampled tree BF 1 in Stand 5.



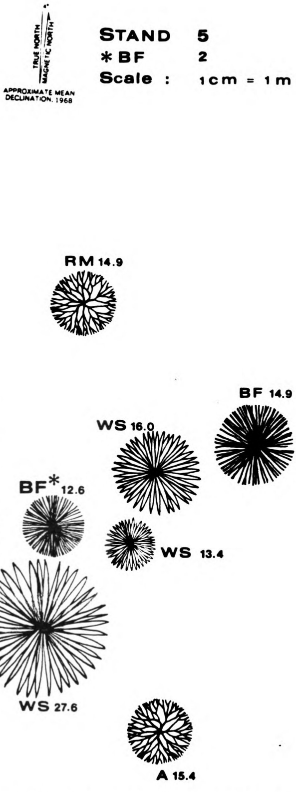


Figure D21. Stem map of the ten nearest trees that encompassed sampled tree BF 2 in Stand 5.

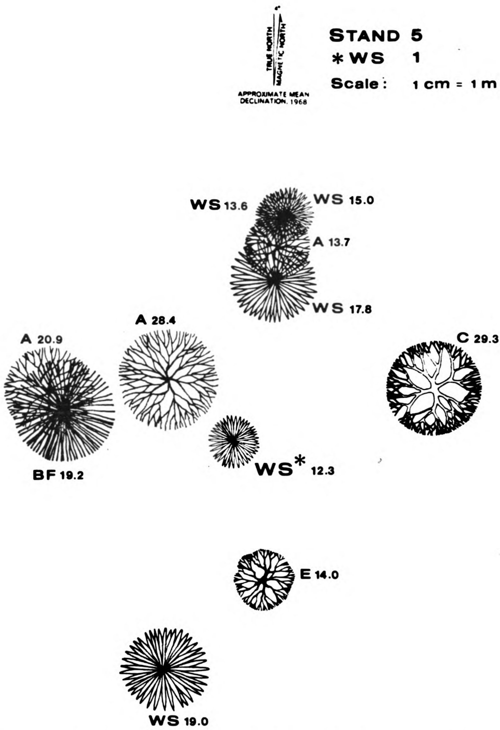


Figure D22. Stem map of the ten nearest trees that encompassed sampled tree WS 1 in Stand 5.

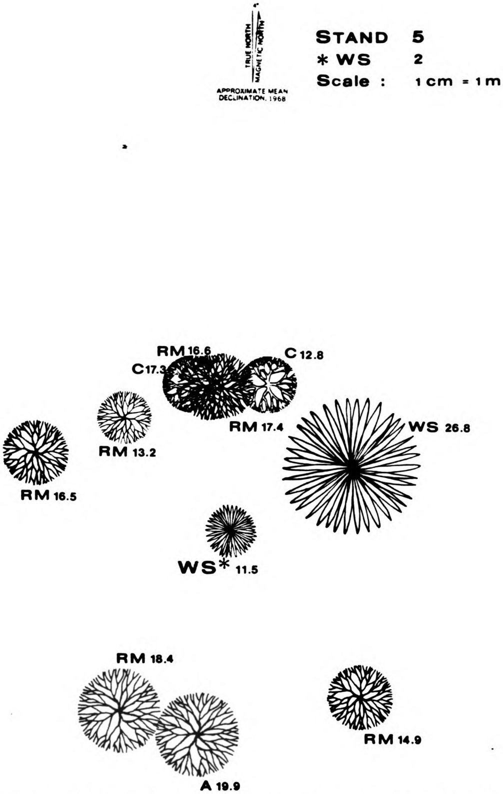


Figure D23. Stem map of the ten nearest trees that encompassed sampled tree WS 2 in Stand 5.

APPENDIX E.

APPENDIX E.

A graphical presentation of the field methods-the procedure used in egg mass sampling research.

At each stand, camp was set up at a convenient location. Two screen tents housed the research crew, while they examined foliage for egg masses. The other tent protected the sampled branches.

Figure E1. The field camp at Stand 5.

Trees that were chosen for sampling were flagged with orange ribbon and their trunks were painted with the appropriate identification letters and numbers.

Figure E2. Sampled tree BF 2 in Stand 3.

Figure E3. Sampled tree WS 1 in Stand 2.

Sampled trees' diameters, heights, ages, and locations within the stand were recorded.

Climbing spikes and harnesses were used in the measurement and collection of branches. Here, a research assistant has positioned the metric tape at the end of his pruning saw into the "center of gravity" of the branch.

Figure E4. Measuring the height of a branch-a research assistant on the sampled tree.

A research assistant below the tree would extend the metric tape perpendicular to the ground and would note the height of the branch to the nearest 0.1 meter and the quadrant that the branch grew in. Orange flagging had been layed on the ground at NW-SE and NE-SW angles, thus forming the four quadrant areas.

Figure E5. Measuring the height of a branch and noting its directional quadrant-a research assistant on the ground.

The research assistant on the ground would record the tree number, branch number, branch height and directional quadrant on a small tag.

Figure E6. Recording the branch number, height and quadrant-a research assistant on the ground.

The research assistant on the sampled tree would sever the branch at its base.

Figure E7. Cutting the sampled branch.

and would gently drop the severed branch to the research assistant on the ground.

Figure E8. Dropping the branch to the "spotter" on the ground.

The spotter would carefully catch the branch.

Figure E9. Catching a sampled branch that was dropped from the tree.

The research assistant on the ground would tie the tag onto the branch.

Figure E10. Tying the identification tag onto the branch.

and the branches would be piled near the tents.

Figure E11. A pile of severed and tagged branches near the screen tents.

Two research assistants would measure the total length, foliated length, and foliated width of each branch. This information would be recorded on the branch tag.

Figure E12. Research assistant measuring the foliated width of a branch.

Each research assistant would choose the top branch from the pile of measured branches and would clip the branch into pieces that were convenient to examine-approximately 10-20 cm in length. Each foliage piece would be thoroughly examined for egg masses.

Figure E13. Research assistant examining foliage for egg masses.

If an egg mass was found, the examiner would remove the needle, holding the egg mass, from the foliage piece (with forceps) and would place the egg mass and needle in a vial. He or she would label the vial with the appropriate stand, branch, and tree number. The number of egg masses and the appropriate data from the branch were recorded in the research assistant's field book.

Figure E14. Research assistant removing a needle and an egg mass from a foliage clipping.

After the foliage clippings had been examined, the research assistant would measure the branches' foliated area on a grid. The grid was marked off in 5 cm segments. Theoretically, the foliage would be placed on the grid so that none of the grid board was visible and none of the foliage pieces overlapped one another.

Figure E15. Measuring the foliated area of a sampled branch on a grid board.

The highest branches were measured and cut, so that only the top of the tree was remaining.

Figure E16. The top of the sampled tree.

The tree was then felled and data was collected on tree height, age, and heart rot.

APPENDIX F.

APPENDIX F.

Normality and homogeneity test results for egg mass groups used in parametric statistics

"Subprogram Condescriptive" (SPSS, pp. 185-193) (Nie et al. 1975) computed skewness and kurtosis, measures of nonnormality for continuous interval-level data. Skewness measures deviation from symmetry while kurtosis measures the flatness or peakedness of the frequency distribution.

$$\text{Skewness} = \frac{\sum_{i=1}^{N} \left((X_i - \bar{X})/s\right)^3}{N}$$

SPSS's (Nie et al. 1975) computational formula:

$$\text{Skewness} = \frac{\left\{\left[\sum_{i=1}^{N} X_i^3 - 3\bar{X}\left(\sum_{i=1}^{N} X_i^2\right) + 3\bar{X}^2\left(\sum_{i=1}^{N} X_i\right)\right]/N\right\} - \bar{X}^3}{\left\{\left(\sum_{i=1}^{N} X_i^2\right) - N\bar{X}^2/(N-1)\right\}^{3/2}}$$

$$\text{Kurtosis} = \frac{\sum_{i=1}^{N} \left((X_i - \bar{X})/S\right)^4}{N} - 3$$

SPSS's (Nie et al. 1975) computational formula:

$$\text{Kurtosis} = \frac{\left\{\left[\sum_{i=1}^{N} X_i^4 - 4\bar{X}\left(\sum_{i=1}^{N} X_i^3\right) + 6\bar{X}^2\left(\sum_{i=1}^{N} X_i^2\right) - 4\bar{X}^3\left(\sum_{i=1}^{N} X_i\right)\right]/N\right\} + \bar{X}^4}{\left\{\left[\left(\sum_{i=1}^{N} X_i^2\right) - N\bar{X}^2\right]/(N-1)\right\}^2} - 3$$

A normal distribution has a skewness of zero and a kurtosis of zero. A two-tailed t-test, as described by Sokal and Rohlf (1969) (pp. 166-172), was used to test for significant deviations from zero (i.e., do the observed skewness and kurtosis values for each egg mass sample group indicate a significant departure from normality?) where:

g_1 = the sample statistic for skewness,

g_2 = the sample statistic for kurtosis,

γ_1 = the expected value of skewness for a normally distributed population (i.e., 0),

γ_2 = the expected value of kurtosis for a normally distributed population (i.e., 0),

s_{g1} = the standard error of g_1,

s_{g2} = the standard error of g_2, and

n = sample size.

Estimations of values were computed with the following formulas:

$$s_{g1} = \sqrt{\frac{6n(n-1)}{(n-2)(n+1)(n+3)}}, \quad df = \infty$$

$$\sqrt{\frac{6}{n}} \quad \text{for large n (>100)}$$

$$s_{g2} = \sqrt{\frac{24n(n-1)^2}{(n-3)(n-2)(n+3)(n+5)}}, \quad df = \infty$$

$$\sqrt{\frac{24}{n}} \quad \text{for large n (>100)}$$

$$t_{s1} = \frac{(g_i-\gamma_i)}{s_{g1}}$$

$$t_{s2} \quad \frac{(g_2-\gamma_2)}{s_{g2}}$$

Estimated values of t_{s1}, and t_{s2} were evaluated with critical values of t with degrees of freedom, v.

Homogeneity of variances (homoscedasticity) was tested for each egg mass group with the Bartlett test (Bartlett-Box F statistic), "Subprogram Oneway", SPSS (pp. 422-433) (Nie et al. 1975). The statistical tests that were used in the thesis require equality of variances in a group of samples. "Subprogram Oneway" incorporates Bartlett's test and computes Bartlett's-Box F statistic and the corresponding significance probability, p, for each egg mass group. Although the SPSS manual does not provide definitional or computational formulas for the statistic, Sokal and Rohlf (1969) provide a good description and an example of the Bartlett test on pages 369-376 of their text. The value p permits easy assessment of the rejection level for homogeneity of variances (i.e., if p was found to be 0.110, homoscedasticity would be rejected for $\alpha > 0.110$ but not for $\alpha < 0.110$).

Normality and homoscedasticity were not confirmed for groups of randomly sampled egg masses that are marked with an (s) (significant departure from normality or homogeneity). These groups required statistical tests other than the parametrical test, oneway analysis of variance.

Table F1. Normality and homogeneity test results for egg masses from balsam fir, used for regression estimates.

Egg Mass Type	Sample Size	Mean Number of Eggs per Egg Mass	Standard Error	Standard Deviation	Homogeneity of Variances	
					Bartlett-Box F	P
2-Row	106	4.000	0.089	0.915	1.341	0.236
2-Row with a Partial Third	98	4.841	0.070	0.690	1.673	0.124
3-Row	104	5.446	0.086	0.882	1.078	0.371

Egg Mass Type	Normality							
	Skewness				Kurtosis			
	g_1	s_{g1}	t_{s1}	2-Tail Probability	g_2	s_{g2}	t_{s2}	2-Tail Probability
2-Row	-0.046	0.238	-0.193	0.90>p>0.80	-0.685	0.476	-1.439	0.20>p>0.10
2-Row with a Partial Third	-0.408	0.243	-1.679	0.10>p>0.05	0.253	0.483	0.524	0.70>p>0.60
3-Row	-0.144	0.240	-0.600	0.60>p>0.50	-0.715	0.480	-1.490	0.20>p>0.10

*square root foot

Table F2. Normality and homogeneity test results for egg masses from white spruce, used for regression estimates.

Egg Mass Type	Sample Size	Mean Number of Eggs per Egg Mass*	Standard Error*	Standard Deviation*	Homogeneity of Variances: Bartlett-Box F	Homogeneity of Variances: P
2-Row	130	4.116	0.070	0.801	1.561	0.168
2-Row with a Partial Third	104	4.812	0.065	0.663	2.447	0.024
3-Row	102	5.486	0.064	0.650	0.431	0.786

	Normality							
	Skewness				Kurtosis			
	g_1	s_{g1}	t_{s1}	2-Tail Probability	g_2	s_{g2}	t_{s2}	2-Tail Probability
2-Row	-0.264	0.214	1.234	0.30>p>0.20	-0.259	0.430	0.602	0.60>p>0.50
2-Row with a Partial Third	0.273	0.240	1.138	0.30>p>0.20	0.214	0.480	0.446	0.70>p>0.60
3-Row	-0.330	0.243	1.358	0.20>p>0.10	-0.127	0.485	0.262	0.80>p>0.70

*square root foot

Table F3. Normality and homogeneity test results for egg count (transformed into square roots) from north, east, south and west quadrants within balsam fir trees.

	Normality							
	Skewness				Kurtosis			
Quadrant	g_1	s_{g1}	t_{s1}	2-Tail Probability	g_2	s_{g2}	t_{s2}	2-Tail Probability
North	0.010	0.340	0.029	$p>0.90$	-0.300	0.668	0.449	$0.70>p>0.60$
East	-0.119	0.309	0.385	$0.80>p>0.70$	-0.968	0.608	1.592	$0.20>p>0.10$
South	-0.060	0.311	0.193	$0.90>p>0.80$	-0.564	0.613	0.920	$0.40>p>0.30$
West	-0.039	0.309	0.126	$p>0.90$	-0.923	0.608	1.518	$0.20>p>0.10$

Homogeneity of Variances

Bartlett-Box F Statistic = 1.004, P = 0.390

Table F4. Normality and homogeneity test results for egg counts (transformed into square roots) from lower, middle, and upper strata within balsam fir trees.

	Normality							
	Skewness				Kurtosis			
Stratum	g_1	s_{g1}	t_{s1}	2-Tail Probability	g_2	s_{g2}	t_{s1}	2-Tail Probability
Lower	0.015	0.501	0.030	$p>0.90$	-0.475	0.972	0.489	$0.70>p>0.60$
Middle	0.153	0.253	0.605	$0.60>p>0.50$	-0.713	0.500	1.426	$0.20>p>0.10$
Upper	-0.167	0.227	0.736	$0.50>p>0.40$	-0.837	0.455	1.840	$0.10>p>0.05$

<u>Homogeneity of Variances</u>

Bartlett-Box F Statistic = 0.295, P = 0.745

Table F5. Normality and homogeneity test results for egg counts (transformed into square roots) from 13 cells within balsam fir trees.

Cell	Normality							
	Skewness				Kurtosis			
	g_1	s_{g1}	t_{s1}	2-Tail Probability	g_2	s_{g2}	t_{s2}	2-Tail Probability
Lower North	1.447	0.949	1.525	0.30>p>0.20	1.653	2.619	0.631	0.60>p>0.50
Lower East	-0.718	0.794	-0.904	0.40>p>0.30	-1.429	1.587	-0.900	0.40>p>0.30
Lower South	1.323	1.225	1.080	0.40>p>0.30	0.000	2.828	0.000	1.0
Lower West	0.265	0.794	0.334	0.80>p>0.70	0.175	1.587	0.110	p>0.90
Middle North	0.630	0.536	1.175	0.30>p>0.20	0.267	1.038	0.257	0.90>p>0.80
Middle East	0.002	0.501	0.004	p>0.90	-0.711	0.972	-0.731	0.50>p>0.40
Middle South	0.274	0.456	0.601	0.60>p>0.50	-0.484	0.887	-0.546	0.60>p>0.50
Middle West	-0.032	0.456	-0.070	p>0.90	-1.360	0.887	-1.533	0.20>p>0.10
Upper North	-0.261	0.448	-0.583	0.60>p>0.50	-0.643	0.872	-0.737	0.50>p>0.40
Upper East	-0.012	0.414	-0.029	p>0.90	-0.935	0.809	-1.156	0.30>p>0.20
Upper South	-0.244	0.427	-0.571	0.60>p>0.50	-0.886	0.833	-1.064	0.30>p>0.20
Upper West	-0.243	0.448	-0.542	0.60>p>0.50	-0.814	0.872	-0.933	0.40>p>0.30
Top	1.149	0.491	2.340	0.05>p>0.02	1.567	0.953	1.644	0.20>p>0.10

Homogeneity of Variances

Bartlett-Box F Statistic = 0.620, P = 0.826

Table F6. Normality and homogeneity test results for egg count (transformed into square roots) from four balsam fir trees within Stand 1.

Tree	Normality							
	Skewness				Kurtosis			
	g_1	s_{g1}	t_{s1}	2-Tail Probability	g_2	s_{g2}	t_{s2}	2-Tail Probability
BF1	-0.888	0.845	-1.051	$0.40>p>0.30$	-1.888	1.741	-1.084	$0.40>p>0.30$
BF2	0.242	0.427	0.567	$0.60>p>0.50$	-0.701	0.833	-0.842	$0.50>p>0.40$
BF5	0.669	0.661	1.012	$0.40>p>0.30$	0.378	1.279	-0.296	$0.80>p>0.70$
BF6	0.581	0.481	1.208	$0.30>p>0.20$	-0.551	0.935	-0.589	$0.60>p>0.50$

Homogeneity of Variances

Bartlett-Box F Statistic = 0.3371, P = 0.293

Table F7. Normality and homogeneity test results for egg counts (transformed into square roots) from two balsam trees within Stand 2.

Tree	Normality							
	Skewness				Kurtosis			
	g_1	s_{g1}	t_{s1}	2-Tail Probability	g_2	s_{g2}	t_{s2}	2-Tail Probability
BF1	0.699	0.472	1.481	0.20>p>0.10	-0.849	0.918	0.925	0.40>p>0.30
BF2	-0.098	0.491	0.200	0.90>p>0.80	-1.020	0.953	1.070	0.30>p>0.20

Homogeneity of Variances

Bartlett-Box F Statistic = 0.318, P = 0.573

Table F8. Normality and homogeneity test results for egg counts (transformed into square roots) from two balsam fir trees within Stand 3.

	Normality							
	Skewness				Kurtosis			
Tree	g_1	s_{g1}	t_{s1}	2-Tail Probability	g_2	s_{g2}	t_{s2}	2-Tail Probability
BF1	-0.381	0.501	-0.760	0.50>p>0.40	-0.908	0.972	0.934	0.40>p>0.30
BF2	0.682	0.550	1.240	0.30>p>0.20	0.516	1.063	0.485	0.70>p>0.60

<u>Homogeneity of Variances</u>

Bartlett-Box F Statistic = 0.016, P = 0.899

Table F9. Normality and homogeneity test results for egg counts (transformed into square roots) from two balsam fir trees within Stand 4.

	Normality							
	Skewness				Kurtosis			
Tree	g_1	s_{g1}	t_{s1}	2-Tail Probability	g_2	s_{g2}	t_{s2}	2-Tail Probability
BF1	0.158	0.393	0.402	0.70>p>0.60	0.464	0.768	0.604	0.60>p>0.50
BF2	-0.044	0.414	-0.106	p>0.90	-0.454	0.809	-0.561	0.60>p>0.50

Homogeneity of Variances

Bartlett-Box F Statistic = 0.066, P = 0.797

Table F10. Normality and homogeneity test results for egg counts (transformed into square roots) from two balsam fir trees within Stand 5.

	Normality							
	Skewness				Kurtosis			
Tree	g_1	s_{g1}	t_{s1}	2-Tail Probability	g_2	s_{g2}	t_{s2}	2-Tail Probability
BF1	0.024	0.398	0.060	p>0.90	-0.690	0.778	-0.887	0.40>p>0.30
BF2	-0.041	0.448	-0.092	p>0.90	-0.541	0.872	-0.620	0.60>p>0.50

Homogeneity of Variance

Bartlett-Box F Statistic = 0.286, P = 0.593

Table F11. Normality and homogeneity test results for egg counts (transformed into square roots) from balsam fir trees in five stands in the Ottawa National Forest.

	Normality							
	Skewness				Kurtosis			
Stand	g_1	s_{g1}	t_{s1}	2-Tail Probability	g_2	s_{g2}	t_{s2}	2-Tail Probability
1	-0.058	0.393	-0.148	0.90>p>0.80	-0.801	0.768	-1.043	0.40>p>0.30
2	0.302	0.350	0.863	0.40>p>0.30	-1.148	0.688	-1.669	0.20>p>0.10
3	0.069	0.383	0.180	0.90>p>0.80	-0.673	0.750	-0.897	0.40>p>0.30
4	0.066	0.291	0.227	0.90>p>0.80	-0.119	0.574	-0.207	0.90>p>0.80
5	0.091	0.304	0.299	0.80>p>0.70	-0.531	0.599	-0.886	0.40>p>0.30

Homogeneity of Variances

Bartlett-Box F Statistic = 0.313, P = 0.869

Table F12. Normality and homogeneity test results for egg counts (transformed into square roots) from North, South, East, and West quadrants within white spruce trees.

	Normality							
	Skewness				Kurtosis			
Quadrant	g_1	s_{g1}	t_{s1}	2-Tail Probability	g_2	s_{g2}	t_{s2}	2-Tail Probability
North	-0.148	0.285	0.520	0.70>p>0.60	-0.037	0.563	-0.066	p>0.90
East	0.398	0.249	1.600	0.20>p>0.10	-0.458	0.497	-0.921	0.40>p>0.30
South	0.427	0.245	1.743	0.10>p>0.05	-0.373	0.490	-0.761	0.50>p>0.40
West	0.165	0.271	0.610	0.60>p>0.50	-0.331	0.535	-0.619	0.60>p>0.50

Homogeneity of Variances

Bartlett-Box F Statistic = 0.770, P = 0.511

Table F13. Normality and homogeneity test results for egg counts (transformed into square roots) from lower, middle, and upper strata within white spruce trees.

	Normality							
	Skewness				Kurtosis			
Stratum	g_1	s_{g1}	t_{s1}	2-Tail Probability	g_2	s_{g2}	t_{s2}	2-Tail Probability
Lower	0.318	0.281	1.132	0.30>p>0.20	-0.234	0.555	-0.421	0.70>p>0.60
Middle	0.328	0.210	1.562	0.20>p>0.10	-0.243	0.420	-0.578	0.60>p>0.50
Upper	0.157	0.209	0.751	0.50>p>0.40	-0.481	0.417	-1.153	0.30>p>0.20

Homogeneity of Variances

Bartlett-Box F Statistic = 0.202, P = 0.817

Table F14. Normality and homogeneity test results for egg counts (transformed into square roots) from 13 cells within white spruce trees.

	Normality							
	Skewness				Kurtosis			
Cell	g_1	s_{g1}	t_{s1}	2-Tail Probability	g_2	s_{g2}	t_{s2}	2-Tail Probability
Lower North	0.796	0.687	1.160	0.30 p 0.20	-0.239	1.334	-0.179	0.90 p 0.80
Lower East	0.486	0.472	1.030	0.40 p 0.30	-0.639	0.918	-0.696	0.50 p 0.40
Lower South	0.250	0.434	0.576	0.60 p 0.50	-0.130	0.845	-0.154	0.90 p 0.80
Lower West	-0.483	0.687	-0.703	0.50 p 0.40	-0.032	1.334	-0.024	p 0.90
Middle North	-0.337	0.441	-0.765	0.50 p 0.40	-0.343	0.858	-0.400	0.70 p 0.60
Middle East	0.289	0.388	0.746	0.50 p 0.40	-0.346	0.759	-0.456	0.70 p 0.60
Middle South	0.557	0.393	1.417	0.20 p 0.10	0.050	0.768	0.065	p 0.90
Middle West	0.249	0.398	0.626	0.60 p 0.50	-0.485	0.778	-0.623	0.60 p 0.50
Upper North	-0.351	0.409	-0.859	0.40 p 0.30	-0.170	0.798	-0.213	0.90 p 0.80
Upper East	0.433	0.393	1.102	0.30 p 0.20	-0.353	0.768	-0.460	0.70 p 0.60
Upper South	0.416	0.398	1.045	0.40 p 0.30	-0.786	0.778	-1.010	0.40 p 0.30
Upper West	0.127	0.403	0.315	0.80 p 0.70	-0.516	0.788	-0.655	0.60 p 0.50
Top	0.524	0.464	1.130	0.30 p 0.20	-0.525	0.902	-0.582	0.60 p 0.50

<u>Homogeneity of Variances</u>

Bartlett-Box F Statistic = 0.424, P = 0.954

Table F15. Normality and homogeneity test results for egg counts (transformed into square roots) from two white spruce trees within Stand 1.

	Normality							
	Skewness				Kurtosis			
Tree	g_1	s_{g1}	t_{s1}	2-Tail Probability	g_2	s_{g2}	t_{s2}	2-Tail Probability
WS1	0.051	0.388	0.131	0.90>p>0.80	-0.819	0.759	-1.079	0.30>p>0.20
WS2	0.161	0.409	0.394	0.70>p>0.60	-0.789	0.798	-0.989	0.40>p>0.30

<u>Homogeneity of Variances</u>

Bartlett-Box F Statistic = 0.219, P = 0.640

Table F16. Normality and homogeneity test results for egg counts (transformed into square roots) from two white spruce trees within Stand 2.

	Normality							
	Skewness				Kurtosis			
Tree	g_1	s_{g1}	t_{s1}	2-Tail Probability	g_2	s_{g2}	t_{s2}	2-Tail Probability
WS1	0.458	0.350	1.309	0.20>p>0.10	-0.059	0.688	-0.086	p>0.90
WS2	0.295	0.448	0.658	0.60>p>0.50	-1.005	0.872	-1.153	0.30>p>0.20

Homogeneity of Variances

Bartlett-Box F Statistic = 0.023, P = 0.880

Table F17. Normality and homogeneity test results for egg counts (transformed into square roots) from two white spruce trees within Stand 3.

	Normality							
	Skewness				Kurtosis			
Tree	g_1	s_{g1}	t_{s1}	2-Tail Probability	g_2	s_{g2}	t_{s2}	2-Tail Probabiltiy
WS1	-0.579	0.441	-1.313	0.20>p>0.10	1.289	0.858	1.502	0.20>p>0.10
WS2	-0.016	0.374	-0.043	p>0.90	-0.761	0.733	-1.038	0.40>p>0.30

Homogeneity of Variances

Bartlett-Box F Statistic = 0.512, P = 0.475

Table F18. Normality and homogeneity test results for egg counts (transformed into square roots) from two white spruce trees within Stand 4.

	Normality							
	Skewness				Kurtosis			
Tree	g_1	s_{g1}	t_{s1}	2-Tail Probability	g_2	s_{g2}	t_{s2}	2-Tail Probability
WS1	0.082	0.343	0.239	0.90>p>0.80	-0.930	0.674	1.380	0.20>p>0.10
WS2	0.596	0.357	1.669	0.20>p>0.10	0.731	0.702	1.041	0.40>p>0.30

Homogeneity of Variances

Bartlett-Box F Statistic = 1.239, P = 0.266

Table F19. Normality and homogeneity test results for egg counts (transformed into square roots) from two white spruce trees within Stand 5.

	Normality							
	Skewness				Kurtosis			
Tree	g_1	s_{g1}	t_{s1}	2-Tail Probability	g_2	s_{g2}	t_{s2}	2-Tail Probability
WS1	0.183	0.354	0.517	0.70>p>0.60	-0.780	0.695	-1.122	0.30>p>0.20
WS2	0.913	0.472	1.934	0.10>p>0.05	1.509	0.918	1.644	0.20>p>0.10

Homogeneity of Variances

Bartlett-Box F Statistic = 0.436, P = 0.509

Table F20. Normality and homogeneity test results for egg counts (transformed into square roots) from white spruce trees in five stands in the Ottawa National Forest.

Stand	Normality							
	Skewness				Kurtosis			
	g_1	s_{g1}	t_{s1}	2-Tail Probability	g_2	s_{g2}	t_{s2}	2-Tail Probability
1	0.102	0.287	0.355	0.80>p>0.70	-0.824	0.566	-1.455	0.20>p>0.10
2	0.356	0.281	1.267	0.30>p>0.20	-0.249	0.551	-0.452	0.70>p>0.60
3	-0.249	0.291	-0.856	0.40>p>0.30	0.089	0.574	0.155	0.90>p>0.80
4	0.342	0.251	1.361	0.20>p>0.10	-0.477	0.500	-0.954	0.40>p>0.30
5	0.394	0.289	1.365	0.20>p>0.10	-0.376	0.570	-0.660	0.60>p>0.50

Homogeneity of Variances

Bartlett-Box F Statistic = 4.039, P = 0.003(s)

Table F21. Normality and homogeneity test results for egg counts (transformed into square roots) from two balsam fir and two white spruce trees within Stand 1.

	Normality							
	Skewness				Kurtosis			
Tree Species	g_1	s_{g1}	t_{s1}	2-Tail Probability	g_2	s_{g2}	t_{s2}	2-Tail Probability
Balsam Fir	-0.058	0.393	-0.148	0.90>p>0.80	-0.801	0.768	-1.043	0.40>p>0.30
White Spruce	0.102	0.287	0.355	0.80>p>0.70	-0.824	0.566	-1.455	0.20>p>0.10

Homogeneity of Variances

Bartlett-Box F Statistic = 0.145, P = 0.703

Table F22. Normality and homogeneity test results for egg counts (transformed into square roots) from two balsam fir and two white spruce trees within Stand 2.

	Normality							
	Skewness				Kurtosis			
Tree Species	g_1	s_{g1}	t_{s1}	2-Tail Probability	g_2	s_{g2}	t_{s2}	2-Tail Probability
Balsam Fir	0.302	0.350	0.863	0.40>p>0.30	-1.148	0.688	-1.669	0.20>p>0.10
White Spruce	0.356	0.281	1.267	0.30>p>0.20	-0.249	0.551	-0.452	0.70>p>0.60

<u>Homogeneity of Variances</u>

Bartlett-Box F Statistic = 1.147, P = 0.284

Table F23. Normality and homogeneity test results for egg counts (transformed into square roots) from two balsam fir and two white spruce trees within Stand 3.

	Normality							
	Skewness				Kurtosis			
Tree Species	g_1	s_{g1}	t_{s1}	2-Tail Probability	g_2	s_{g2}	t_{s2}	2-Tail Probability
Balsam Fir	0.069	0.383	0.180	0.90>p>0.80	-0.673	0.750	-0.897	0.40>p>0.30
White Spruce	-0.249	0.291	-0.856	0.40>p>0.30	0.089	0.574	0.155	0.90>p>0.80

<u>Homogeneity of Variances</u>

Bartlett-Box F Statistic = 13.256, P = 0.000(s)

Table F24. Normality and homogeneity test results for egg counts (transformed into square roots) from two balsam fir and two white spruce trees within Stand 4.

	Normality							
	Skewness				Kurtosis			
Tree Species	g_1	s_{g1}	t_{s1}	2-Tail Probability	g_2	s_{g2}	t_{s2}	2-Tail Probability
Balsam Fir	0.066	0.291	0.227	0.90>p>0.80	-0.119	0.574	-0.207	0.90>p>0.80
White Spruce	0.342	0.251	1.361	0.20>p>0.10	-0.477	0.500	-0.954	0.40>p>0.30

Homogeneity of Variances

Bartlett-Box F Statistic = 0.423, P = 0.516

Table F25. Normality and homogeneity test results for egg counts (transformed into square roots) from two balsam fir and two white spruce trees within Stand 5.

	Normality							
	Skewness				Kurtosis			
Tree Species	g_1	s_{g1}	t_{s1}	2-Tail Probability	g_2	s_{g2}	t_{s2}	2-Tail Probability
Balsam Fir	0.091	0.304	0.299	0.80>p>0.70	-0.531	0.599	-0.886	0.40>p>0.30
White Spruce	0.394	0.289	1.365	0.20>p>0.10	-0.376	0.570	-0.660	0.60>p>0.50

<u>Homogeneity of Variances</u>

Bartlett-Box F Statistic = 3.071, P = 0.080

Table F26. Normality and homogeneity test results for egg counts (transformed into square roots) from ten balsam fir and ten white spruce trees in five stands within the Ottawa National Forest.

	Normality							
	Skewness				Kurtosis			
Tree Species	g_1	s_{g1}	t_{s1}	2-Tail Probability	g_2	s_{g2}	t_{s2}	2-Tail Probability
Balsam Fir	0.099	0.155	0.639	$0.60 > p > 0.50$	-0.649	0.310	-2.094	$0.05 > p > 0.02$(s)
White Spruce	0.278	0.127	2.189	$0.05 > p > 0.02$(s)	-0.321	0.254	-1.264	$0.30 > p > 0.20$

Homogeneity of Variances

Bartlett-Box F Statistic = 4.516, P = 0.034(s)

APPENDIX G.

APPENDIX G.

Number of eggs per mass per cell

Four egg masses were randomly chosen from four branches that had resided in one of the predesignated cells. As reported in the text, the egg masses were measured and the number of eggs were estimated using Leonard's et al. (1973) technique. Table G1 reports these counts. A key for the headings and units is provided at the end of the table (0 eggs per mass always indicates that there was not an egg mass measured for that cell).

Table G1. Distribution of individual egg counts within each sampled tree.

STD	SPP	TREE	QUADRANT	STRATUM	#EGGS/MASS
1	BF	1	LOWER	NORTH	-
1	BF	1	LOWER	NORTH	-
1	BF	1	LOWER	NORTH	-
1	BF	1	LOWER	NORTH	-
1	BF	1	LOWER	EAST	35
1	BF	1	LOWER	EAST	-
1	BF	1	LOWER	EAST	-
1	BF	1	LOWER	EAST	-
1	BF	1	LOWER	SOUTH	-
1	BF	1	LOWER	SOUTH	-
1	BF	1	LOWER	SOUTH	-
1	BF	1	LOWER	SOUTH	-
1	BF	1	LOWER	WEST	09
1	BF	1	LOWER	WEST	-
1	BF	1	LOWER	WEST	-
1	BF	1	LOWER	WEST	-
1	BF	1	MIDDLE	NORTH	-
1	BF	1	MIDDLE	NORTH	-
1	BF	1	MIDDLE	NORTH	-
1	BF	1	MIDDLE	NORTH	-
1	BF	1	MIDDLE	EAST	-
1	BF	1	MIDDLE	EAST	-
1	BF	1	MIDDLE	EAST	-
1	BF	1	MIDDLE	EAST	-
1	BF	1	MIDDLE	SOUTH	-
1	BF	1	MIDDLE	SOUTH	09
1	BF	1	MIDDLE	SOUTH	35
1	BF	1	MIDDLE	SOUTH	-
1	BF	1	MIDDLE	WEST	-
1	BF	1	MIDDLE	WEST	-
1	BF	1	MIDDLE	WEST	-
1	BF	1	MIDDLE	WEST	-
1	BF	1	UPPER	NORTH	29
1	BF	1	UPPER	NORTH	-
1	BF	1	UPPER	NORTH	-
1	BF	1	UPPER	NORTH	-
1	BF	1	UPPER	EAST	-
1	BF	1	UPPER	EAST	-
1	BF	1	UPPER	EAST	-
1	BF	1	UPPER	EAST	-

Table G1. Continued.

STD	SPP	TREE	QUADRANT	STRATUM	#EGGS/MASS
1	BF	1	UPPER	SOUTH	32
1	BF	1	UPPER	SOUTH	-
1	BF	1	UPPER	SOUTH	-
1	BF	1	UPPER	SOUTH	-
1	BF	1	UPPER	WEST	-
1	BF	1	UPPER	WEST	-
1	BF	1	UPPER	WEST	-
1	BF	1	UPPER	WEST	-
1	BF	1	TOP	TOP	-
1	BF	1	TOP	TOP	-
1	BF	1	TOP	TOP	-
1	BF	1	TOP	TOP	-
1	BF	2	LOWER	NORTH	-
1	BF	2	LOWER	NORTH	-
1	BF	2	LOWER	NORTH	-
1	BF	2	LOWER	NORTH	-
1	BF	2	LOWER	EAST	12
1	BF	2	LOWER	EAST	12
1	BF	2	LOWER	EAST	-
1	BF	2	LOWER	EAST	-
1	BF	2	LOWER	SOUTH	50
1	BF	2	LOWER	SOUTH	29
1	BF	2	LOWER	SOUTH	-
1	BF	2	LOWER	SOUTH	-
1	BF	2	LOWER	WEST	-
1	BF	2	LOWER	WEST	-
1	BF	2	LOWER	WEST	-
1	BF	2	LOWER	WEST	-
1	BF	2	MIDDLE	NORTH	26
1	BF	2	MIDDLE	NORTH	25
1	BF	2	MIDDLE	NORTH	12
1	BF	2	MIDDLE	NORTH	26
1	BF	2	MIDDLE	EAST	32
1	BF	2	MIDDLE	EAST	35
1	BF	2	MIDDLE	EAST	20
1	BF	2	MIDDLE	EAST	26
1	BF	2	MIDDLE	SOUTH	19
1	BF	2	MIDDLE	SOUTH	-
1	BF	2	MIDDLE	SOUTH	-
1	BF	2	MIDDLE	SOUTH	-

Table G1. Continued.

STD	SPP	TREE	QUADRANT	STRATUM	#EGGS/MASS
1	BF	2	MIDDLE	WEST	12
1	BF	2	MIDDLE	WEST	32
1	BF	2	MIDDLE	WEST	12
1	BF	2	MIDDLE	WEST	29
1	BF	2	UPPER	NORTH	15
1	BF	2	UPPER	NORTH	38
1	BF	2	UPPER	NORTH	-
1	BF	2	UPPER	NORTH	-
1	BF	2	UPPER	EAST	20
1	BF	2	UPPER	EAST	17
1	BF	2	UPPER	EAST	-
1	BF	2	UPPER	EAST	-
1	BF	2	UPPER	SOUTH	46
1	BF	2	UPPER	SOUTH	24
1	BF	2	UPPER	SOUTH	38
1	BF	2	UPPER	SOUTH	32
1	BF	2	UPPER	WEST	41
1	BF	2	UPPER	WEST	-
1	BF	2	UPPER	WEST	-
1	BF	2	UPPER	WEST	-
1	BF	2	TOP	TOP	20
1	BF	2	TOP	TOP	22
1	BF	2	TOP	TOP	20
1	BF	2	TOP	TOP	17
1	BF	5	LOWER	NORTH	-
1	BF	5	LOWER	NORTH	-
1	BF	5	LOWER	NORTH	-
1	BF	5	LOWER	NORTH	-
1	BF	5	LOWER	EAST	-
1	BF	5	LOWER	EAST	-
1	BF	5	LOWER	EAST	-
1	BF	5	LOWER	EAST	-
1	BF	5	LOWER	SOUTH	26
1	BF	5	LOWER	SOUTH	-
1	BF	5	LOWER	SOUTH	-
1	BF	5	LOWER	SOUTH	-
1	BF	5	LOWER	WEST	-
1	BF	5	LOWER	WEST	-
1	BF	5	LOWER	WEST	-
1	BF	5	LOWER	WEST	-

Table G1. Continued.

STD	SPP	TREE	QUADRANT	STRATUM	#EGGS/MASS
1	BF	5	MIDDLE	NORTH	-
1	BF	5	MIDDLE	NORTH	-
1	BF	5	MIDDLE	NORTH	-
1	BF	5	MIDDLE	NORTH	-
1	BF	5	MIDDLE	EAST	-
1	BF	5	MIDDLE	EAST	-
1	BF	5	MIDDLE	EAST	-
1	BF	5	MIDDLE	EAST	-
1	BF	5	MIDDLE	SOUTH	13
1	BF	5	MIDDLE	SOUTH	-
1	BF	5	MIDDLE	SOUTH	-
1	BF	5	MIDDLE	SOUTH	-
1	BF	5	MIDDLE	WEST	17
1	BF	5	MIDDLE	WEST	20
1	BF	5	MIDDLE	WEST	18
1	BF	5	MIDDLE	WEST	22
1	BF	5	UPPER	NORTH	35
1	BF	5	UPPER	NORTH	-
1	BF	5	UPPER	NORTH	-
1	BF	5	UPPER	NORTH	-
1	BF	5	UPPER	EAST	-
1	BF	5	UPPER	EAST	-
1	BF	5	UPPER	EAST	-
1	BF	5	UPPER	EAST	-
1	BF	5	UPPER	SOUTH	42
1	BF	5	UPPER	SOUTH	22
1	BF	5	UPPER	SOUTH	10
1	BF	5	UPPER	SOUTH	-
1	BF	5	UPPER	WEST	17
1	BF	5	UPPER	WEST	-
1	BF	5	UPPER	WEST	-
1	BF	5	UPPER	WEST	-
1	BF	5	TOP	TOP	-
1	BF	5	TOP	TOP	-
1	BF	5	TOP	TOP	-
1	BF	5	TOP	TOP	-
1	BF	6	LOWER	NORTH	19
1	BF	6	LOWER	NORTH	-
1	BF	6	LOWER	NORTH	-
1	BF	6	LOWER	NORTH	-

Table G1. Continued.

STD	SPP	TREE	QUADRANT	STRATUM	#EGGS/MASS
1	BF	6	LOWER	EAST	-
1	BF	6	LOWER	EAST	-
1	BF	6	LOWER	EAST	-
1	BF	6	LOWER	EAST	-
1	BF	6	LOWER	SOUTH	-
1	BF	6	LOWER	SOUTH	-
1	BF	6	LOWER	SOUTH	-
1	BF	6	LOWER	SOUTH	-
1	BF	6	LOWER	WEST	10
1	BF	6	LOWER	WEST	-
1	BF	6	LOWER	WEST	-
1	BF	6	LOWER	WEST	-
1	BF	6	MIDDLE	NORTH	13
1	BF	6	MIDDLE	NORTH	46
1	BF	6	MIDDLE	NORTH	10
1	BF	6	MIDDLE	NORTH	-
1	BF	6	MIDDLE	EAST	29
1	BF	6	MIDDLE	EAST	24
1	BF	6	MIDDLE	EAST	12
1	BF	6	MIDDLE	EAST	13
1	BF	6	MIDDLE	SOUTH	62
1	BF	6	MIDDLE	SOUTH	-
1	BF	6	MIDDLE	SOUTH	-
1	BF	6	MIDDLE	SOUTH	-
1	BF	6	MIDDLE	WEST	32
1	BF	6	MIDDLE	WEST	32
1	BF	6	MIDDLE	WEST	26
1	BF	6	MIDDLE	WEST	42
1	BF	6	UPPER	NORTH	09
1	BF	6	UPPER	NORTH	23
1	BF	6	UPPER	NORTH	22
1	BF	6	UPPER	NORTH	-
1	BF	6	UPPER	EAST	29
1	BF	6	UPPER	EAST	42
1	BF	6	UPPER	EAST	-
1	BF	6	UPPER	EAST	-
1	BF	6	UPPER	SOUTH	-
1	BF	6	UPPER	SOUTH	-
1	BF	6	UPPER	SOUTH	-
1	BF	6	UPPER	SOUTH	-

Table G1. Continued.

STD	SPP	TREE	QUADRANT	STRATUM	#EGGS/MASS
1	BF	6	UPPER	WEST	13
1	BF	6	UPPER	WEST	09
1	BF	6	UPPER	WEST	09
1	BF	6	UPPER	WEST	10
1	BF	6	TOP	TOP	-
1	BF	6	TOP	TOP	-
1	BF	6	TOP	TOP	-
1	BF	6	TOP	TOP	-
2	BF	1	LOWER	NORTH	19
2	BF	1	LOWER	NORTH	-
2	BF	1	LOWER	NORTH	-
2	BF	1	LOWER	NORTH	-
2	BF	1	LOWER	EAST	-
2	BF	1	LOWER	EAST	-
2	BF	1	LOWER	EAST	-
2	BF	1	LOWER	EAST	-
2	BF	1	LOWER	SOUTH	-
2	BF	1	LOWER	SOUTH	-
2	BF	1	LOWER	SOUTH	-
2	BF	1	LOWER	SOUTH	-
2	BF	1	LOWER	WEST	-
2	BF	1	LOWER	WEST	-
2	BF	1	LOWER	WEST	-
2	BF	1	LOWER	WEST	-
2	BF	1	MIDDLE	NORTH	-
2	BF	1	MIDDLE	NORTH	-
2	BF	1	MIDDLE	NORTH	-
2	BF	1	MIDDLE	NORTH	-
2	BF	1	MIDDLE	EAST	-
2	BF	1	MIDDLE	EAST	-
2	BF	1	MIDDLE	EAST	-
2	BF	1	MIDDLE	EAST	-
2	BF	1	MIDDLE	SOUTH	15
2	BF	1	MIDDLE	SOUTH	13
2	BF	1	MIDDLE	SOUTH	-
2	BF	1	MIDDLE	SOUTH	-
2	BF	1	MIDDLE	WEST	10
2	BF	1	MIDDLE	WEST	32
2	BF	1	MIDDLE	WEST	17
2	BF	1	MIDDLE	WEST	12

Table G1. Continued.

STD	SPP	TREE	QUADRANT	STRATUM	#EGGS/MASS
2	BF	1	UPPER	NORTH	20
2	BF	1	UPPER	NORTH	17
2	BF	1	UPPER	NORTH	20
2	BF	1	UPPER	NORTH	19
2	BF	1	UPPER	EAST	38
2	BF	1	UPPER	EAST	15
2	BF	1	UPPER	EAST	-
2	BF	1	UPPER	EAST	-
2	BF	1	UPPER	SOUTH	38
2	BF	1	UPPER	SOUTH	13
2	BF	1	UPPER	SOUTH	-
2	BF	1	UPPER	SOUTH	13
2	BF	1	UPPER	WEST	35
2	BF	1	UPPER	WEST	29
2	BF	1	UPPER	WEST	26
2	BF	1	UPPER	WEST	17
2	BF	1	TOP	TOP	12
2	BF	1	TOP	TOP	12
2	BF	1	TOP	TOP	32
2	BF	1	TOP	TOP	13
2	BF	2	LOWER	NORTH	-
2	BF	2	LOWER	NORTH	-
2	BF	2	LOWER	NORTH	-
2	BF	2	LOWER	NORTH	-
2	BF	2	LOWER	EAST	-
2	BF	2	LOWER	EAST	-
2	BF	2	LOWER	EAST	-
2	BF	2	LOWER	EAST	-
2	BF	2	LOWER	SOUTH	-
2	BF	2	LOWER	SOUTH	-
2	BF	2	LOWER	SOUTH	-
2	BF	2	LOWER	SOUTH	-
2	BF	2	LOWER	WEST	-
2	BF	2	LOWER	WEST	-
2	BF	2	LOWER	WEST	-
2	BF	2	LOWER	WEST	-
2	BF	2	MIDDLE	NORTH	29
2	BF	2	MIDDLE	NORTH	-
2	BF	2	MIDDLE	NORTH	-
2	BF	2	MIDDLE	NORTH	-

Table Gl. Continued.

STD	SPP	TREE	QUADRANT	STRATUM	#EGGS/MASS
2	BF	2	MIDDLE	EAST	19
2	BF	2	MIDDLE	EAST	29
2	BF	2	MIDDLE	EAST	19
2	BF	2	MIDDLE	EAST	-
2	BF	2	MIDDLE	SOUTH	17
2	BF	2	MIDDLE	SOUTH	38
2	BF	2	MIDDLE	SOUTH	35
2	BF	2	MIDDLE	SOUTH	17
2	BF	2	MIDDLE	WEST	29
2	BF	2	MIDDLE	WEST	46
2	BF	2	MIDDLE	WEST	12
2	BF	2	MIDDLE	WEST	-
2	BF	2	UPPER	NORTH	35
2	BF	2	UPPER	NORTH	24
2	BF	2	UPPER	NORTH	-
2	BF	2	UPPER	NORTH	-
2	BF	2	UPPER	EAST	26
2	BF	2	UPPER	EAST	10
2	BF	2	UPPER	EAST	13
2	BF	2	UPPER	EAST	17
2	BF	2	UPPER	SOUTH	09
2	BF	2	UPPER	SOUTH	-
2	BF	2	UPPER	SOUTH	-
2	BF	2	UPPER	SOUTH	-
2	BF	2	UPPER	WEST	32
2	BF	2	UPPER	WEST	32
2	BF	2	UPPER	WEST	17
2	BF	2	UPPER	WEST	38
2	BF	2	TOP	TOP	-
2	BF	2	TOP	TOP	-
2	BF	2	TOP	TOP	-
2	BF	2	TOP	TOP	-
3	BF	1	LOWER	NORTH	-
3	BF	1	LOWER	NORTH	-
3	BF	1	LOWER	NORTH	-
3	BF	1	LOWER	NORTH	-
3	BF	1	LOWER	EAST	-
3	BF	1	LOWER	EAST	-
3	BF	1	LOWER	EAST	-
3	BF	1	LOWER	EAST	-

Table G1. Continued.

STD	SPP	TREE	QUADRANT	STRATUM	#EGGS/MASS
3	BF	1	LOWER	SOUTH	-
3	BF	1	LOWER	SOUTH	-
3	BF	1	LOWER	SOUTH	-
3	BF	1	LOWER	SOUTH	-
3	BF	1	LOWER	WEST	-
3	BF	1	LOWER	WEST	-
3	BF	1	LOWER	WEST	-
3	BF	1	LOWER	WEST	-
3	BF	1	MIDDLE	NORTH	32
3	BF	1	MIDDLE	NORTH	46
3	BF	1	MIDDLE	NORTH	19
3	BF	1	MIDDLE	NORTH	-
3	BF	1	MIDDLE	EAST	46
3	BF	1	MIDDLE	EAST	-
3	BF	1	MIDDLE	EAST	-
3	BF	1	MIDDLE	EAST	-
3	BF	1	MIDDLE	SOUTH	-
3	BF	1	MIDDLE	SOUTH	-
3	BF	1	MIDDLE	SOUTH	-
3	BF	1	MIDDLE	SOUTH	-
3	BF	1	MIDDLE	WEST	35
3	BF	1	MIDDLE	WEST	10
3	BF	1	MIDDLE	WEST	29
3	BF	1	MIDDLE	WEST	-
3	BF	1	UPPER	NORTH	22
3	BF	1	UPPER	NORTH	35
3	BF	1	UPPER	NORTH	-
3	BF	1	UPPER	NORTH	-
3	BF	1	UPPER	EAST	29
3	BF	1	UPPER	EAST	35
3	BF	1	UPPER	EAST	38
3	BF	1	UPPER	EAST	09
3	BF	1	UPPER	SOUTH	15
3	BF	1	UPPER	SOUTH	17
3	BF	1	UPPER	SOUTH	09
3	BF	1	UPPER	SOUTH	29
3	BF	1	UPPER	WEST	29
3	BF	1	UPPER	WEST	32
3	BF	1	UPPER	WEST	23
3	BF	1	UPPER	WEST	12

Table G1. Continued.

STD	SPP	TREE	QUADRANT	STRATUM	#EGGS/MASS
3	BF	1	TOP	TOP	-
3	BF	1	TOP	TOP	-
3	BF	1	TOP	TOP	-
3	BF	1	TOP	TOP	-
3	BF	2	LOWER	NORTH	22
3	BF	2	LOWER	NORTH	-
3	BF	2	LOWER	NORTH	-
3	BF	2	LOWER	NORTH	-
3	BF	2	LOWER	EAST	-
3	BF	2	LOWER	EAST	-
3	BF	2	LOWER	EAST	-
3	BF	2	LOWER	EAST	-
3	BF	2	LOWER	SOUTH	-
3	BF	2	LOWER	SOUTH	-
3	BF	2	LOWER	SOUTH	-
3	BF	2	LOWER	SOUTH	-
3	BF	2	LOWER	WEST	50
3	BF	2	LOWER	WEST	-
3	BF	2	LOWER	WEST	-
3	BF	2	LOWER	WEST	-
3	BF	2	MIDDLE	NORTH	-
3	BF	2	MIDDLE	NORTH	-
3	BF	2	MIDDLE	NORTH	-
3	BF	2	MIDDLE	NORTH	-
3	BF	2	MIDDLE	EAST	18
3	BF	2	MIDDLE	EAST	-
3	BF	2	MIDDLE	EAST	-
3	BF	2	MIDDLE	EAST	-
3	BF	2	MIDDLE	SOUTH	22
3	BF	2	MIDDLE	SOUTH	09
3	BF	2	MIDDLE	SOUTH	50
3	BF	2	MIDDLE	SOUTH	26
3	BF	2	MIDDLE	WEST	32
3	BF	2	MIDDLE	WEST	09
3	BF	2	MIDDLE	WEST	17
3	BF	2	MIDDLE	WEST	20
3	BF	2	UPPER	NORTH	-
3	BF	2	UPPER	NORTH	-
3	BF	2	UPPER	NORTH	-
3	BF	2	UPPER	NORTH	-

Table G1. Continued.

STD	SPP	TREE	QUADRANT	STRATUM	#EGGS/MASS
3	BF	2	UPPER	EAST	15
3	BF	2	UPPER	EAST	17
3	BF	2	UPPER	EAST	32
3	BF	2	UPPER	EAST	17
3	BF	2	UPPER	SOUTH	26
3	BF	2	UPPER	SOUTH	-
3	BF	2	UPPER	SOUTH	-
3	BF	2	UPPER	SOUTH	-
3	BF	2	UPPER	WEST	22
3	BF	2	UPPER	WEST	-
3	BF	2	UPPER	WEST	-
3	BF	2	UPPER	WEST	-
3	BF	2	TOP	TOP	-
3	BF	2	TOP	TOP	-
3	BF	2	TOP	TOP	-
3	BF	2	TOP	TOP	-
4	BF	1	LOWER	NORTH	-
4	BF	1	LOWER	NORTH	-
4	BF	1	LOWER	NORTH	-
4	BF	1	LOWER	NORTH	-
4	BF	1	LOWER	EAST	35
4	BF	1	LOWER	EAST	-
4	BF	1	LOWER	EAST	-
4	BF	1	LOWER	EAST	-
4	BF	1	LOWER	SOUTH	-
4	BF	1	LOWER	SOUTH	-
4	BF	1	LOWER	SOUTH	-
4	BF	1	LOWER	SOUTH	-
4	BF	1	LOWER	WEST	32
4	BF	1	LOWER	WEST	12
4	BF	1	LOWER	WEST	24
4	BF	1	LOWER	WEST	-
4	BF	1	MIDDLE	NORTH	15
4	BF	1	MIDDLE	NORTH	19
4	BF	1	MIDDLE	NORTH	22
4	BF	1	MIDDLE	NORTH	13
4	BF	1	MIDDLE	EAST	-
4	BF	1	MIDDLE	EAST	-
4	BF	1	MIDDLE	EAST	-
4	BF	1	MIDDLE	EAST	-

Table G1. Continued.

STD	SPP	TREE	QUADRANT	STRATUM	#EGGS/MASS
4	BF	1	MIDDLE	SOUTH	26
4	BF	1	MIDDLE	SOUTH	29
4	BF	1	MIDDLE	SOUTH	10
4	BF	1	MIDDLE	SOUTH	24
4	BF	1	MIDDLE	WEST	20
4	BF	1	MIDDLE	WEST	42
4	BF	1	MIDDLE	WEST	27
4	BF	1	MIDDLE	WEST	35
4	BF	1	UPPER	NORTH	16
4	BF	1	UPPER	NORTH	23
4	BF	1	UPPER	NORTH	35
4	BF	1	UPPER	NORTH	17
4	BF	1	UPPER	EAST	24
4	BF	1	UPPER	EAST	13
4	BF	1	UPPER	EAST	07
4	BF	1	UPPER	EAST	29
4	BF	1	UPPER	SOUTH	32
4	BF	1	UPPER	SOUTH	26
4	BF	1	UPPER	SOUTH	26
4	BF	1	UPPER	SOUTH	18
4	BF	1	UPPER	WEST	29
4	BF	1	UPPER	WEST	22
4	BF	1	UPPER	WEST	19
4	BF	1	UPPER	WEST	22
4	BF	1	TOP	TOP	54
4	BF	1	TOP	TOP	19
4	BF	1	TOP	TOP	10
4	BF	1	TOP	TOP	23
4	BF	2	LOWER	NORTH	-
4	BF	2	LOWER	NORTH	-
4	BF	2	LOWER	NORTH	-
4	BF	2	LOWER	NORTH	-
4	BF	2	LOWER	EAST	24
4	BF	2	LOWER	EAST	42
4	BF	2	LOWER	EAST	-
4	BF	2	LOWER	EAST	-
4	BF	2	LOWER	SOUTH	-
4	BF	2	LOWER	SOUTH	-
4	BF	2	LOWER	SOUTH	-
4	BF	2	LOWER	SOUTH	-

Table G1. Continued.

STD	SPP	TREE	QUADRANT	STRATUM	#EGGS/MASS
4	BF	2	LOWER	WEST	-
4	BF	2	LOWER	WEST	-
4	BF	2	LOWER	WEST	-
4	BF	2	LOWER	WEST	-
4	BF	2	MIDDLE	NORTH	32
4	BF	2	MIDDLE	NORTH	15
4	BF	2	MIDDLE	NORTH	-
4	BF	2	MIDDLE	NORTH	-
4	BF	2	MIDDLE	EAST	42
4	BF	2	MIDDLE	EAST	19
4	BF	2	MIDDLE	EAST	32
4	BF	2	MIDDLE	EAST	29
4	BF	2	MIDDLE	SOUTH	22
4	BF	2	MIDDLE	SOUTH	29
4	BF	2	MIDDLE	SOUTH	46
4	BF	2	MIDDLE	SOUTH	1Ø
4	BF	2	MIDDLE	WEST	-
4	BF	2	MIDDLE	WEST	-
4	BF	2	MIDDLE	WEST	-
4	BF	2	MIDDLE	WEST	-
4	BF	2	UPPER	NORTH	29
4	BF	2	UPPER	NORTH	29
4	BF	2	UPPER	NORTH	19
4	BF	2	UPPER	NORTH	38
4	BF	2	UPPER	EAST	26
4	BF	2	UPPER	EAST	29
4	BF	2	UPPER	EAST	19
4	BF	2	UPPER	EAST	26
4	BF	2	UPPER	SOUTH	26
4	BF	2	UPPER	SOUTH	26
4	BF	2	UPPER	SOUTH	19
4	BF	2	UPPER	SOUTH	1Ø
4	BF	2	UPPER	WEST	15
4	BF	2	UPPER	WEST	26
4	BF	2	UPPER	WEST	24
4	BF	2	UPPER	WEST	13
4	BF	2	TOP	TOP	Ø9
4	BF	2	TOP	TOP	46
4	BF	2	TOP	TOP	13
4	BF	2	TOP	TOP	22

Table G1. Continued.

STD	SPP	TREE	QUADRANT	STRATUM	#EGGS/MASS
5	BF	1	LOWER	NORTH	-
5	BF	1	LOWER	NORTH	-
5	BF	1	LOWER	NORTH	-
5	BF	1	LOWER	NORTH	-
5	BF	1	LOWER	EAST	-
5	BF	1	LOWER	EAST	-
5	BF	1	LOWER	EAST	-
5	BF	1	LOWER	EAST	-
5	BF	1	LOWER	SOUTH	-
5	BF	1	LOWER	SOUTH	-
5	BF	1	LOWER	SOUTH	-
5	BF	1	LOWER	SOUTH	-
5	BF	1	LOWER	WEST	26
5	BF	1	LOWER	WEST	-
5	BF	1	LOWER	WEST	-
5	BF	1	LOWER	WEST	-
5	BF	1	MIDDLE	NORTH	19
5	BF	1	MIDDLE	NORTH	17
5	BF	1	MIDDLE	NORTH	13
5	BF	1	MIDDLE	NORTH	26
5	BF	1	MIDDLE	EAST	22
5	BF	1	MIDDLE	EAST	10
5	BF	1	MIDDLE	EAST	22
5	BF	1	MIDDLE	EAST	15
5	BF	1	MIDDLE	SOUTH	32
5	BF	1	MIDDLE	SOUTH	24
5	BF	1	MIDDLE	SOUTH	24
5	BF	1	MIDDLE	SOUTH	17
5	BF	1	MIDDLE	WEST	35
5	BF	1	MIDDLE	WEST	32
5	BF	1	MIDDLE	WEST	19
5	BF	1	MIDDLE	WEST	13
5	BF	1	UPPER	NORTH	17
5	BF	1	UPPER	NORTH	07
5	BF	1	UPPER	NORTH	10
5	BF	1	UPPER	NORTH	09
5	BF	1	UPPER	EAST	26
5	BF	1	UPPER	EAST	13
5	BF	1	UPPER	EAST	26
5	BF	1	UPPER	EAST	42

Table G1. Continued.

STD	SPP	TREE	QUADRANT	STRATUM	#EGGS/MASS
5	BF	1	UPPER	SOUTH	29
5	BF	1	UPPER	SOUTH	23
5	BF	1	UPPER	SOUTH	13
5	BF	1	UPPER	SOUTH	Ø7
5	BF	1	UPPER	WEST	1Ø
5	BF	1	UPPER	WEST	29
5	BF	1	UPPER	WEST	1Ø
5	BF	1	UPPER	WEST	22
5	BF	1	TOP	TOP	16
5	BF	1	TOP	TOP	22
5	BF	1	TOP	TOP	-
5	BF	1	TOP	TOP	-
5	BF	2	LOWER	NORTH	19
5	BF	2	LOWER	NORTH	29
5	BF	2	LOWER	NORTH	-
5	BF	2	LOWER	NORTH	-
5	BF	2	LOWER	EAST	35
5	BF	2	LOWER	EAST	-
5	BF	2	LOWER	EAST	-
5	BF	2	LOWER	EAST	-
5	BF	2	LOWER	SOUTH	23
5	BF	2	LOWER	SOUTH	-
5	BF	2	LOWER	SOUTH	-
5	BF	2	LOWER	SOUTH	-
5	BF	2	LOWER	WEST	22
5	BF	2	LOWER	WEST	-
5	BF	2	LOWER	WEST	-
5	BF	2	LOWER	WEST	-
5	BF	2	MIDDLE	NORTH	-
5	BF	2	MIDDLE	NORTH	-
5	BF	2	MIDDLE	NORTH	-
5	BF	2	MIDDLE	NORTH	-
5	BF	2	MIDDLE	EAST	29
5	BF	2	MIDDLE	EAST	38
5	BF	2	MIDDLE	EAST	15
5	BF	2	MIDDLE	EAST	38
5	BF	2	MIDDLE	SOUTH	54
5	BF	2	MIDDLE	SOUTH	-
5	BF	2	MIDDLE	SOUTH	-
5	BF	2	MIDDLE	SOUTH	-

Table G1. Continued.

STD	SPP	TREE	QUADRANT	STRATUM	#EGGS/MASS
5	BF	2	MIDDLE	WEST	-
5	BF	2	MIDDLE	WEST	-
5	BF	2	MIDDLE	WEST	-
5	BF	2	MIDDLE	WEST	-
5	BF	2	UPPER	NORTH	32
5	BF	2	UPPER	NORTH	26
5	BF	2	UPPER	NORTH	10
5	BF	2	UPPER	NORTH	22
5	BF	2	UPPER	EAST	13
5	BF	2	UPPER	EAST	46
5	BF	2	UPPER	EAST	38
5	BF	2	UPPER	EAST	35
5	BF	2	UPPER	SOUTH	26
5	BF	2	UPPER	SOUTH	12
5	BF	2	UPPER	SOUTH	32
5	BF	2	UPPER	SOUTH	35
5	BF	2	UPPER	WEST	12
5	BF	2	UPPER	WEST	-
5	BF	2	UPPER	WEST	-
5	BF	2	UPPER	WEST	-
5	BF	2	TOP	TOP	29
5	BF	2	TOP	TOP	24
5	BF	2	TOP	TOP	20
5	BF	2	TOP	TOP	15
1	WS	1	LOWER	NORTH	43
1	WS	1	LOWER	NORTH	33
1	WS	1	LOWER	NORTH	-
1	WS	1	LOWER	NORTH	-
1	WS	1	LOWER	EAST	35
1	WS	1	LOWER	EAST	25
1	WS	1	LOWER	EAST	18
1	WS	1	LOWER	EAST	-
1	WS	1	LOWER	SOUTH	27
1	WS	1	LOWER	SOUTH	09
1	WS	1	LOWER	SOUTH	20
1	WS	1	LOWER	SOUTH	-
1	WS	1	LOWER	WEST	-
1	WS	1	LOWER	WEST	-
1	WS	1	LOWER	WEST	-
1	WS	1	LOWER	WEST	-

Table G1. Continued.

STD	SPP	TREE	QUADRANT	STRATUM	#EGGS/MASS
1	WS	1	MIDDLE	NORTH	25
1	WS	1	MIDDLE	NORTH	22
1	WS	1	MIDDLE	NORTH	-
1	WS	1	MIDDLE	NORTH	-
1	WS	1	MIDDLE	EAST	36
1	WS	1	MIDDLE	EAST	32
1	WS	1	MIDDLE	EAST	43
1	WS	1	MIDDLE	EAST	28
1	WS	1	MIDDLE	SOUTH	13
1	WS	1	MIDDLE	SOUTH	09
1	WS	1	MIDDLE	SOUTH	20
1	WS	1	MIDDLE	SOUTH	15
1	WS	1	MIDDLE	WEST	22
1	WS	1	MIDDLE	WEST	18
1	WS	1	MIDDLE	WEST	13
1	WS	1	MIDDLE	WEST	13
1	WS	1	UPPER	NORTH	39
1	WS	1	UPPER	NORTH	30
1	WS	1	UPPER	NORTH	27
1	WS	1	UPPER	NORTH	25
1	WS	1	UPPER	EAST	11
1	WS	1	UPPER	EAST	22
1	WS	1	UPPER	EAST	20
1	WS	1	UPPER	EAST	11
1	WS	1	UPPER	SOUTH	31
1	WS	1	UPPER	SOUTH	36
1	WS	1	UPPER	SOUTH	23
1	WS	1	UPPER	SOUTH	13
1	WS	1	UPPER	WEST	22
1	WS	1	UPPER	WEST	15
1	WS	1	UPPER	WEST	18
1	WS	1	UPPER	WEST	-
1	WS	1	TOP	TOP	-
1	WS	1	TOP	TOP	-
1	WS	1	TOP	TOP	-
1	WS	1	TOP	TOP	-
1	WS	2	LOWER	NORTH	15
1	WS	2	LOWER	NORTH	-
1	WS	2	LOWER	NORTH	-
1	WS	2	LOWER	NORTH	-

Table G1. Continued.

STD	SPP	TREE	QUADRANT	STRATUM	#EGGS/MASS
1	WS	2	LOWER	EAST	28
1	WS	2	LOWER	EAST	-
1	WS	2	LOWER	EAST	-
1	WS	2	LOWER	EAST	-
1	WS	2	LOWER	SOUTH	-
1	WS	2	LOWER	SOUTH	-
1	WS	2	LOWER	SOUTH	-
1	WS	2	LOWER	SOUTH	-
1	WS	2	LOWER	WEST	-
1	WS	2	LOWER	WEST	-
1	WS	2	LOWER	WEST	-
1	WS	2	LOWER	WEST	-
1	WS	2	MIDDLE	NORTH	25
1	WS	2	MIDDLE	NORTH	25
1	WS	2	MIDDLE	NORTH	33
1	WS	2	MIDDLE	NORTH	22
1	WS	2	MIDDLE	EAST	23
1	WS	2	MIDDLE	EAST	11
1	WS	2	MIDDLE	EAST	43
1	WS	2	MIDDLE	EAST	30
1	WS	2	MIDDLE	SOUTH	15
1	WS	2	MIDDLE	SOUTH	13
1	WS	2	MIDDLE	SOUTH	23
1	WS	2	MIDDLE	SOUTH	33
1	WS	2	MIDDLE	WEST	43
1	WS	2	MIDDLE	WEST	27
1	WS	2	MIDDLE	WEST	15
1	WS	2	MIDDLE	WEST	23
1	WS	2	UPPER	NORTH	25
1	WS	2	UPPER	NORTH	22
1	WS	2	UPPER	NORTH	11
1	WS	2	UPPER	NORTH	-
1	WS	2	UPPER	EAST	-
1	WS	2	UPPER	EAST	-
1	WS	2	UPPER	EAST	-
1	WS	2	UPPER	EAST	-
1	WS	2	UPPER	SOUTH	31
1	WS	2	UPPER	SOUTH	11
1	WS	2	UPPER	SOUTH	13
1	WS	2	UPPER	SOUTH	18

Table G1. Continued.

STD	SPP	TREE	QUADRANT	STRATUM	#EGGS/MASS
1	WS	2	UPPER	WEST	28
1	WS	2	UPPER	WEST	11
1	WS	2	UPPER	WEST	18
1	WS	2	UPPER	WEST	09
1	WS	2	TOP	TOP	24
1	WS	2	TOP	TOP	09
1	WS	2	TOP	TOP	46
1	WS	2	TOP	TOP	39
2	WS	1	LOWER	NORTH	20
2	WS	1	LOWER	NORTH	15
2	WS	1	LOWER	NORTH	32
2	WS	1	LOWER	NORTH	18
2	WS	1	LOWER	EAST	-
2	WS	1	LOWER	EAST	-
2	WS	1	LOWER	EAST	-
2	WS	1	LOWER	EAST	-
2	WS	1	LOWER	SOUTH	25
2	WS	1	LOWER	SOUTH	20
2	WS	1	LOWER	SOUTH	43
2	WS	1	LOWER	SOUTH	18
2	WS	1	LOWER	WEST	18
2	WS	1	LOWER	WEST	18
2	WS	1	LOWER	WEST	31
2	WS	1	LOWER	WEST	-
2	WS	1	MIDDLE	NORTH	27
2	WS	1	MIDDLE	NORTH	13
2	WS	1	MIDDLE	NORTH	18
2	WS	1	MIDDLE	NORTH	20
2	WS	1	MIDDLE	EAST	13
2	WS	1	MIDDLE	EAST	25
2	WS	1	MIDDLE	EAST	28
2	WS	1	MIDDLE	EAST	18
2	WS	1	MIDDLE	SOUTH	27
2	WS	1	MIDDLE	SOUTH	39
2	WS	1	MIDDLE	SOUTH	20
2	WS	1	MIDDLE	SOUTH	23
2	WS	1	MIDDLE	WEST	41
2	WS	1	MIDDLE	WEST	18
2	WS	1	MIDDLE	WEST	22
2	WS	1	MIDDLE	WEST	27

Table G1. Continued.

STD	SPP	TREE	QUADRANT	STRATUM	#EGGS/MASS
2	WS	1	UPPER	NORTH	20
2	WS	1	UPPER	NORTH	13
2	WS	1	UPPER	NORTH	13
2	WS	1	UPPER	NORTH	08
2	WS	1	UPPER	EAST	27
2	WS	1	UPPER	EAST	23
2	WS	1	UPPER	EAST	11
2	WS	1	UPPER	EAST	13
2	WS	1	UPPER	SOUTH	13
2	WS	1	UPPER	SOUTH	17
2	WS	1	UPPER	SOUTH	39
2	WS	1	UPPER	SOUTH	18
2	WS	1	UPPER	WEST	11
2	WS	1	UPPER	WEST	25
2	WS	1	UPPER	WEST	13
2	WS	1	UPPER	WEST	22
2	WS	1	TOP	TOP	31
2	WS	1	TOP	TOP	18
2	WS	1	TOP	TOP	20
2	WS	1	TOP	TOP	-
2	WS	2	LOWER	NORTH	-
2	WS	2	LOWER	NORTH	-
2	WS	2	LOWER	NORTH	-
2	WS	2	LOWER	NORTH	-
2	WS	2	LOWER	EAST	18
2	WS	2	LOWER	EAST	25
2	WS	2	LOWER	EAST	11
2	WS	2	LOWER	EAST	11
2	WS	2	LOWER	SOUTH	09
2	WS	2	LOWER	SOUTH	-
2	WS	2	LOWER	SOUTH	-
2	WS	2	LOWER	SOUTH	-
2	WS	2	LOWER	WEST	-
2	WS	2	LOWER	WEST	-
2	WS	2	LOWER	WEST	-
2	WS	2	LOWER	WEST	-
2	WS	2	MIDDLE	NORTH	15
2	WS	2	MIDDLE	NORTH	20
2	WS	2	MIDDLE	NORTH	-
2	WS	2	MIDDLE	NORTH	-

Table G1. Continued.

STD	SPP	TREE	QUADRANT	STRATUM	#EGGS/MASS
2	WS	2	MIDDLE	EAST	15
2	WS	2	MIDDLE	EAST	18
2	WS	2	MIDDLE	EAST	08
2	WS	2	MIDDLE	EAST	13
2	WS	2	MIDDLE	SOUTH	-
2	WS	2	MIDDLE	SOUTH	-
2	WS	2	MIDDLE	SOUTH	-
2	WS	2	MIDDLE	SOUTH	-
2	WS	2	MIDDLE	WEST	08
2	WS	2	MIDDLE	WEST	15
2	WS	2	MIDDLE	WEST	-
2	WS	2	MIDDLE	WEST	-
2	WS	2	UPPER	NORTH	31
2	WS	2	UPPER	NORTH	15
2	WS	2	UPPER	NORTH	25
2	WS	2	UPPER	NORTH	20
2	WS	2	UPPER	EAST	18
2	WS	2	UPPER	EAST	09
2	WS	2	UPPER	EAST	11
2	WS	2	UPPER	EAST	09
2	WS	2	UPPER	SOUTH	28
2	WS	2	UPPER	SOUTH	-
2	WS	2	UPPER	SOUTH	-
2	WS	2	UPPER	SOUTH	-
2	WS	2	UPPER	WEST	25
2	WS	2	UPPER	WEST	13
2	WS	2	UPPER	WEST	23
2	WS	2	UPPER	WEST	13
2	WS	2	TOP	TOP	30
2	WS	2	TOP	TOP	-
2	WS	2	TOP	TOP	-
2	WS	2	TOP	TOP	-
3	WS	1	LOWER	NORTH	-
3	WS	1	LOWER	NORTH	-
3	WS	1	LOWER	NORTH	-
3	WS	1	LOWER	NORTH	-
3	WS	1	LOWER	EAST	-
3	WS	1	LOWER	EAST	-
3	WS	1	LOWER	EAST	-
3	WS	1	LOWER	EAST	-

Table G1. **Continued.**

STD	SPP	TREE	QUADRANT	STRATUM	#EGGS/MASS
3	WS	1	LOWER	SOUTH	22
3	WS	1	LOWER	SOUTH	22
3	WS	1	LOWER	SOUTH	-
3	WS	1	LOWER	SOUTH	-
3	WS	1	LOWER	WEST	23
3	WS	1	LOWER	WEST	Ø6
3	WS	1	LOWER	WEST	-
3	WS	1	LOWER	WEST	-
3	WS	1	MIDDLE	NORTH	28
3	WS	1	MIDDLE	NORTH	22
3	WS	1	MIDDLE	NORTH	23
3	WS	1	MIDDLE	NORTH	-
3	WS	1	MIDDLE	EAST	15
3	WS	1	MIDDLE	EAST	18
3	WS	1	MIDDLE	EAST	-
3	WS	1	MIDDLE	EAST	-
3	WS	1	MIDDLE	SOUTH	18
3	WS	1	MIDDLE	SOUTH	18
3	WS	1	MIDDLE	SOUTH	18
3	WS	1	MIDDLE	SOUTH	15
3	WS	1	MIDDLE	WEST	Ø9
3	WS	1	MIDDLE	WEST	22
3	WS	1	MIDDLE	WEST	23
3	WS	1	MIDDLE	WEST	-
3	WS	1	UPPER	NORTH	3Ø
3	WS	1	UPPER	NORTH	-
3	WS	1	UPPER	NORTH	-
3	WS	1	UPPER	NORTH	-
3	WS	1	UPPER	EAST	18
3	WS	1	UPPER	EAST	18
3	WS	1	UPPER	EAST	23
3	WS	1	UPPER	EAST	25
3	WS	1	UPPER	SOUTH	2Ø
3	WS	1	UPPER	SOUTH	3Ø
3	WS	1	UPPER	SOUTH	-
3	WS	1	UPPER	SOUTH	-
3	WS	1	UPPER	WEST	18
3	WS	1	UPPER	WEST	15
3	WS	1	UPPER	WEST	22
3	WS	1	UPPER	WEST	36

Table G1. Continued.

STD	SPP	TREE	QUADRANT	STRATUM	#EGGS/MASS
3	WS	1	TOP	TOP	11
3	WS	1	TOP	TOP	-
3	WS	1	TOP	TOP	-
3	WS	1	TOP	TOP	-
3	WS	2	LOWER	NORTH	11
3	WS	2	LOWER	NORTH	18
3	WS	2	LOWER	NORTH	-
3	WS	2	LOWER	NORTH	-
3	WS	2	LOWER	EAST	15
3	WS	2	LOWER	EAST	13
3	WS	2	LOWER	EAST	20
3	WS	2	LOWER	EAST	-
3	WS	2	LOWER	SOUTH	23
3	WS	2	LOWER	SOUTH	31
3	WS	2	LOWER	SOUTH	22
3	WS	2	LOWER	SOUTH	-
3	WS	2	LOWER	WEST	-
3	WS	2	LOWER	WEST	-
3	WS	2	LOWER	WEST	-
3	WS	2	LOWER	WEST	-
3	WS	2	MIDDLE	NORTH	-
3	WS	2	MIDDLE	NORTH	-
3	WS	2	MIDDLE	NORTH	-
3	WS	2	MIDDLE	NORTH	-
3	WS	2	MIDDLE	EAST	18
3	WS	2	MIDDLE	EAST	25
3	WS	2	MIDDLE	EAST	18
3	WS	2	MIDDLE	EAST	25
3	WS	2	MIDDLE	SOUTH	20
3	WS	2	MIDDLE	SOUTH	22
3	WS	2	MIDDLE	SOUTH	15
3	WS	2	MIDDLE	SOUTH	25
3	WS	2	MIDDLE	WEST	31
3	WS	2	MIDDLE	WEST	20
3	WS	2	MIDDLE	WEST	20
3	WS	2	MIDDLE	WEST	24
3	WS	2	UPPER	NORTH	13
3	WS	2	UPPER	NORTH	20
3	WS	2	UPPER	NORTH	13
3	WS	2	UPPER	NORTH	11

Table G1. **Continued.**

STD	SPP	TREE	QUADRANT	STRATUM	#EGGS/MASS
3	WS	2	UPPER	EAST	13
3	WS	2	UPPER	EAST	18
3	WS	2	UPPER	EAST	22
3	WS	2	UPPER	EAST	27
3	WS	2	UPPER	SOUTH	13
3	WS	2	UPPER	SOUTH	25
3	WS	2	UPPER	SOUTH	11
3	WS	2	UPPER	SOUTH	28
3	WS	2	UPPER	WEST	20
3	WS	2	UPPER	WEST	13
3	WS	2	UPPER	WEST	20
3	WS	2	UPPER	WEST	18
3	WS	2	TOP	TOP	09
3	WS	2	TOP	TOP	15
3	WS	2	TOP	TOP	13
3	WS	2	TOP	TOP	20
4	WS	1	LOWER	NORTH	-
4	WS	1	LOWER	NORTH	-
4	WS	1	LOWER	NORTH	-
4	WS	1	LOWER	NORTH	-
4	WS	1	LOWER	EAST	23
4	WS	1	LOWER	EAST	11
4	WS	1	LOWER	EAST	18
4	WS	1	LOWER	EAST	24
4	WS	1	LOWER	SOUTH	43
4	WS	1	LOWER	SOUTH	46
4	WS	1	LOWER	SOUTH	13
4	WS	1	LOWER	SOUTH	30
4	WS	1	LOWER	WEST	20
4	WS	1	LOWER	WEST	09
4	WS	1	LOWER	WEST	20
4	WS	1	LOWER	WEST	20
4	WS	1	MIDDLE	NORTH	18
4	WS	1	MIDDLE	NORTH	33
4	WS	1	MIDDLE	NORTH	15
4	WS	1	MIDDLE	NORTH	08
4	WS	1	MIDDLE	EAST	30
4	WS	1	MIDDLE	EAST	25
4	WS	1	MIDDLE	EAST	27
4	WS	1	MIDDLE	EAST	35

Table Gl. Continued.

STD	SPP	TREE	QUADRANT	STRATUM	#EGGS/MASS
4	WS	1	MIDDLE	SOUTH	31
4	WS	1	MIDDLE	SOUTH	11
4	WS	1	MIDDLE	SOUTH	15
4	WS	1	MIDDLE	SOUTH	15
4	WS	1	MIDDLE	WEST	25
4	WS	1	MIDDLE	WEST	30
4	WS	1	MIDDLE	WEST	39
4	WS	1	MIDDLE	WEST	36
4	WS	1	UPPER	NORTH	11
4	WS	1	UPPER	NORTH	15
4	WS	1	UPPER	NORTH	13
4	WS	1	UPPER	NORTH	08
4	WS	1	UPPER	EAST	13
4	WS	1	UPPER	EAST	39
4	WS	1	UPPER	EAST	13
4	WS	1	UPPER	EAST	15
4	WS	1	UPPER	SOUTH	24
4	WS	1	UPPER	SOUTH	15
4	WS	1	UPPER	SOUTH	09
4	WS	1	UPPER	SOUTH	15
4	WS	1	UPPER	WEST	39
4	WS	1	UPPER	WEST	05
4	WS	1	UPPER	WEST	30
4	WS	1	UPPER	WEST	33
4	WS	1	TOP	TOP	27
4	WS	1	TOP	TOP	18
4	WS	1	TOP	TOP	39
4	WS	1	TOP	TOP	18
4	WS	2	LOWER	NORTH	-
4	WS	2	LOWER	NORTH	-
4	WS	2	LOWER	NORTH	-
4	WS	2	LOWER	NORTH	-
4	WS	2	LOWER	EAST	13
4	WS	2	LOWER	EAST	15
4	WS	2	LOWER	EAST	18
4	WS	2	LOWER	EAST	33
4	WS	2	LOWER	SOUTH	11
4	WS	2	LOWER	SOUTH	13
4	WS	2	LOWER	SOUTH	18
4	WS	2	LOWER	SOUTH	23

Table G1. **Continued.**

STD	SPP	TREE	QUADRANT	STRATUM	#EGGS/MASS
4	WS	2	LOWER	WEST	-
4	WS	2	LOWER	WEST	-
4	WS	2	LOWER	WEST	-
4	WS	2	LOWER	WEST	-
4	WS	2	MIDDLE	NORTH	13
4	WS	2	MIDDLE	NORTH	20
4	WS	2	MIDDLE	NORTH	15
4	WS	2	MIDDLE	NORTH	08
4	WS	2	MIDDLE	EAST	13
4	WS	2	MIDDLE	EAST	20
4	WS	2	MIDDLE	EAST	18
4	WS	2	MIDDLE	EAST	23
4	WS	2	MIDDLE	SOUTH	08
4	WS	2	MIDDLE	SOUTH	43
4	WS	2	MIDDLE	SOUTH	25
4	WS	2	MIDDLE	SOUTH	15
4	WS	2	MIDDLE	WEST	20
4	WS	2	MIDDLE	WEST	39
4	WS	2	MIDDLE	WEST	43
4	WS	2	MIDDLE	WEST	27
4	WS	2	UPPER	NORTH	04
4	WS	2	UPPER	NORTH	25
4	WS	2	UPPER	NORTH	18
4	WS	2	UPPER	NORTH	20
4	WS	2	UPPER	EAST	09
4	WS	2	UPPER	EAST	13
4	WS	2	UPPER	EAST	25
4	WS	2	UPPER	EAST	20
4	WS	2	UPPER	SOUTH	11
4	WS	2	UPPER	SOUTH	11
4	WS	2	UPPER	SOUTH	20
4	WS	2	UPPER	SOUTH	13
4	WS	2	UPPER	WEST	09
4	WS	2	UPPER	WEST	25
4	WS	2	UPPER	WEST	15
4	WS	2	UPPER	WEST	15
4	WS	2	TOP	TOP	20
4	WS	2	TOP	TOP	13
4	WS	2	TOP	TOP	13
4	WS	2	TOP	TOP	13

Table G1. Continued.

STD	SPP	TREE	QUADRANT	STRATUM	#EGGS/MASS
5	WS	1	LOWER	NORTH	20
5	WS	1	LOWER	NORTH	-
5	WS	1	LOWER	NORTH	-
5	WS	1	LOWER	NORTH	-
5	WS	1	LOWER	EAST	39
5	WS	1	LOWER	EAST	11
5	WS	1	LOWER	EAST	20
5	WS	1	LOWER	EAST	38
5	WS	1	LOWER	SOUTH	22
5	WS	1	LOWER	SOUTH	15
5	WS	1	LOWER	SOUTH	38
5	WS	1	LOWER	SOUTH	22
5	WS	1	LOWER	WEST	11
5	WS	1	LOWER	WEST	-
5	WS	1	LOWER	WEST	-
5	WS	1	LOWER	WEST	-
5	WS	1	MIDDLE	NORTH	13
5	WS	1	MIDDLE	NORTH	30
5	WS	1	MIDDLE	NORTH	13
5	WS	1	MIDDLE	NORTH	25
5	WS	1	MIDDLE	EAST	28
5	WS	1	MIDDLE	EAST	18
5	WS	1	MIDDLE	EAST	15
5	WS	1	MIDDLE	EAST	15
5	WS	1	MIDDLE	SOUTH	30
5	WS	1	MIDDLE	SOUTH	13
5	WS	1	MIDDLE	SOUTH	25
5	WS	1	MIDDLE	SOUTH	25
5	WS	1	MIDDLE	WEST	15
5	WS	1	MIDDLE	WEST	15
5	WS	1	MIDDLE	WEST	23
5	WS	1	MIDDLE	WEST	15
5	WS	1	UPPER	NORTH	23
5	WS	1	UPPER	NORTH	23
5	WS	1	UPPER	NORTH	28
5	WS	1	UPPER	NORTH	23
5	WS	1	UPPER	EAST	11
5	WS	1	UPPER	EAST	18
5	WS	1	UPPER	EAST	20
5	WS	1	UPPER	EAST	33

Table G1. Continued.

STD	SPP	TREE	QUADRANT	STRATUM	#EGGS/MASS
5	WS	1	UPPER	SOUTH	25
5	WS	1	UPPER	SOUTH	20
5	WS	1	UPPER	SOUTH	40
5	WS	1	UPPER	SOUTH	22
5	WS	1	UPPER	WEST	38
5	WS	1	UPPER	WEST	09
5	WS	1	UPPER	WEST	33
5	WS	1	UPPER	WEST	-
5	WS	1	TOP	TOP	13
5	WS	1	TOP	TOP	25
5	WS	1	TOP	TOP	20
5	WS	1	TOP	TOP	33
5	WS	2	LOWER	NORTH	-
5	WS	2	LOWER	NORTH	-
5	WS	2	LOWER	NORTH	-
5	WS	2	LOWER	NORTH	-
5	WS	2	LOWER	EAST	20
5	WS	2	LOWER	EAST	-
5	WS	2	LOWER	EAST	-
5	WS	2	LOWER	EAST	-
5	WS	2	LOWER	SOUTH	22
5	WS	2	LOWER	SOUTH	31
5	WS	2	LOWER	SOUTH	28
5	WS	2	LOWER	SOUTH	18
5	WS	2	LOWER	WEST	-
5	WS	2	LOWER	WEST	-
5	WS	2	LOWER	WEST	-
5	WS	2	LOWER	WEST	-
5	WS	2	MIDDLE	NORTH	20
5	WS	2	MIDDLE	NORTH	-
5	WS	2	MIDDLE	NORTH	-
5	WS	2	MIDDLE	NORTH	-
5	WS	2	MIDDLE	EAST	18
5	WS	2	MIDDLE	EAST	25
5	WS	2	MIDDLE	EAST	13
5	WS	2	MIDDLE	EAST	-
5	WS	2	MIDDLE	SOUTH	13
5	WS	2	MIDDLE	SOUTH	22
5	WS	2	MIDDLE	SOUTH	15
5	WS	2	MIDDLE	SOUTH	11

Table G1. Continued.

STD	SPP	TREE	QUADRANT	STRATUM	#EGGS/MASS
5	WS	2	MIDDLE	WEST	46
5	WS	2	MIDDLE	WEST	20
5	WS	2	MIDDLE	WEST	-
5	WS	2	MIDDLE	WEST	-
5	WS	2	UPPER	NORTH	23
5	WS	2	UPPER	NORTH	-
5	WS	2	UPPER	NORTH	-
5	WS	2	UPPER	NORTH	-
5	WS	2	UPPER	EAST	13
5	WS	2	UPPER	EAST	23
5	WS	2	UPPER	EAST	15
5	WS	2	UPPER	EAST	27
5	WS	2	UPPER	SOUTH	28
5	WS	2	UPPER	SOUTH	15
5	WS	2	UPPER	SOUTH	13
5	WS	2	UPPER	SOUTH	20
5	WS	2	UPPER	WEST	-
5	WS	2	UPPER	WEST	-
5	WS	2	UPPER	WEST	-
5	WS	2	UPPER	WEST	-
5	WS	2	TOP	TOP	-
5	WS	2	TOP	TOP	-
5	WS	2	TOP	TOP	-
5	WS	2	TOP	TOP	-

STAND:	Stand number
SPP:	Sampled tree specie BF = Balsam fir WS = White spruce
TREE:	Tree number
STRATUM:	Stratum (Fig. 10) that the branch grew in from which the needle(s) and egg mass(es) were retained and the eggs counted.
QUADRANT:	Quadrant (Fig. 11) that the branch grew in from which the needle(s) and the egg mass(es) were retained and the eggs counted.
# EGGS PER MASS:	The estimated number of eggs per randomly selected egg mass. Four egg masses were selected from each cell, within each tree.