NYS IPM PROGRAM FINAL REPORT

1. Title:
Controlling Forest Tent Caterpillar in Limited Acreage Maple-Producing Woodlots

2. Project Leader(s):
Peter Smallidge, Extension Forester, Director of the Arnot Forest, Cornell University,
Paul Weston, Department of Entomology, Cornell University,
Stephen Childs, NYS Extension Maple Specialist, Cornell University

3. Cooperator(s):
Steve VanderMark, Natural Resources and Horticulture, CCE St. Lawrence County, St. Lawrence CCE Canton Research Farm.
Arnot Reserarch Forest, Anna Barensfeld, Arnot Intern, 611 County Route 13, Van etten, NY 14889
Daniel Weed, Schoolyard Sugarbush, 5967 Appletree Pt Rd., Moravia, NY 13118

4. Abstract:
Many maple producers operate woodlots smaller than the 15 acres normally required by aerial pesticide applicators to treat for forest tent caterpillar. Only tolerance-exempt pesticides are legal in woods used for maple syrup production. forest tent caterpillar is currently a serious defoliator in many places in New York, and poses a serious threat to maple sugar production (maple producers are advised not to tap heavily defoliated trees). These woodlot owners need proven techniques to limit defoliation due to caterpillars to avoid losing syrup production and markets. In 2006 experiments to control forest tent caterpillar damage in the sugar bush were attempted at three different locations in New York State, all with limited success.

Since the forest tent caterpillar are known to move around in the tree during periods of eating then congregating, Tanglefoot sticky traps were placed on the trunks of sugar maple trees. This technique showed a reduction of about 22% defoliation by restricting the caterpillar movement.

Caterpillars have been found to follow a pheromone trail when moving between eating and congregating sites. Several experiments attempted to disrupt movement by placing this pheromone on strings and on the trunks of trees. The pheromone had no observable effect on caterpillar movement.

Caterpillars stop eating and pupate at about the same time as when the maple tree growth stops and terminal buds are set. One sixth acre areas of sugarbush were fertilized in early May with 25 and 50 pounds of nitrogen to see if growth could be forced and trees immediately re-foliated beyond the caterpillar damage. Because of the earlier timing of pupation and sufficient moisture in the woods this summer most trees quickly re-foliated with fertilizer plots showing only small improvement.

Pheromone traps were also used to capture adult moths but not enough were collected to make a serious difference to woodlot populations.

In conclusion, none of our attempts to control the forest tent caterpillar with sticky traps, trail pheromones, fertilization or attractant pheromones resulted in enough reduction in defoliation to make a positive recommendation for control to a limited acreage maple producer.

5. Background and justification:

Many maple producers operate woodlots of less than the 15 acres normally required by aerial pesticide applicators to treat for forest tent caterpillar. Alternative methods of spraying pesticides on the canopy are generally not possible as the canopy is often 30 to over 100 feet high on unimproved or rugged terrain covered with trees. Only tolerance-exempt pesticides are legal in woods used for maple syrup production. Forest tent caterpillar is currently a serious defoliator in many places in New York. Even though the pest is usually a serious problem for three or four years in a given woodlot, maple producers must limit defoliation in order to continue tapping maple trees. The common recommendation is not to tap trees that have been severely defoliated the previous summer. Not tapping for a year can jeopardize a producer's market in future years, and may be harmful to a small farm's income and livelihood. These woodlot owners need proven techniques to limit defoliation due to caterpillars to avoid losing syrup production and markets. Several methods of reducing defoliation were tested in woods where serious defoliation was experienced in 2006. The goal was to keep defoliation to 50% or less, or to encourage rapid re-foliation following damage through fertilization.

The literature suggests that use of sticky traps or tree apron traps may provide some control, but these methods had not been tested on individual trees in a small woodlot setting. Reports also mention the use of light and pheromone traps for adult moths as possibilities, but these would not reduce defoliation until 2007. Since the timing of terminal bud set and cessation of caterpillar feeding are almost synchronous, fertilizing woodlots in May with low levels (25 and 50 # per acre) of nitrogen may allow for immediate re-foliation from continued growth of the terminals, thereby avoiding or reducing tree stress. Synthetic trail pheromone of forest tent caterpillar has just recently been identified and made available for testing. In this project we tested two methods of applying the travel pheromone to trees where they might interrupt forest tent feeding habits. The use of biological control agents such as virus, fungi, bacteria, or predators are not well developed for this pest, and application methods are likely to suffer from the same problems as applying pesticides in these small woodlot blocks.

Many questions have come to County Extension Offices and Cornell staff on the options for controlling forest tent caterpillar. DEC has conducted population evaluations many places in the state. Following this season of research we have no proven options to offer the small maple producer, or the small woodlot owner. This project fit well with the Nursery IPM Project Priorities**,** 2. Pest biology in relationship to pest management, 3. Bio-rational approaches to pest management, and 6. Interactions between abiotic stress and pest management. This project expresses the IPM objective - Demonstrate or investigate innovative pest management approaches that minimize environmental, health, and economic risks.

6. Objectives:

1. Test at two sites, one in central and one in northern New York the ability of sticky traps and tree aprons to reduce maple tree defoliation from forest tent caterpillar.
2. Test alternative ways to reduce defoliation in maple trees to less than 50% from forest tent caterpillar including trail pheromone and adult pheromone traps.
3. Test the effectiveness of light nitrogen applications to overcome defoliations due to forest tent caterpillar
4. Demonstrate the methods tested to manage forest tent caterpillar to maple producers and

small woodlot owners at maple producer meeting in New York State

5. Evaluate the practicality and economy of the effective tests methods by keeping track of labor needed and costs incurred.
6. Develop proven recommendations for small maple producers and woodlot owners to manage defoliation from forest tent caterpillar to less than 50% with out the use of chemical pesticides that have no tolerance exemption.

7. Procedures:

1. Selected plots in three test locations (Canton, Skaneateles, and Arnot Forest) . Three plots at each site had sticky traps and tree aprons installed, and three controls. Treatments were installed in early May and left in place until forest tent caterpillar pupated. Defoliation was rated in each plot in mid-July using visual estimation and photographic analysis. Labor was provided by the Cornell Maple Specialist, Cornell Arnot intern Anna Barensfeld and St. Lawrence CCE technical staff.
2. In blocks of 6 trees with dominant or co-dominant canopy, tests for trail pheromone were placed intending to disrupt defoliation by caterpillars. Nearby, 6 tree blocks served as controls. At each of the three sites we placed adult forest tent caterpillar pheromone traps to determine significance of catch following pupation.
3. At each Skaneateles Lake and Canton nine plots 1/6 acre in size were selected for evaluating the effect of nitrogen on tree health following defoliation by forest tent caterpillar. Three plots received 25 pounds of nitrogen per acre, three received 50 pounds of nitrogen per acre, and three served as controls. Treatments were applied in early May. After the forest tent caterpillar pupated, defoliation was rated in each plot in mid-July, and mid-August.
4. In November a training session on the project was held for county extension educators, and a training session for maple producers is scheduled for January 7th, 2007 as part of the 2007 New York State Maple Conference.
5. During the project, records of costs required to install treatments were recorded. From this data the economics of the treatments were evaluated.
6. From the data collected it is determined that none of the treatments showed sufficient reduction in defoliation to warrant including them in recommendations to maple producers.

7. Results and discussion:

Tanglefoot is a sticky anti-pest paste of castor oil, resin, and wax. It requires considerable labor to install such traps. We hypothesized that sticky trap applications would result in a reduction in defoliation of treated maple trees. To determine the defoliation of sample and control trees, Anna analyzed digital photographs of each tree to measure the amount of light passing through the canopy. By comparing this data with the same data from completely foliated trees was able to determine how much defoliation had occurred with each sample and control tree. Data from the Canton and Arnot sites was erratic due to premature caterpillar die-off. As a result only data from the Skaneateles site was included in data analysis. We found that sticky trap application at this site reduced defoliation of treated trees. Trees with burlap aprons as well as Tanglefoot applications exhibited less defoliation than trees with only Tanglefoot applications.
Reduction in defoliation was not significant enough to warrant further investigation of Tanglefoot as a method for reducing forest tent caterpillar defoliation in maple woodlots. The cost and labor inputs for treating a woodlot with sticky traps are prohibitive. However, sticky

traps could be employed in limited use to curb the breadth of defoliation by limiting the crawling of caterpillars from a defoliated area to another.

An important aspect of the experiment was visual observation in addition to the numerical analysis. Visual observation notes are included and discussed later in this paper.
Sticky traps were installed at three locations: on May 9, 2006 at the Cornell Cooperative Extension of St. Lawrence County Learning Farm in Canton, New York; on May 18 at a participating woodlot near Skaneateles Lake managed by Dan Weed; and on May 22 in the sugarbush at the Arnot Research Forest. Tanglefoot bands were applied at heights between 7 and 8 feet on maple tree boles to keep sticky traps out of tapping areas on the trees and above normal human contact. Bands were applied with approximately 4 inch width. This width was chosen in order to prevent the possibility of many caterpillars, at 2 to 2.5 inch mature length, becoming trapped in the Tanglefoot and creating a "bridge" of carcasses, enabling live caterpillars to travel over the trap. Two sticky trap bands were applied on sample trees at the Canton and Skaneateles sites, to differentiate between caterpillars crawling up boles or down from canopies in case caterpillars were able to cross the barrier.
At the Canton site, we studied 15 sticky trap trees and 13 control trees; at the Skaneateles site, 28 sticky trap trees and 9 control trees; at the Arnot site, 8 sticky trap trees and 6 control trees. The number of treated trees was determined by the amount of Tanglefoot available given the project budget.

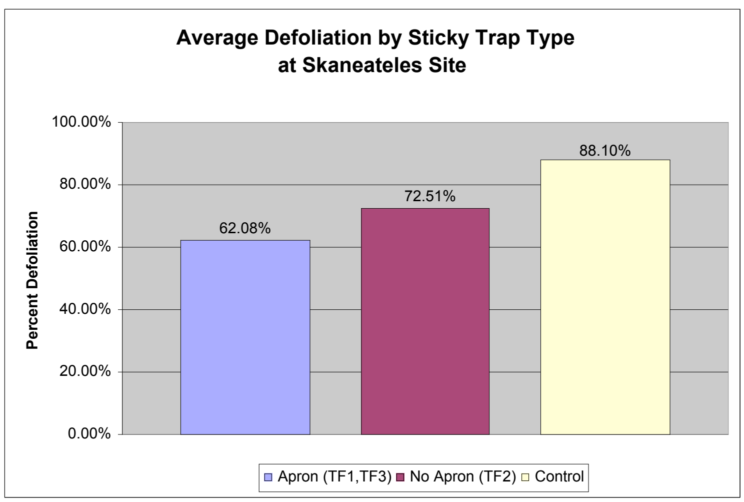
At each site, the following steps were performed on these dates: Skaneateles site, July 16; Arnot sugarbush site, July 20; Canton site, July 21. Anna noted the weather and any general site observations and took GPS coordinates. Then we tagged each sticky trap tree and numbered it according to plot. Anna applied a colored wax dot to each trunk at a height of 83" and took a digital photograph of the crown at a distance of 8.5" directly out from the trunk at this dot. I aimed the viewfinder directly at the center of the crown, then recorded the diameter of each tagged tree with diameter tape, noted the crown class, determined height using a clinometer, and visually estimated percent foliation. Counts were then made of forest tent caterpillar in a 12" band flanking the Tanglefoot application; if two bands of Tanglefoot were present, two counts were made. Also visual observations of crowns and boles including caterpillar density and movement were recorded. This process was repeated for every tree in each plot at the site. Anna tagged, numbered, and made observations (diameter, height, crown class, foliation, forest tent caterpillar count at 4.5 feet height, and visual observations) on the control trees, then applied wax dots and took photographs in the same fashion as on the sticky trap trees.

Next the photographs were analyzed in Adobe Photoshop. For each sample and control tree, Anna opened the appropriate photo file with the program. Next she set the foreground color to bright red (RGB 255:0:0) and the background color to white (RGB 255:255:255). Next she opened the *Histogram* window under the *Image* menu to determine the total pixel area of the photograph and selected the *Elliptical Marquee* tool, setting the tool style on *fixed size* with width of 50px and height of 50px. This tool was used to select five circles of identical area to sample the canopy of the tree. The following rules were followed in order to maintain a regular sampling method:

1. Begin in the northwestern corner of the canopy

2. Select five circles along the northwest-southeast axis with equal spacing, with a goal of encompassing leaf and sky area only.
3. If any circle encompasses significant branch area, wiggle the circle selection area either north or south slightly until a suitable area can be selected. If this does not provide a suitable area, move further along the axis until a circle can be selected that encompasses only leaf and sky area.
4. Jump over the trunk of the tree and select a circle to the southeast of the trunk.
5. If many branches interfere with the foliation along the northwest-southeast axis, use the same selection process beginning in the southeast corner and selecting circles along the southwest-northeast axis.
6. Once the five circles were selected, the *Inverse* command was used under the *Select* menu to select all areas not sampled. Then the *Delete* key was used to eliminate the photo area not sampled. Next the *Magic Wand* tool, set tolerance to 60, and selected all leafy areas within each of the five circles in one successive step (holding down the shift key to sequentially select all areas), being careful not to select any branchy areas. Once all desired areas were selected, the *Fill* command was used under the *Edit* menu to fill the selected areas with the foreground red color . The *Inverse* command was then used again to select the non-red area over the entire photograph, and used the *Delete* key to eliminate this area. This was followed by then clicking anywhere in the white area to deselect the sample area, and opened the *Histogram* again. Instead of the widely distributed graph of pixel color levels, only two spikes remain after the selected areas are converted to red: a spike at the red level (76) and a spike at the white level (255). The cursor was then moved over the red spike and the number of pixels present observed at that level. The ratio of number of red pixels to number of total pixels in the photograph represents the level of foliation for the tree.

An Excel spreadsheet was then used to enter the pixel data. For each sample tree, Anna entered the number of red pixels, number of total pixels, and asked Excel to calculate the percentage of red pixels to total pixels. She then selected a foliar standard tree with which to compare the sample tree. From the portfolio of foliar standard trees, a tree was picked which most closely matched the sample tree in height, crown class, and diameter at breast height (dbh). She then repeated the photograph analysis process above, and entered the data in Excel. Excel was then asked to calculate the percentage defoliation for each sample tree, subtracting the percentage of red pixels to total pixels of the sample tree from the percentage of red pixels to total pixels in the foliar standard tree, then dividing by the percentage of red pixels to total pixels in the foliar standard tree. Average defoliation in the Skaneateles control plot was 88.10% (+/-12.97%, n=9) while the three sticky trap plots



(TF1, TF2, TF3) averaged 65.56% (+/-26.64%, n=27) defoliation collectively. Plot TF1 averaged 58.37% (+/-25.44%, n=8) defoliation, plot TF2 averaged 72.51% (+/-27.26%, n=9) and plot TF3 averaged 65.78% (+/-28.14%, n=10).
Apron plots (TF1, TF3) averaged 62.08% (+/-26.46%, n=18) defoliation, against 72.51% (+/-27.26%, n=9) average defoliation in the non-apron plot (TF2).
Trees in the shortest height category, from 30 to 53 feet in height, showed 72.27% (+/-25.59%, n=8) defoliation in sample plots versus 43.60% (+/-5.98%, n=2) in control plot. Mid-height category trees, from 54 to 76 feet in height, showed 75.52% (+/-12.26%, n=14) defoliation in sample plots plus versus 83.91% (+/-5.80%, n=4) in the control plot. The tallest category of trees, from 77 to 100 feet in height, showed 94.93% (+/-23.74, n=5) defoliation versus 50.77% (+/-9.00%, n=3).

Grouped by crown class, sample trees in the overtopped category show 53.42% (+/-19.19%, n=3) average defoliation while control trees showed 72.27% (n=1). In the intermediate catergory, sample tree defoliation increased slightly to 60.01% (+/-31.84%, n=7). Control trees showed 75.52% (+/-16.56%, n=). Codominant crown class sample trees showed still higher defoliation, at 75.61% (+/-22.58, n=15) and control trees were almost completely defoliated at 94.93% (+/-6.7%, n=6). Sample trees in the dominant crown class exhibit 31.48% average defoliation (+/-0.00%, n=2), a departure from the 68.83% average over all sample classes, +/-26.64%, n=27). No control trees fell into the dominant crown class.

Visual observations at the Arnot site on June 14 (Weather: partly cloudy, some drizzle, Time: afternoon) showed massive congregations of forest tent caterpillars above and below sticky traps. Caterpillars grouped on tree boles appeared more populous below sticky traps than above. There were also high numbers of individual caterpillars spread around tree boles. Total average forest caterpillar count flanking Tanglefoot applications at this site was 73. Caterpillars were also numerous on control trees, but numbered only approximately one-half the population seen on sample trees. Total average forest caterpillar count on the boles of control trees was 37. On these trees, caterpillars were grouped in smaller, more widely distributed clumps.

On June 20 at the Arnot site (Weather: cool, humid; Time: morning), average number of caterpillars grouped around sticky traps was still high, at 70, while control trees showed an average of 24 caterpillars. At this date, caterpillars had begun to cocoon. Tree leaves (particularly of beech near to maple trees), crannies in bark, and plastic identification flagging were used as cocoon locations. The remains of many caterpillars were seen on tree boles, exhibiting signs of attack by NPV and *F. crustos.*
On June 29 at the Arnot site (Weather: warm, sunny; Time: afternoon), cocoons were widespread and live forest tent caterpillar numbers had dropped to just a few per tree, both sample and control. These caterpillars were observed to be very active, moving upwards quickly. *S. aldrichi* numbers were low.

On June 16 at the Skaneateles site (Weather: warm, very sunny; Time: mid morning to mid afternoon), forest tent caterpillar counts were low, averaging just 2 caterpillars flanking the sticky trap area on each sample tree. Control trees averaged no caterpillars on each tree; only 2 were observed in the plot. However, defoliation had clearly taken place. There was a great deal of silk trails laid down by caterpillars traveling from tree to tree, and silk mats showing where caterpillars had congregated. At this site, unlike the Arnot and Canton sites, numerous caterpillars had attempted to travel through the sticky traps; these were observed on the burlap aprons between dual sticky trap bands covered in Tanglefoot. There were also many dead caterpillars caught in the band of Tanglefoot.

At the Canton site, forest tent caterpillars were populous at the time of sticky trap applications on May 14, but by June 21 (Weather: sunny, cool in shade, humid; Time: mid morning to early afternoon) they appeared to have died off at an early instar. The few carcasses present on the boles of sample trees were generally old; many carcasses may have been washed off by rain. The remaining carcasses exhibited signs of infection by NPV, and *F. crustosa*. *S. aldrichi* flies were notably largely absent; however, many dead *S. aldrichi* were caught in sticky traps. Defoliation was clearly visible, despite the low number of caterpillars (dead or alive). Only four live caterpillars were observed on trees in the entire site, all in plot TF1. Three were seen below the lower band of Tanglefoot, and exhibited the slim foregut characteristic of the onset of NPV, while one had been caught on the apron between two bands of Tanglefoot and exhibited early signs of *F. crustosa*.

Data from the Skaneateles plot indicates that sticky trap application results in a reduction in defoliation of treated maple trees. Defoliation in the sample plots was lower than in the control plot, with an average reduction of 22.54%. This is less than half the goal of 50.00% reduction in defoliation. Plots with burlap aprons showed less defoliation on average than those without, an improvement of 10.43%. Whether this further reduction justifies the extra labor associated with installing burlap aprons will depend on individual producers' goals and time availability. The height of trees appears to have no bearing on level of defoliation (sample R^2=0.03, control R^2=0.53). Shorter sample trees showed a higher average defoliation than control trees of similar height; tall trees showed the same relationship. Mid-height trees, however, exhibited the opposite relationship, with sample trees showing lower defoliation than comparable control trees. The data appears to show that crown class, however, has an effect on the level of defoliation (R^2=0.95, control R^2=0.86), with defoliation increasing from the overtopped, to intermediate, to co-dominant classes. The relationship ceases in the dominant class, which exhibits low defoliation for the crown class group. Thus producers wishing to reduce defoliation in their woodlots but limited in budget, time, and effort may choose to focus applications on co-dominant classes, which are generally those trees that are tapped.

Tanglefoot cost averages to $2.64 per tree for treatment of fifty trees, the recommended density in maple woodlots to maximize tree health and sap production (Krasny). Per acre cost is $132. This cost is prohibitive for a small maple producer. For comparison, aerial treatment of Bt costs only $35-$55 per acre. While spraying is not an option for producers with woodlots smaller than 10 ten to 15 acres, this price reveals that the cost to apply sticky traps is far above typical pest treatments. The high cost of Tanglefoot, combined with the considerable labor necessary to treat a woodlot, renders a 22.54% reduction too low to justify use of sticky traps to counter defoliation by forest tent caterpillars.

Sticky traps could be used, however, in limited instances where the maple producer's goal is to curb the spread of forest tent caterpillars within the woodlot or beyond. Tanglefoot seems to be effective at disrupting caterpillar movement from tree to tree. Forest tent caterpillars are gregarious foragers that move about looking for feeding sites, following pheromone lines laid down by the most active among them. Sticky bands restrict their free movement up and down the boles of trees. While we expected caterpillars to actually attempt to cross Tanglefoot bands and become mired in it, the overwhelming majority of caterpillars simply stopped forward movement when a band was reached. Frequently a period of confusion would ensue, as the caterpillar would move up and down several times and circumnavigate the tree, looking for a path past the barrier. Unable to discover a way through, some of those caterpillars attempting to descend returned to the canopy, but most remained stationary at the sticky trap. Those caterpillars trying to move upwards stayed just below the sticky trap. Eventually large congregations of caterpillars gathered above or below Tanglefoot bands; this would occur regardless of the level of defoliation of the sample tree crown or neighboring crowns. This behavior seems odd when caterpillars gathered above or below sticky traps could either return to the canopy to feed, or travel on to the next tree, respectively. Disease was very prevalent once forest tent caterpillars began to congregate at sticky traps, with NPV and *F. crustosa* killing high numbers of caterpillars. One explanation is that the large numbers of caterpillars gathered in one place hastened the spread of contagion. It is also possible that these groups provided easy feeding for natural predators such as beetles and spiders.

Sticky trap use could be a drawback as it could promote increased feeding of treated tree crowns by keeping those caterpillars "locked" into a particular tree. However, this also combats the spread of caterpillars to other sections of woodlot. Furthermore, as indicated above, caterpillars often failed to return to the canopy, remaining on the lower bole once a sticky trap was encountered. Dropping from the crown to the forest floor is the only path out of a treated tree; this was actually a common occurrence, but not frequent enough to allow high numbers of caterpillars to move from a treated to an untreated tree.

Due to the early die off of caterpillars at the Canton site both the control and fertilized plots re-leafed quickly and treatment differences were indistinguishable. At the Skaneateles site the trees also re-foliated rapidly following the caterpillar mortality and pupation. 70 to 80% of the live caterpillars died on the tree trunks before developing into pupa Here the tree foliage color was slightly darker in plots that were fertilized and selected branches appeared to have greater growth, however the visual differences up in the canopy again were indistinguishable.

The caterpillars did not show any reaction to the trail pheromone in either application format. Pheromones were also used in traps for adult forest tent moths. We wanted to determine if these traps are successful at trapping moths in a small woodlot setting. This application would not reduce defoliation until the following year, 2007. The moth traps only drew marginal numbers of forest tent individuals. The trap model used, Pherotech's Unitrap, does not seem to be a real solution for reducing FTC numbers or future defoliation. Over the 10-day period when the moths were most active, the traps averaged only 1 moth per trap at the Arnot Forest and less at Canton and Skaneateles. As the moths are attracted to lights, we set up a light-trap near the sugarhouse to test the effectiveness of the pheromone traps. 13 moths were trapped overnight, whereas only 3 moths were trapped in the proximate pheromone trap.

Again, the final conclusion is that none of the control systems tested in the project yielded results indicating that they should be recommended to limited acreage maple producers to control the forest tent caterpillar defoliation.

Adult moth pheromone trap

9. Project location(s): This research was conducted in St. Lawrence County in Northern New York, Cayuga County in Central New York and in Schuyler County in the Southern Tier and should apply to any location in the Northeast.

10. Samples of resources developed:
Two separate reports and a powerpoint presentation used to train Extension Educators and maple producers are included.


Example of continued tree growth and refoliation
Following pupation where 50# nitrogen applied.