

BIOECOLOGY OF PEAR THRIPS: DISTRIBUTION IN FOREST SOILS

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Abstract

The vertical and horizontal distribution of pear thrips in Vermont sugar maple forest soils was investigated. In the fall, about 86% of the thrips were found in the upper 10 cm of soil, though a few were found as deep as 20 cm. No thrips were found in the leaf litter. Soil sampling tools to determine thrips populations within an entire forest were tested and a standard hand-held bulb planter was found to be the most effective. No consistent pattern in thrips distribution around individual sugar maple trees was found. Pear thrips distribution within a forest stand predominating in sugar maple appeared to be random, but clumped, and variation in the density of pear thrips among individual samples was relatively high. For conducting soil sampling on a statewide scale, ten soil samples per sugarbush was found to be sufficient for estimating pear thrips population levels within an acceptable error range.

Introduction

For the past several years in Vermont, widespread defoliation of sugar maple (*Acer saccharum* Marsh.) has occurred in the early spring as a result of feeding by the pear thrips, *Taeniothrips inconsequens* (Uzel). In 1988 alone, over 200 thousand hectares (500 thousand acres) were severely defoliated (Parker et al. 1988). A cooperative research and management project, coordinated by the University of

Vermont and the VT Department of Forests, Parks and Recreation, was initiated in September, 1988 to address this potential threat to the health of sugar maples. The question raised most commonly at meetings of landowners and sugarmakers around the state was "How many pear thrips are there in my sugarbush¹?" and "Will pear thrips cause damage in my stand next year?"

In an effort to address these questions and to begin to design an integrated pest management plan, a method of predicting thrips damage was needed. Because pear thrips remain in the soil for 10 months of the year (Bailey 1944, Moulton 1907), from mid-June until mid-April in Vermont (Skinner & Parker, poster presentation, this publication) we felt this was potentially an ideal location for population monitoring, as it provided information about thrips population levels prior to their emergence in the spring, allowing sugarmakers an opportunity to take appropriate action.

Information on the distribution of pear thrips in forest soils is limited. Most previous research on this subject was done in California orchard soils. In cultivated, porous soils such as these, pear thrips were found to a depth of 61 cm, though most were at 15-30 cm below the soil surface (Bailey 1944). In uncultivated soils, pear thrips were found predominantly in the top 5-7 cm, at the interface between the grass roots and soil (Moulton 1907). The horizontal distribution pattern of pear thrips in soil was entirely unknown. The objectives of this research were to determine the vertical distribution of pear thrips in forest soils, their horizontal distribution within a sugar maple stand, and the number of samples needed to estimate thrips populations in a forest stand. Reported here are results from soil sampling conducted in 1988.

¹ A sugarbush is a hardwood forest stand with sugar maple comprising 75% or more of the basal area. Maple trees in these stands are tapped to produce maple syrup.

Materials and Methods

Vertical Distribution

A 2-hectare forest stand predominating in sugar maple, located in central Vermont, was chosen for the research site (called Perry site). This site was selected because it was known to have a relatively homogeneous fine, sandy loam soil and a large thrips population. This soil type was unusually deep in the region, reaching to a depth of over 1.5 m in the Perry site, which was generally well-drained, having no unusually wet or swampy areas. The sugar maple trees averaged 23-30 m in height, and 35-40 cm in diameter and had received about 70% defoliation due to thrips feeding in the spring of 1988.

Eight sample plots (each 12.5 cm²) were established about 3.5-4 m from the bole of eight dominant or co-dominant sugar maple trees. The direction of the plot from the tree, north, south, east or west, was determined on site based on suitability for excavation.

The sample plot was marked and the loose litter layer removed and placed in a plastic bag. Soil samples were then taken at 2 cm intervals to a depth of 18 cm; each sample was bagged separately. To facilitate sampling, a trench, about 30 cm wide and 40 cm deep, was dug 5 cm from the plot on three sides. A steel box, 12.5 x 12.5 x 2.5 cm, having a top with a 5.5 cm² opening cut in the middle, and no bottom, was used for sampling (Fig. 1). The lower edge of the box was sharpened. A piece of sheet metal 15.5 x 17.5 cm was hammered to a depth of 18 cm on the plot side lacking a trench. The box was then lightly hammered into the soil to a depth of 2 cm. A putty knife having a 12 cm blade was used to cut under the box and remove the soil sample. This process was continued until 10 samples, including the litter sample, were taken.



Figure 1. Pit sampling to determine vertical distribution of pear thrips in forest soil.

Prior to extraction, samples were stored in a refrigerator at 4°C. Thrips were extracted in the laboratory, using the magnesium sulfate flotation method² modified from Edwards & Fletcher (1970) (Parker et al. 1989), and counted with the aid of a microscope (8x) to determine the number of thrips per sample. Extraction was completed within one month of collection. All samples were collected within a three-month period between September and December 1988. The mean percentage of thrips at each depth was determined.

² For the first 6 months of our research, thrips extraction from soil was done with magnesium sulfate flotation. We later found flotation using heptane to be more efficient and this process was used for subsequent extractions (see Grehan & Parker, poster presentation, this publication).

Spatial Distribution

Distribution around a tree. Four dominant or co-dominant sugar maple trees were selected randomly for sampling in the Perry site. One soil sample was taken with a hand-held bulb planter (about 5.72 cm diameter, 10.16 cm in length, 261 cm³ volume) at 1, 2 and 4 meters from the bole of each tree in the four cardinal directions ($n = 22$ samples per tree). Each soil sample was extracted individually to determine the number of thrips per sample. This sampling was replicated around the same trees one month later. A square-root + 0.375 transformation was done to normalize the data prior to analysis of variance (ANOVA) to determine significant differences in the mean number of thrips by direction and distance from the tree.

Distribution within a sugarbush. Two 2-4 hectare sugarbushes, having relatively high thrips populations in the soil, were selected for intensive sampling to determine the pattern of thrips distribution within an entire sugarbush. These sites, the Williams and Perry sites, were located on fairly flat terrain about 0.4 km apart and both were bordered on the north and south by open pasture land (Fig. 2).

A grid system for sampling was established within each site. In the 2-hectare Perry site, grid points were established every 25 meters, and the nearest dominant or co-dominant sugar maple tree at each grid point was selected for sampling (total of 34 sample trees) (Fig. 2). Because the Williams site covered approximately 4 hectares, grid points were established every 50 meters (total of 37 sample trees) (Fig. 2).

Two soil samples were taken with a bulb planter, one at 2 m and one at 4 m from the south side of each sample tree. Each sample was bagged separately and then stored and extracted as described previously.

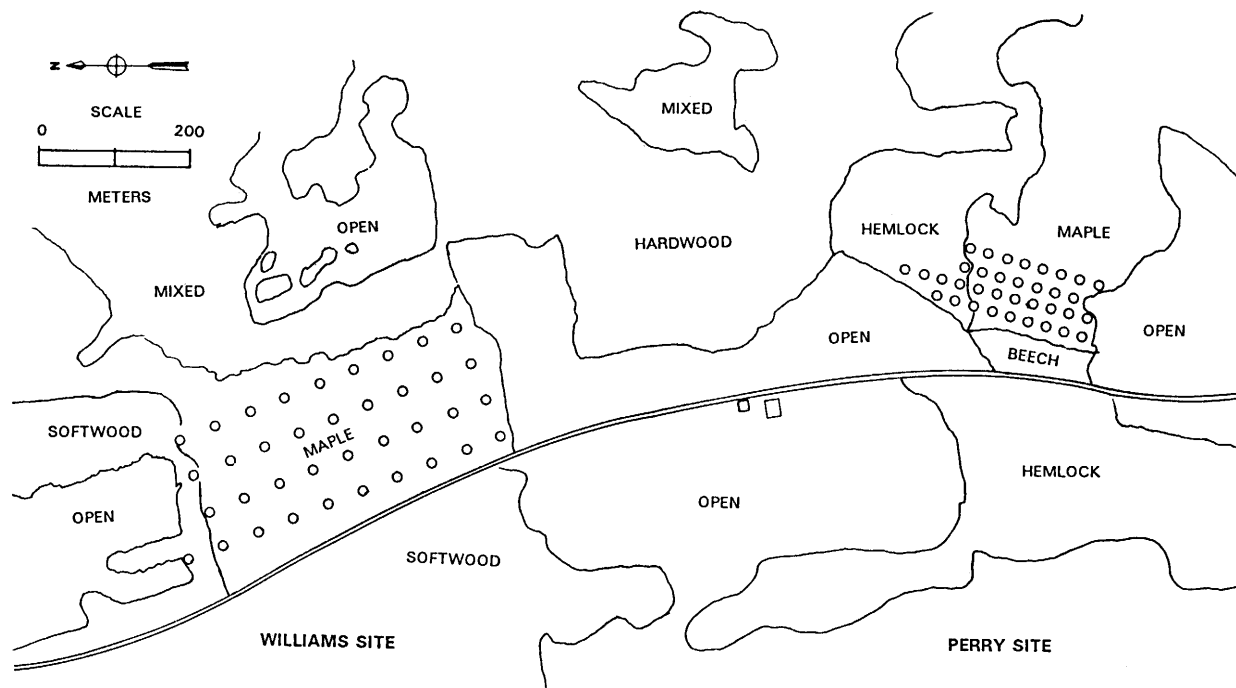


Figure 2. Sampling grid system in pear thrips research sites to determine thrips distribution in forest soil; open circles indicate location of sample tree. Predominant vegetation type within and adjacent to sites are indicated, Mixed = mixture of softwoods and hardwoods, open = pasture land (drawn by J. R. Lackey).

Results and Discussion

Vertical Distribution

Approximately 86% of the pear thrips extracted from the pit samples were found in the upper 10 cm of the soil (Table 1). No thrips were found in the leaf litter layer. The number of thrips decreased as soil depth increased with the exception of samples from 4-6 cm, where the greatest percentage of thrips, 27.4%, was found (Table 1). This is the approximate location of the interface of the soil and roots of understory vegetation. Similar results were obtained in California in uncultivated, sod-covered soils (Moulton 1907). It is possible that pear thrips prefer the soil conditions at this depth. Further research to characterize the features of this strata could explain this apparent distribution pattern. Though few thrips were found at a depth of 18 cm, additional sampling to 30 cm will be done to determine exactly how deeply pear thrips go. Large variation in thrips density occurred among sample trees. The number of thrips per pit (total number of thrips found from all samples in one pit) ranged from 14 to 394 among the four sample trees.

Previous research has indicated that the vertical distribution of pear thrips varied with soil type, texture and moisture content. Pear thrips penetrated deeper into light, well-drained soils than into heavy clay or gravelly soils (Bailey 1944). The light, well-drained soil at our research site suggests that the vertical distribution there is likely to be deeper than that of other sugarbushes in Vermont, which are located on heavier or shallower soils. Research is underway to further evaluate vertical distribution in water-logged, clay, sandy and shallow soil types to more completely characterize patterns of pear thrips vertical distribution.

Table 1. Vertical distribution of pear thrips in a Vermont sugarbush soil

Depth	Mean # thrips/ sample depth	Thrips/sample (%) ^a	Cumulative % thrips
0 cm (litter)	0.00 ± 0.00	0.00	0.00
0 - 2 cm	32.88 ± 62.60	19.86	19.86
2 - 4 cm	27.88 ± 27.62	16.84	36.70
4 - 6 cm	45.38 ± 52.07	27.42	64.12
6 - 8 cm	19.50 ± 23.00	11.78	75.90
8 - 10 cm	17.25 ± 18.43	10.42	86.32
10 - 12 cm	9.50 ± 12.80	5.74	92.05
12 - 14 cm	5.13 ± 6.31	3.10	95.16
14 - 16 cm	4.00 ± 5.34	2.42	97.58
16 - 18 cm	4.00 ± 5.18	2.42	100.00

^a Percentages were calculated from the mean number of thrips per sample depth from eight pit sample plots in the Perry site in Randolph, Vt.

Selection of sampling tool. Using results from this research we evaluated soil sampling tools to select the best one for large scale intensive sampling to determine the horizontal distribution of thrips within a sugarbush. Three tools were used, a bucket auger, a tube sampler and a hand-held bulb planter (Fig. 3).

With the bucket auger, a sample was taken to a depth of 18 cm, which was a greater depth than most thrips were found. This tool provided a relatively large volume of soil (1,368 cm³) that took over an hour to extract. This tool was therefore rejected. The tube sampler was also judged unsatisfactory for surveying thrips populations. This tool gave us a sample to a depth of ca 30.5 cm (394 cm³), which was deeper than was needed based on the vertical distribution of pear thrips. In addition, this tool sampled a very small surface area, which we felt would not accurately reflect thrips density over a large area.

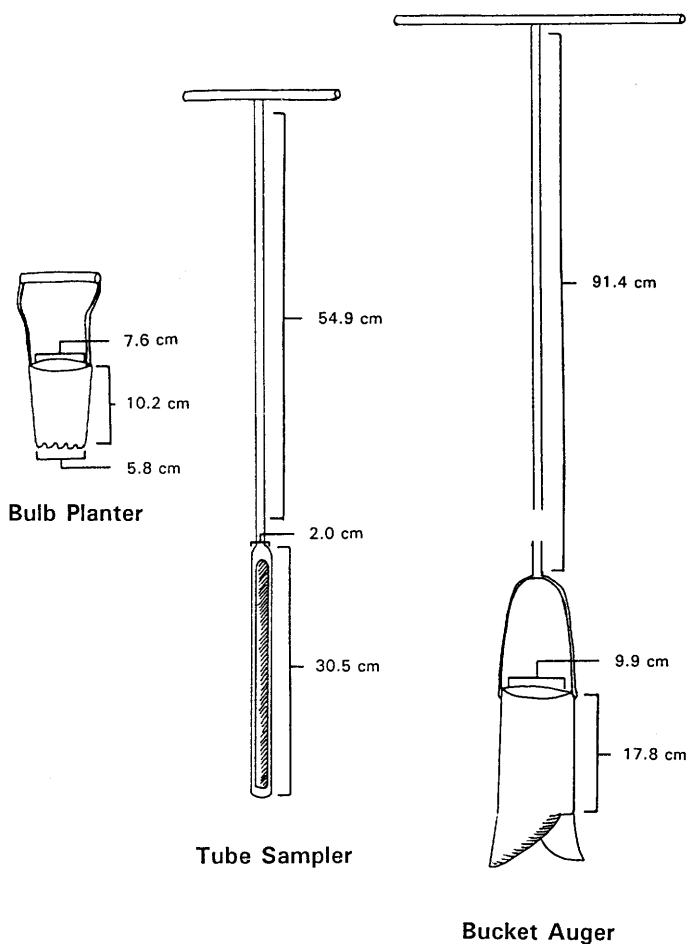


Figure 3. Soil sampling tools tested for sampling pear thrips in Vermont forest soils (drawn by L. Cravedi-Cheng).

The standard hand-held bulb planter, 7.6 cm in diameter and 10 cm long, was judged the most suitable for our large scale soil sampling purposes. This tool sampled the soil to a depth of 10 cm, which was the region within which the majority of thrips were found. The volume of soil obtained from this tool, 272 cm^3 , was small enough to allow relatively rapid processing, approximately one-half hour per sample. Finally, it was inexpensive (around \$5.00) and readily available at most hardware stores, making it ideal for use in a large scale sampling program conducted by many people statewide.

Spatial Distribution

Distribution around a tree. The mean number of thrips per sample tree (averaged among 24 samples) ranged from 4.2-9.7. A range of 2.87 thrips per sample (2 m from south side)-15.8 thrips per sample (4 m from south side) was obtained from the four sample trees (Fig. 4). Though differences in the mean number of thrips per sample were significant among sample trees ($P = 0.001$), differences in the number of thrips obtained at the four cardinal directions were not significant. There tended to be more thrips in samples taken at 4 m from the tree than in samples taken at 1 m, though these differences also were not significant. The distance from a tree at which a sample was taken was confounded by the fact that the bole was sometimes located within the sample distance of other adjacent maple trees. For example, a sample that was taken 4 m from the sample tree may have been only 2 m from another tree. This effect will be considered in subsequent analyses.

Results indicate that the distance and direction from the tree does not significantly affect the distribution of thrips in the soil. However, for standardization we chose to take soil samples for further distribution studies from the south side of the tree at 2 and 4 m.

Distribution within a sugarbush. An average of 10 ± 12 thrips per sample and 5 ± 4 thrips per sample was found in the Perry and Williams sites, respectively. When the number of thrips per sample was compared separately within rows and columns in each sugarbush, densities were not significantly greater inside the sugarbush than at the forest edge (Figs. 5 and 6). Despite previous reports that thrips damage tended to be highest along the sugarbush edge, we did not find higher thrips populations there in the soil. Different rates of bud development within and at the edge of forest stands or migratory patterns of the insect may be responsible for differences in the damage levels within a sugarbush rather than their density in the soil.

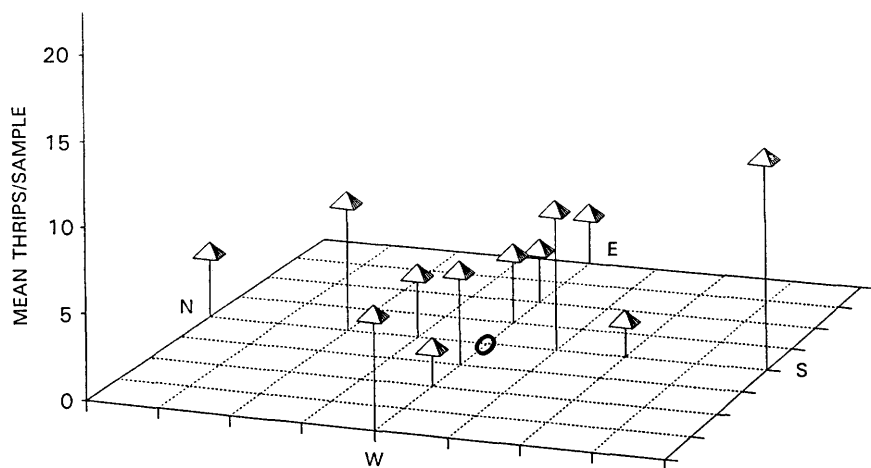


Figure 4. Mean number of pear thrips per sample at 1, 2 and 4 m from the bole of sugar maple trees at the four cardinal directions (mean derived from four sample trees). The center circle represents the bole of the sample tree and the pyramids indicate the mean number of thrips at each sample location. Grid points in this figure are spaced 1 meter apart.

The number of thrips per sample varied from tree to tree and from sample to sample around a tree. For example, at one tree, 43 pear thrips were found in the sample taken at 2 m and 10 thrips were found at 4 m, and at another 35 thrips were found at 2 m and 73 thrips at 4 m (Fig. 5). The reasons for this variation in thrips density between samples is as yet unknown. No observable differences in soil or vegetation type existed that could have explained these differences. Further characterization of thrips distribution in a sugarbush is currently underway.

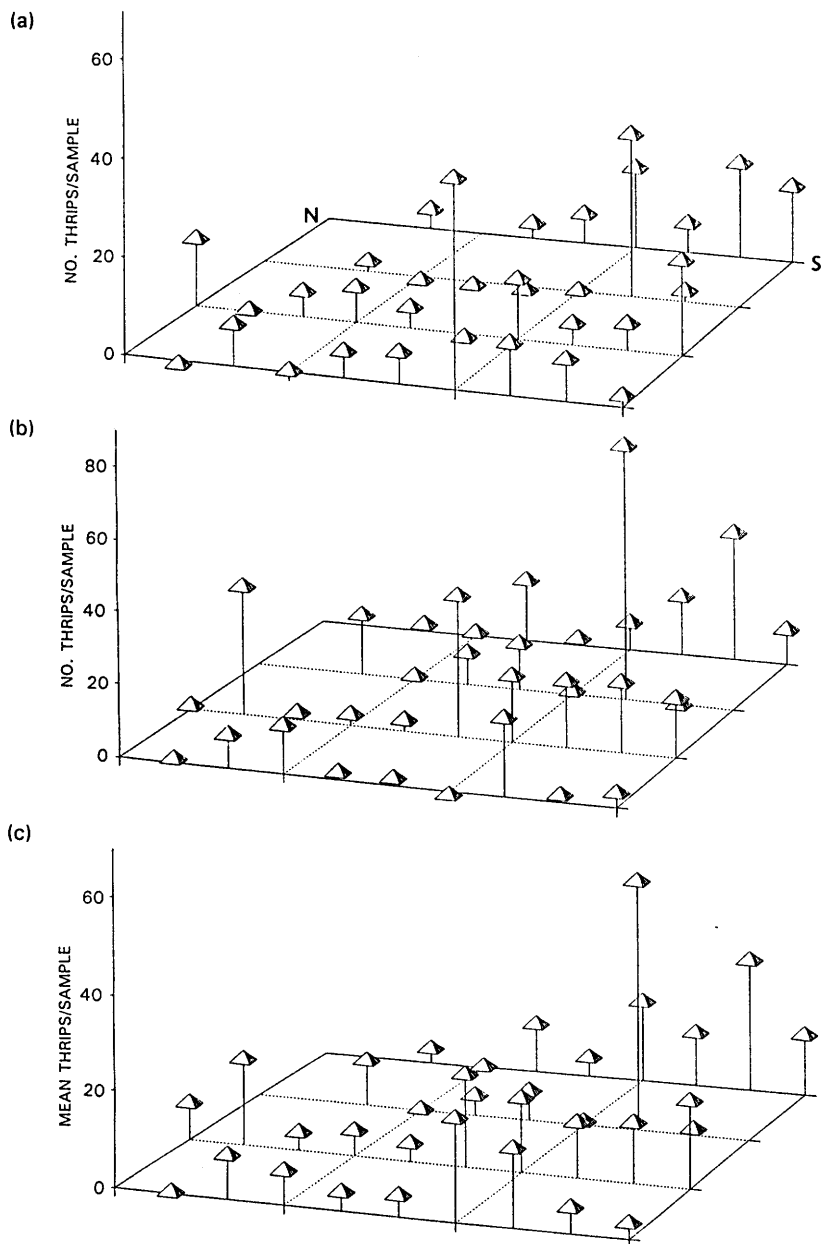
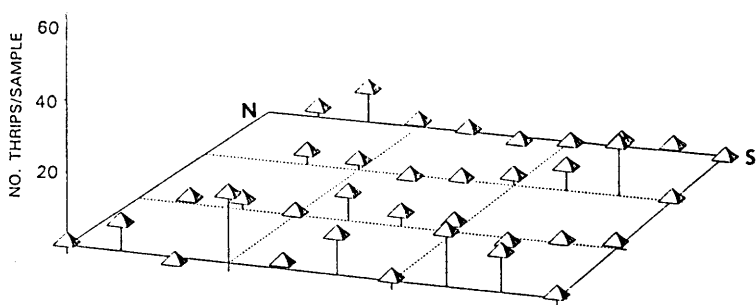
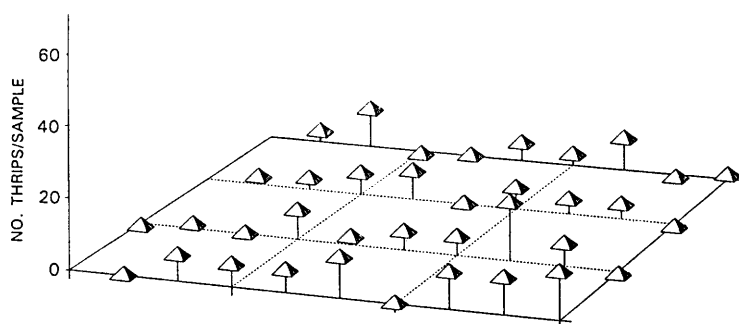


Figure 5. Number of pear thrips per sample in the Perry sampling grid (see Fig. 2) at (a) 2 m from the tree, (b) 4 m from the tree, and (c) the mean from samples at 2 and 4 m. All samples were taken on the south side of each tree and trees were located about 25 m apart.

(a)



(b)



(c)

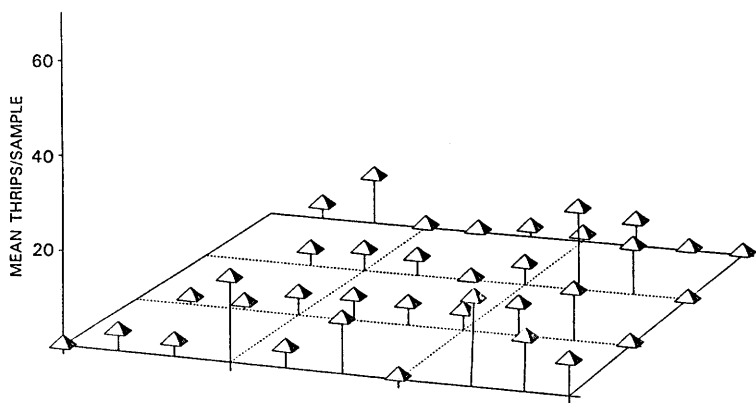


Figure 6. Number of pear thrips per sample in the Williams sampling grid (see Fig. 2) at (a) 2 m from the tree, (b) 4 m from the tree, and (c) the mean from samples at 2 and 4 m. All samples were taken from the south side of each tree and trees were located about 50 m apart.

Statewide Soil Survey

Statistical analysis showed that, at the population levels found in the Perry sugarbush (an average of 5-10 thrips per sample), the thrips population could be estimated with 10 samples per sugarbush, with an error rate of ± 6.5 thrips. Further analysis is needed to determine the error rate in sites having higher and lower thrips populations than that found in the Perry site.

Based on the results of this research we developed a protocol to determine pear thrips density and distribution in Vermont and to determine if a relationship existed between the number of thrips in the soil and the amount of subsequent damage (Skinner & Parker 1989). Results from this work may prove useful for predicting damage based on thrips numbers in the soil. This survey was implemented by the Vermont Department of Forests, Parks and Recreation in January 1989. Though this is not an ideal time of year to take samples, it was the earliest we could develop the protocol. In future years, samples will be taken in September and October.

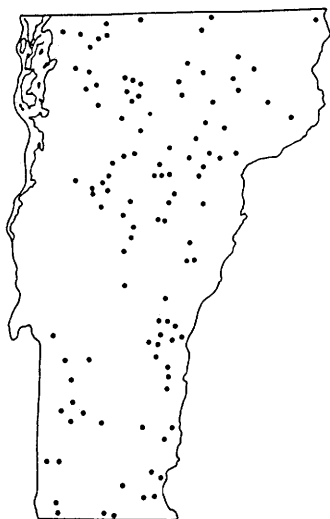


Figure 7. Map of Vermont showing the location of sites in which soil sampling was conducted for the Statewide Pear Thrips Soil Survey.

For this survey in each site, two soil samples, one at 2 m and one at 4 m from the south side of the tree, were taken around five dominant sugar maple trees duplicating the basic design used in the research on horizontal distribution studies. Over 100 sugarbushes were selected for sampling in areas showing low, moderate and heavy thrips damage in 1988 (Fig. 7). Our goal is to repeat this sampling and foliage assessment at the same sites for the next 3-4 years to gather information on population dynamics and the annual pattern of damage as it relates to thrips density.

Acknowledgment

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Discussion Period

Question: Taking the soil samples is very easy but extracting and analyzing them is very time consuming. Would it be conceivable to use some kind of sequential sampling scheme whereby 25 samples per site are taken, five samples are initially processed to see what the thrips population is and additional samples are processed only if necessary?

Skinner: We don't know enough about how many thrips per soil sample are needed for damage to occur to be able to use a sampling system like that. However, it would certainly be nice to reduce soil extraction if possible.

Question: How many soil samples did you take at each distance from the tree?

Skinner: For determining the thrips population within a sugarbush, we selected five trees per site and took two samples on the south side of each tree, one at 2 meters and the other at 4 meters.

Question: Did you take only one soil sample from each sample distance? Did you check to see if taking samples in a cluster reduced the variation between samples or removed the chance of getting zeroes from your data?

Skinner: If the tree is considered the sampling point then we were taking two samples, but if you consider each distance a different point then we were taking one sample per location. We did not assess the value of taking samples in a cluster. It would have been nice to do but time was a factor. We needed to develop a sampling protocol within a few months and therefore could not test all sampling options.

Comment: We had a similar problem in variability and sample clustering reduced that variability.

Skinner: One problem with clustering to determine thrips populations within a sugarbush might be that less area within the entire site would be sampled. There are bound to be variations in thrips density as a result of environmental conditions. Sampling in only a few clusters would reduce the opportunity to determine that variation.

Comment: By clustering I meant taking a cluster of three samples rather than one at each site.

Skinner: Yes, I understand that, but this would significantly increase the number of samples needed to evaluate thrips density within an entire sugarbush. It was felt that 10 samples per sugarbush was feasible to use in a statewide survey. More samples per sugarbush would have required us to reduce the number of sites we surveyed.

Question: If you look at the number of thrips per sample at the 2 and 4 meter distances, was there any indication why you might find more thrips at 4 m?

Skinner: The drip line of the tree was generally at about 4 meters from the trees we sampled. This could have influenced the thrips density in the soil. You must also realize that other trees adjacent to the sample tree may have influenced the situation. Though the sample was taken at 2 or 4 meters from the sample tree, other adjacent trees were sometimes closer to the sample point. We have mapped the location and distance of trees within 8 meters of each sample tree in the research site. Ultimately we hope to analyze this information to determine the influence of these factors.

Question: Have you done any studies to relate thrips density to physical and chemical characteristics of the soil in which they reside?

Skinner: One reason we selected this particular site for thrips research was that the soil type and conditions were relatively homogeneous throughout. We hoped that this homogeneity would reduce variability in distribution due to soil conditions. We have not done any analyses of the chemical makeup or moisture content of the soil, but this would be interesting to consider.

Question: Do you think thrips can survive better in some soil types than others?

Skinner: I don't know. However, for the statewide thrips soil survey, we will collect information on soil type, elevation, basal area of sugar maple and the abundance of maple seedlings in the understory in each site, as well as the level of pear thrips damage last year. We hope to correlate these variables on a statewide scale.

Question: Do you miss thrips that are in the litter layer by removing this layer before taking the soil sample?

Skinner: No. In all of the research we have done on the vertical distribution of thrips in the soil, we have never found them in the litter layer.

Question: What about in the early spring when they begin to emerge from the soil?

Skinner: You are right, as thrips come out of the ground they must crawl through the litter on their way to the foliage. At the time we take soil samples for thrips population studies however, the thrips are still in the soil. If samples were taken in the spring, however, the litter layer would need to be extracted for the presence of thrips. Our plan is to take all samples early enough so that the thrips will not have moved up to the litter. We are also monitoring soil temperature at various depths in the research site. This will give us information on when soil temperatures begin to rise and when thrips begin to ascend.

Question: If there is no canopy on the south side of the sample tree is it part of the protocol to take the samples somewhere else?

Skinner: No. Generally there is enough of a canopy over the sampling area, so this has not been a problem. When developing the protocol we tried to keep the methodology uniform in an effort to reduce confusion. This also reduces the variability that must be accounted for in later statistical analysis.