THE RELATIONSHIP BETWEEN MEASURES OF TREE VIGOR AND PEAR THRIPS DAMAGE IN SUGAR MAPLE

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Introduction

In this presentation I will address three points associated with pear thrips damage and sugar maple. First, I will describe the impact of pear thrips on sugar maple in Massachusetts, in both the sugarbush and the natural forest stand, based on root starch assays that were completed this fall (1988). Secondly, I will discuss the relationship between tree health and thrips damage, specifically addressing the question of whether this insect preferentially selects trees or stands of trees having high or low vigor. Finally, I will offer some speculative comments concerning the influence of air pollutants (e.g., ozone) on the sugar maple/pear thrips interaction.

Pear thrips damage has been most severe in areas of the state where sugar maple is concentrated (Fig. 1). Obvious feeding damage by the pear thrips was first reported in Massachusetts in 1987, although it had been present in the area for a few years previously. In 1988, the amount and severity of damage increased dramatically. Approximately 81,000 hectares (200,000 acres) were defoliated.

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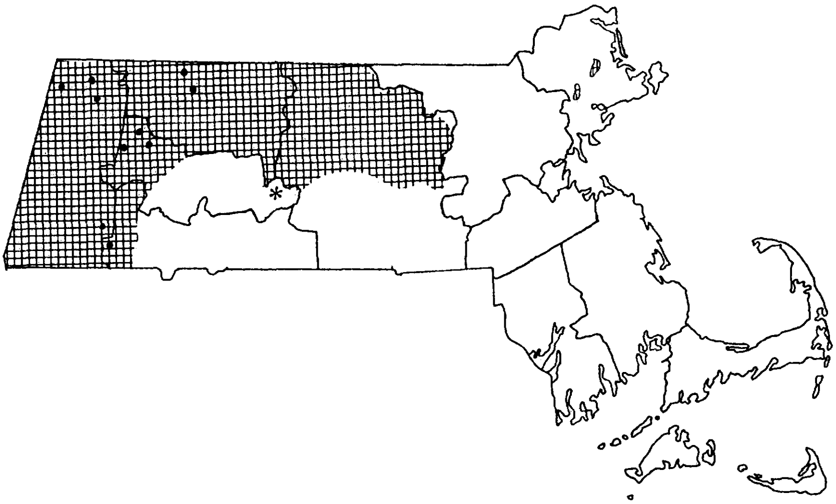

Figure 1. Map of Massachusetts with shaded portion showing area predominating in sugar maple where pear thrips damage has been most severe. Root starch analyses were conducted in permanent forest health monitoring sites (indicated by dots) and a control plot (indicated by asterisk).

Materials and Methods

Ten permanent forest health monitoring sites were established in 1988 as part of the North American Sugar Maple Decline Project (NAMP) (Millers & Lachance 1989) (Fig. 1). The timing of plot establishment and the current thrips outbreak were coincidental but also fortuitous in that it allowed us to examine some specific relationships between sugar maple tree condition and thrips damage. Five of the ten plots were located in intensively managed sugarbushes and five were in unmanaged or natural forest stands. In addition, a control plot was established outside the region of severe thrips damage.

My discussion will focus on data (Table 1) collected on 334 trees selected at random from the ten permanent plots and 20 trees from the control plot that were rated for thrips damage.

Table 1. Field data collected for tree health in the North American Sugar Maple Decline Project[a]

Site, Stand and Tree Characteristics
Site description
Stand description
Sugar maple inventory
- Growth measurements
- Tapping record
- Bole quality
- Branch and foliar characteristics
- Damage causal agents
Soil characteristics
Root starch analyses
Thrips damage ratings

[a] Supported in part by the Mass. Dep. of Environ. Management.

Each sample tree was assessed for thrips damage using a standardized thrips damage rating system based on methods developed by the VT Department of Forests, Parks and Recreation (Table 2). Each tree was given a score from 1 to 3 depending on the percentage of the crown volume that had been defoliated by thrips and subsequently refoliated in June.

Table 2. Thrips damage rating system used in plots of the North American Sugar Maple Decline Project[a] in Massachusetts

Numerical Rating	Rating Description
1	Defoliation greater than 60% of the tree
	Refoliation greater than 60% occurring in late June, new leaves being smaller in size and lighter green in color than normal
2	Many leaves mottled with some stunting and browning
	De/refoliation 30-60%
	Refoliation occurring in June with new leaves smaller and lighter green in color than normal
3	Leaves mostly lightly mottled with some stunting
	Defoliation less than 30% of the tree
	Refoliation visible as scattered tufts of new leaves at the branch terminals

[a] Based on rating system developed by the Vermont Department of Forests, Parks and Recreation, though numerical ratings differ.

Starch analysis was conducted on trees assessed for thrips damage from ten maple decline plots (n = 334) and the control plot (n = 20). The root starch assay was used as an indication of tree vigor and to assess the relative impact of thrips feeding on a tree's energy reserves (Wargo 1975).

Results

Damage Rating and Root Starch Assay

Most of the sample trees were in the first or third damage category (Fig. 2). Trees receiving a rating of 1 were severely defoliated by pear thrips and yet by late June had produced a second flush of leaves that provided a relatively full crown. In contrast, those trees receiving a rating of 3 retained the first flush of leaves although they were heavily damaged.

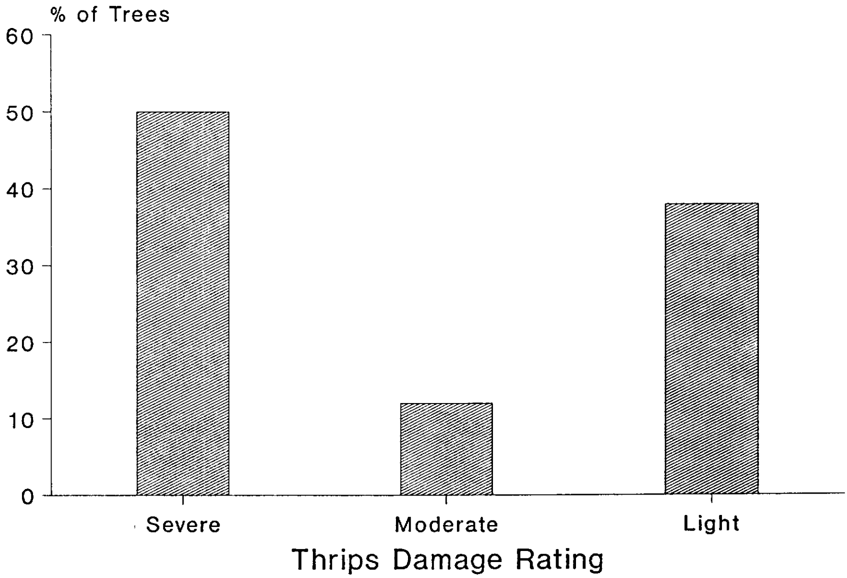

Figure 2. Rate of thrips damage in the summer, 1988 for sugar maple trees in ten permanent plots of the North American Sugar Maple Decline Project. Damage is a de/refoliation percentage: 1 = greater than 60%, 2 = 30 - 60%, 3 = less than 30%.

Some variation in thrips damage between trees within stands was observed. However, the majority of the trees within a given stand were generally found to be one of the three categories. This suggests that there may be some site or stand characteristic that strongly influences thrips damage. There was no strong indication that trees in the managed sugarbushes were more or less damaged by the pear thrips than the trees in the natural forest stands.

A majority of the trees from the ten permanent sites were assessed as having low or depleted starch reserves (Fig. 3). Only 56 of 334 trees received a high or moderate starch rating. In contrast, trees sampled from the control site, just outside the range of the thrips infestation, largely fell into the moderate starch category. These results suggest that pear thrips had a significant impact on tree vigor, whether or not they were completely or partially defoliated. (Fig. 3).

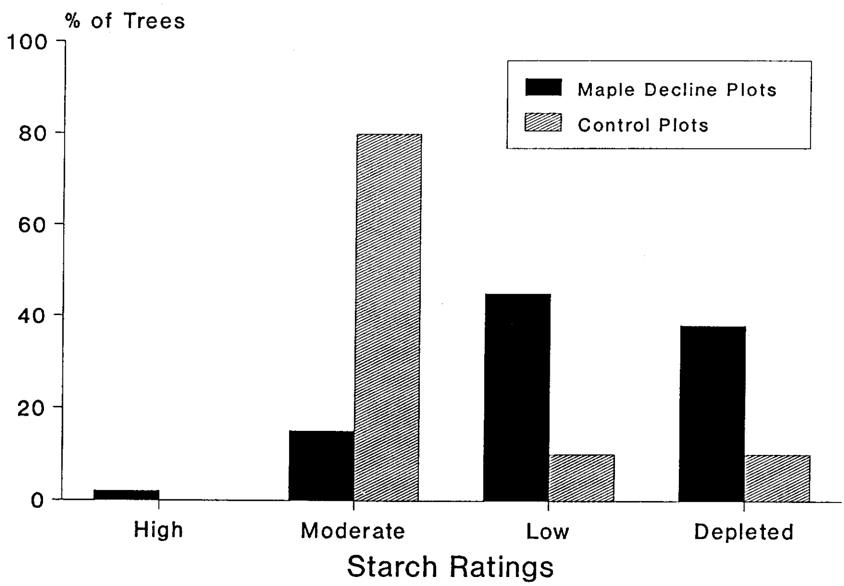

Figure 3. Mean root starch levels of sugar maple trees in 10 plots (within the area of thrips damage in 1988 [*n* = 334]) of the North American Sugar Maple Decline Project and one control plot (outside the thrips-damaged area [*n* = 20]) sampled in 1988 in Massachusetts.

All of the trees rated high in starch, and half of the trees rated moderate were in the highest or most severe defoliation class, which was an unexpected result. This suggests that a tree that is in relatively good health prior to a thrips attack may recover from severe thrips damage in one growing season. In fact, it may be better for the tree to go through a refoliation process and produce a second flush of relatively normal leaves than for it to rely on a first flush of heavily damaged foliage for all its energy needs. Presumably, this response is only possible because pear thrips is an early season defoliator.

These results are encouraging with respect to the long-term health of sugar maple. They imply that the impact of the pear thrips may be minimized by refoliation. They may also partly explain why the 10-year infestation of pear thrips in Pennsylvania has not resulted in a significant amount of tree mortality. Perhaps it is less the level of insect colonization than the response of a given tree to insect attack that determines the level of defoliation and subsequent impact on energy reserves.

Tree Vigor and Thrips Damage

My second point addresses the question of whether or not the apparent vigor or decline status of a sugar maple stand might influence the amount or severity of thrips damage. This relationship is important because it may explain the tree-to-tree variation in thrips damage we have observed. It is not uncommon, for example, to find two trees standing side by side, one of which is severely defoliated by thrips whereas the other is only minimally damaged. This suggests that thrips may be preferentially selecting one tree over another. There could be many reasons for this variation, such as slight differences in bud development during the insect emergence period, or differences in tree vigor that influence the thrips colonization process.

In 1987, a preliminary survey of sugar maple tree health was conducted at 22 sugarbushes in Massachusetts. Four of these sugarbushes became part of the North American Sugar Maple Decline Project in 1988. We compared the decline of the trees evaluated in 1987 to the severity of thrips damage on those same trees in 1988 (Table 3).

Table 3. Comparison of decline status to thrips damage in plots of the North American Sugar Maple Decline Project[a] in Massachusetts

Plot location - Region	1987 Relative Decline Status[b]	1988 Thrips Damage Rating[c]
Williamstown - North West	Healthy	1.1
Tolland - South	↓	1.4
Chesterfield - Central	↓	2.4
Worthington - Central	Declining	2.7

[a] Supported in part by the Massachusetts Dep. of Environ. Management.

[b] Based on foliar and branch characteristics using a system developed by the Ontario Ministry of the Environment.

[c] Mean rate of damage for all sugar maple trees in the stand using the damage rating system described in Table 2.

These data suggest that there is an inverse relationship between tree health and thrips damage, i.e., the healthier stands in 1987 had greater defoliation in 1988 (Table 3). However, this relationship could be explained by the geographic location of the plots relative to the population density of the insect. At this time, we have no data on insect population densities in Massachusetts so there is no way to validate this relationship.

Discussion

Pollution Stress and the Thrips Outbreak

Considering the relationship between tree vigor or decline and thrips damage, I would like to discuss whether air pollution stress is acting as a predisposing factor. Within the context of Paul Manion's conceptual framework for considering the types of stress factors that can contribute to a decline problem (Table 4), I could hypothesize the following: air pollutants, such as acid rain and ozone, have weakened the maple trees over time, making them more susceptible to pear thrips attack. Whether or not the combined stress of air pollution and pear thrips will push the maple forest towards a serious decline situation remains to be seen and most likely depends on the degree to which other interacting stress factors play a contributing role.

Table 4. Classification of stress factors in forest decline[a]

Types of Factors		
Predisposing	Inciting	Accelerators
Climate	Insect defoliation[b]	Bark beetles
Soil moisture	Frost	Canker fungi
Host genotype	Drought	Viruses
Soil nutrients	Salt	Root-decay fungi[b]
Air pollutants[b]	Air pollutants	Competition
Competition	Mechanical injury	

[a] Modified after Manion (1981).
[b] Associated with maple decline.

A slightly different approach to the problem is to consider how acid rain or ozone might influence insect survivorship or reproduction. For example, acid rain effects on soil fertility or ozone effects on maple physiology may have altered the leaf chemistry or nutrient balance of sugar maples in such a way as to increase insect fecundity and/or survival rate. Specific hypotheses that have been formulated by other researchers (most notably by Patrick Hughes from Boyce Thompson Institute, Ithaca, N.Y.) suggest that many plants respond to moderate levels of air pollutants by manifesting higher levels of free amino acids and lower levels of plant defensive compounds such as phenolics. Both of these processes would raise the effective level of nitrogen in the insect diet and as a consequence raise its fertility.

A summary of possible direct and indirect effects of air pollutants on insect success is presented in Table 5. I would also suggest that, given the length of time pear thrips spend in the soil that it is appropriate to consider whether or not pollution loading of the soil environment has created a more favorable habitat for pear thrips survival.

Table 5. How air pollutants can affect insect success[a]

Direct effects	Indirect effects
Toxicity	Effect on predators, parasites or pathogens
Stimulation of metabolism	Altering the microclimate or microhabitat
Alteration of behavior	Inducing changes in the host plant chemistry/morphology
	Altering plant abundance or distribution

[a] Taken from Hughes (1988).

There are a number of examples where air pollutants have been shown to affect insect populations on plants (Table 6). These references can be found in the recent publication by Hughes (1988). These examples emphasize that there does exist a body of evidence that air pollutants, including acid rain and ozone, affect the success of leaf feeding insects (e.g., pear thrips). My hope is that this information will provide an impetus for investigation into the influence of air pollutants on the pear thrips/sugar maple interaction.

Table 6. Experimental studies concerning effects of air pollutants on the success of leaf feeding insects[a]

Pollutants	Insect	Plant
Hydrogen fluoride	Mexican bean beetle	Bean
SO_2	Mexican bean beetle	Bean, soybean
Ozone	Mexican bean beetle Gypsy moth	Bean, soybean White oak
Ambient air	Green apple aphid Rose aphid	Hawthorn Rose
Acid rain	Mites/springtails	Humus
SO_2, O_3 and acid rain	Elm leaf beetle	Elm

Many additional studies show a correlation between insect populations and the presence of air pollution in non-forest areas.

[a] Taken from Hughes (1988).

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