



Report: Gypsy Moth in Rhode Island 2014-2016



Introduction.

During the spring of 2015 and 2016 Rhode Island forests, parks and trees, experienced the defoliation of 226,800 acres of forestland caused by gypsy moth larval (caterpillar) feeding. The last significant “outbreak” of this kind occurred in 1985, when 411,800 acres were defoliated. DEM has monitored gypsy moth populations in the hope of being able to forewarn of a future outbreak so that management and control strategies could be considered. This report is meant to provide readers with the results of the monitoring effort, an assessment of the current condition, and a forecast for the short term future outlook.

The Gypsy moth (*Lymantria dispar*) is a non-native invasive species that has naturalized in the United States, particularly in the northeast. The gypsy moth is now persistent in the environment, generally causing little to no harm, kept in check by environmental conditions and naturally occurring bio-controls.

Gypsy moth populations fluctuate as environmental conditions change. In commercial timber management operations these fluctuations are closely watched. When monitoring and survey results indicate that gypsy moth numbers are on the rise, human intervention (i.e. use of pesticides), is sometimes used to reduce gypsy moth populations before gypsy moth larval (caterpillar) feeding behavior can impact tree growth or cause tree mortality. An aerial pesticide application program may be implemented when it is economical and practical to do so.

Gypsy moth numbers periodically increase rapidly over large geographic areas. During these “outbreaks” gypsy moth caterpillars cause significant defoliation events as they consume foliage of their preferred host tree or shrub species. The last time Rhode Island experienced a significant outbreak was in 1985.

In 2014 below average rainfall started a cascade of events that heralded the start of the current outbreak. Analysis of data collected by Rhode Island DEM Forest Environment during routine monitoring prior to 2014 gave no indication of an impending outbreak. In 2015 a moderate defoliation event occurred, in scattered areas throughout the state. By 2016 the defoliation had spread in extent and intensity throughout most of the western half of the State. Areas of Connecticut and Massachusetts also experienced defoliations caused by Gypsy moth, but not as concentrated as the defoliation in Rhode Island.

A review of the conditions leading up to the infestation, data from monitoring surveys, and lessons from previous outbreaks is warranted to help formulate expectations for 2017.

Methodology/Results.

Since at least 1985 the RIDEM Division of Forest Environment (DFE) has been monitoring gypsy moth populations generally using two techniques: fixed point ground sampling where gypsy moth (GM) egg masses are counted, and aerial detection surveys where acres defoliated are mapped. When taken

together the data collected can be used to document population trends, and to map the extent and geographic distribution of defoliation and/or tree mortality caused by GM larval feeding behavior.

The egg mass survey has been undertaken using variants of the sequential fixed plot sampling method. One hundred forty-two plots have been established in a grid pattern throughout the most heavily forested portions of the state: western RI and Tiverton/Little Compton. The sequentially numbered survey points start in the NW corner of the state, are located in appropriate forest habitat types (upland hardwood dominated) and are spaced approximately 2-miles apart E-W, and 3-miles apart N-S. (Figure 1).

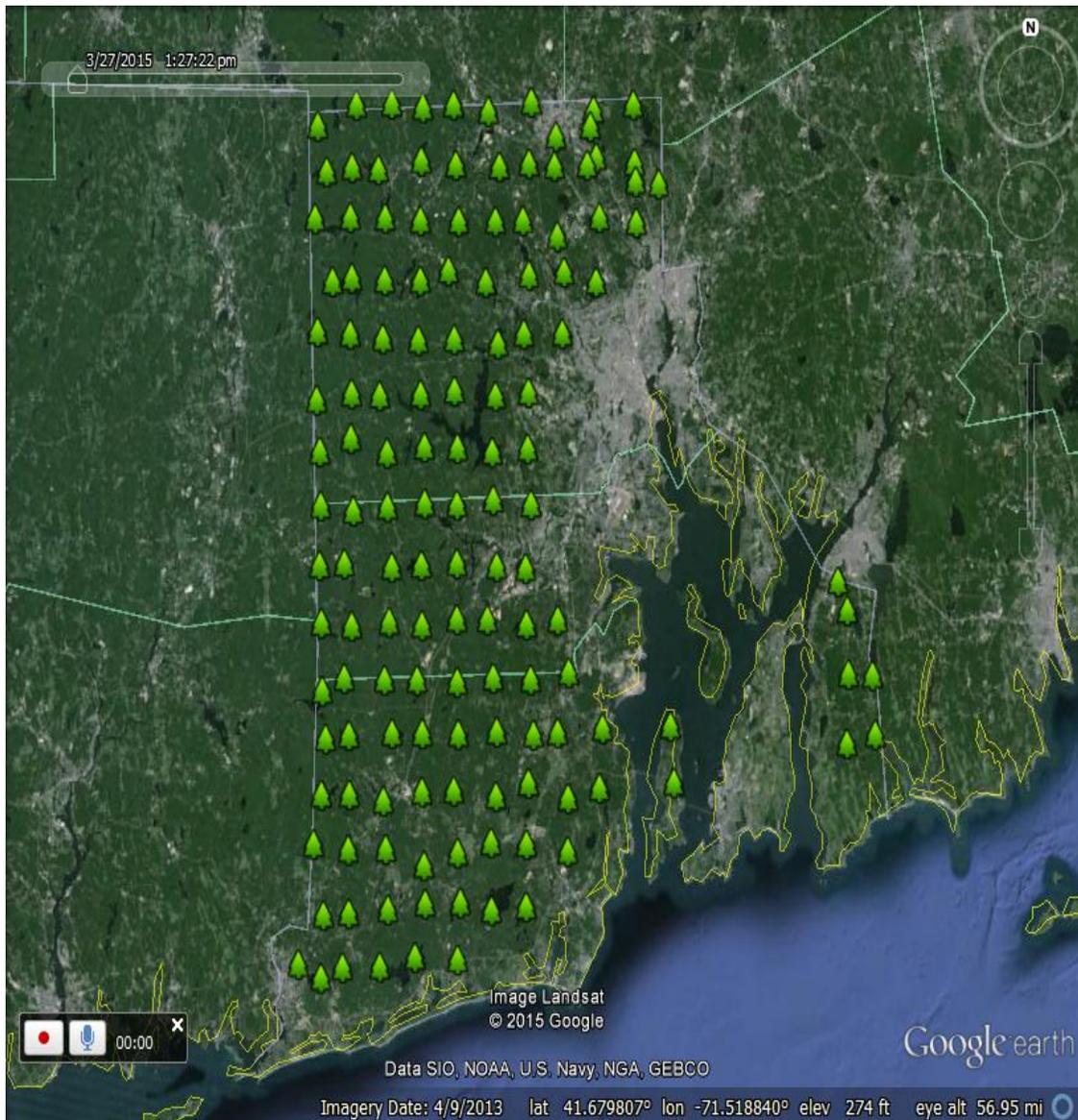


Figure 1. Gypsy moth fixed plot locations.

The plots are surveyed annually during leaf-off, no snow conditions. At each plot, observers count the number of egg masses deposited on the ground and in all trees rooted within the plot, using binoculars

as needed. Once the tally for an individual tree reaches 50 masses the observer begins estimating in groups of 25 until the tally reaches 200, at which point if there are more the observer notes “200+” and continues surveying the remaining trees.

A review of archived field data sheets from 2004-2013 indicates only minor annual fluctuations in egg mass numbers, with over 90% of the plots having no egg masses counted, and the remainder having a combined total of less than 10 egg masses statewide (2 tallied statewide in 2013). It isn’t until the survey conducted in 2014 that we find an uptick in total egg masses counted (44), followed by successive years of exponential increase in egg mass numbers with 3,523 tallied in 2015, and 36,226+ tallied in 2016 (Figure 2).

Data from egg mass counts can be used to generate statewide estimates of egg masses from which the potential number of larvae hatching the following spring can be derived.

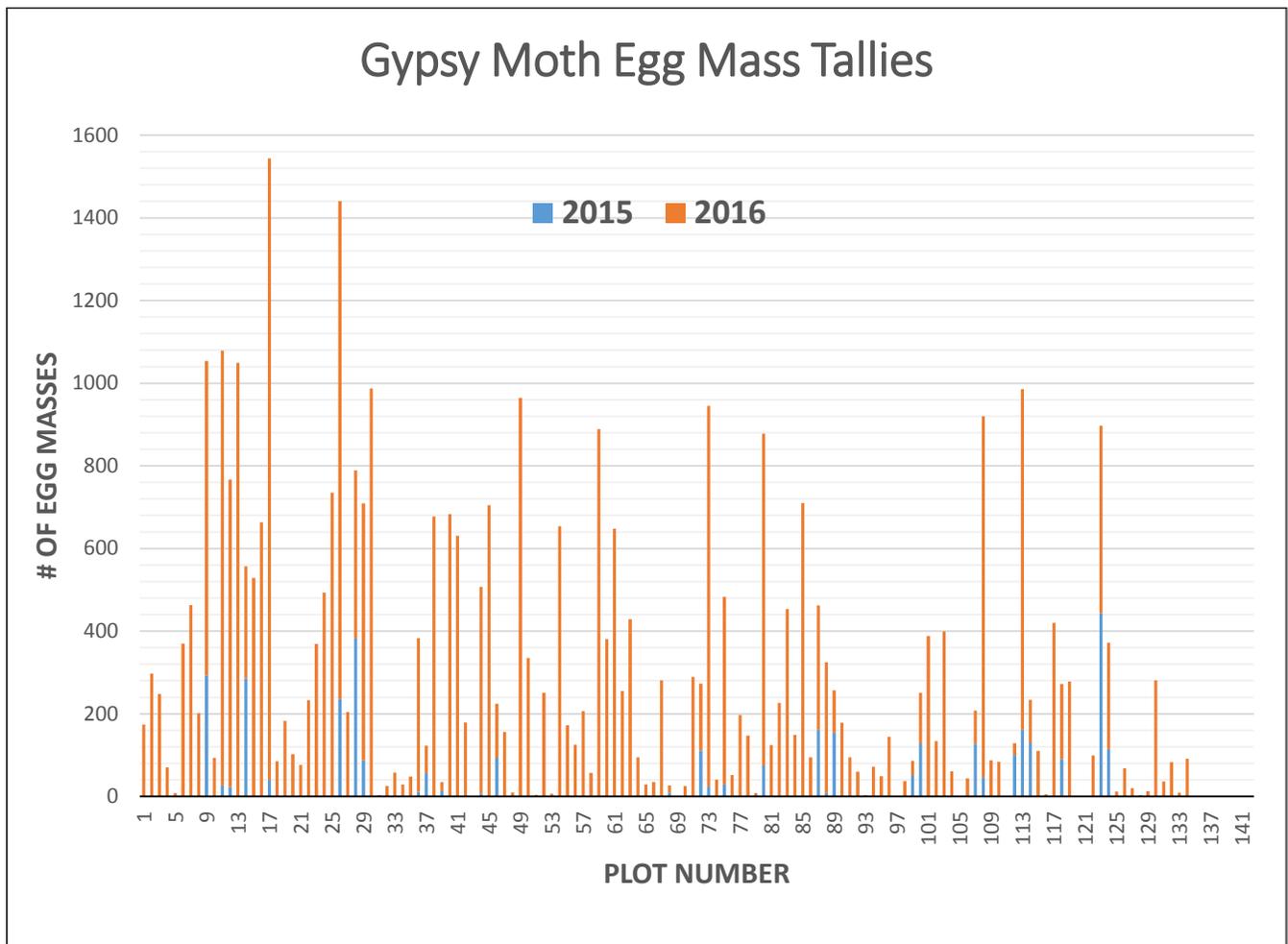


Figure 2. Comparison of the number of gypsy moth egg masses counted/plot during the 2015 and 2016 egg mass surveys.

Due to the significant expansion of canopy defoliation in historically surveyed forest environments from 2014-2016, additional observations to detect the relative abundance and distribution of GM egg masses were made in suitable treed habitats located in urban settings not typically surveyed. (Table 1).

Table 1. Location and relative abundance and distribution of gypsy moth egg masses observed during supplemental surveys conducted in 2016.

<u>Location</u>	<u>Abundance & Distribution</u>
<u>Barrington</u>	
Veterans Memorial Park/YMCA	Light, scattered
New Meadow Neck	None found
<u>Bristol</u>	
Colt State Park	Light, scattered
Vicinity of Roger Williams University	Light, scattered
Mount Hope Point	None found
<u>Cranston/Warwick line</u>	
Pawtuxet River/DEM Warehouse	Light, Widely scattered
<u>East Providence</u>	
Squantum Woods/Bradley Hospital	Light, widely scattered
Haines Park	Moderate, scattered
<u>Newport</u>	
Miantonomi Park	Light, scattered
Hazard Road	None found
Brenton Point State Park	None found
<u>Portsmouth</u>	
Melville Recreation Area	None
“The Glen”	None
<u>Providence</u>	
Neutaconkanut Hill	Moderate, dense
Roger Williams Park	Moderate, scattered
Blackstone River Park	Moderate, scattered
Swan Point Cemetery	None. (Spray program.)
<u>Warwick</u>	
Goddard Memorial State Park	Moderate, scattered

Results of the combined 2016 gypsy moth egg mass counts and supplemental visual observations are depicted in Figure 3.

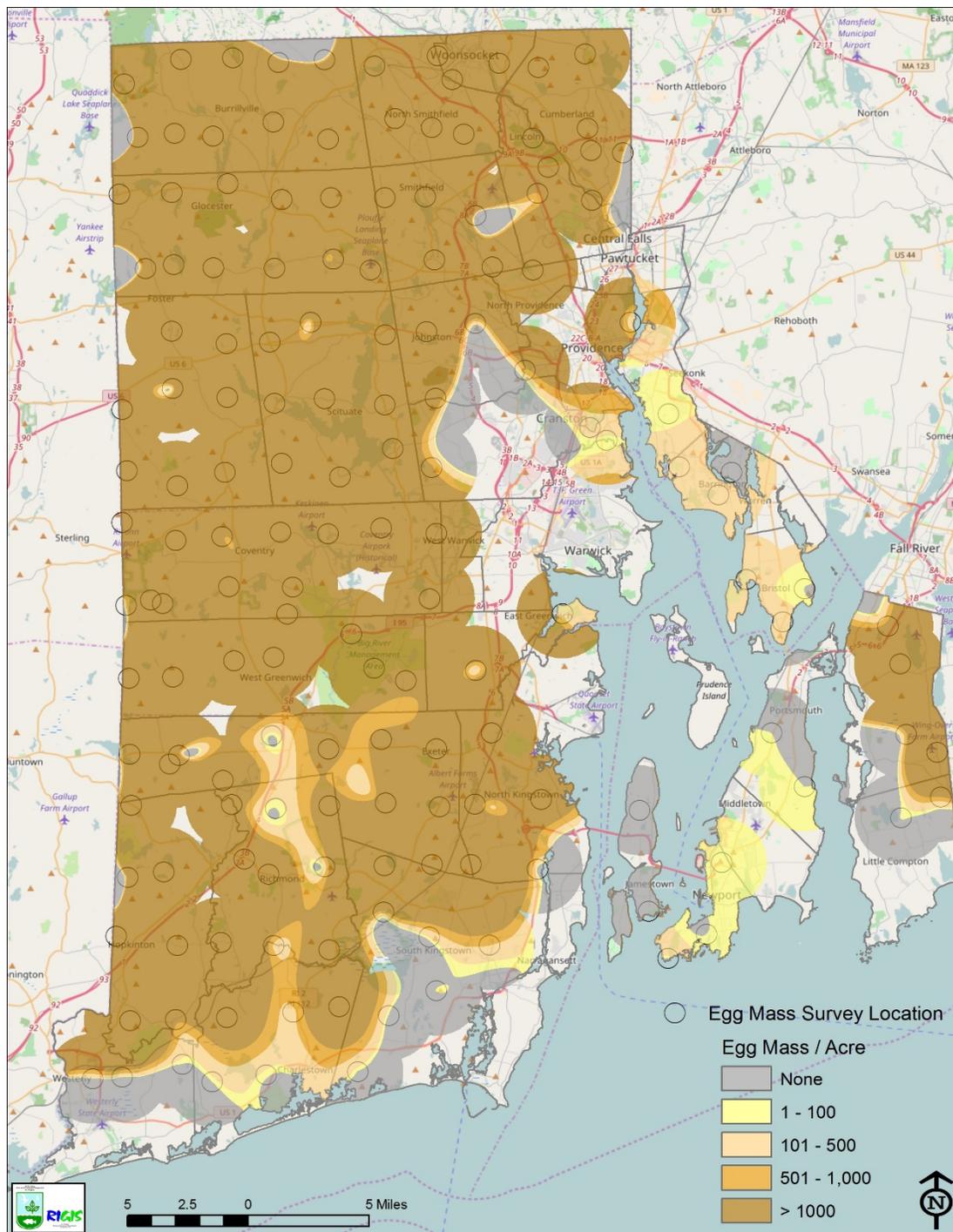


Figure 3. Relative abundance and distribution of gypsy moth egg masses counted or observed during fixed plot and visual surveys conducted in 2016.

In 2015 there was a significant increase in defoliations when 46,800 acres were mapped, throughout the state (Figure 5).

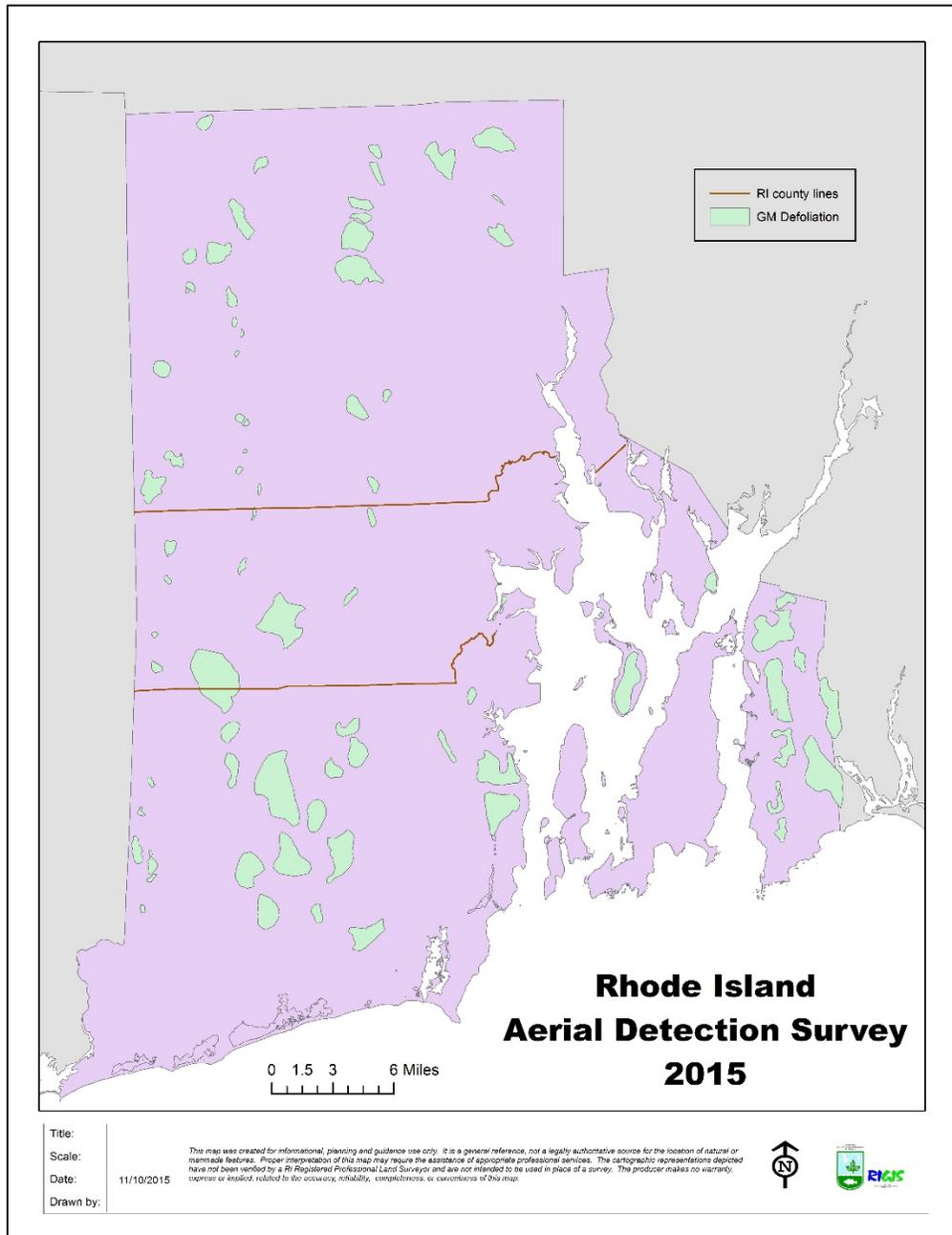


Figure 5. Locations of defoliation attributed to gypsy moth larvae, mapped during the 2015 aerial detection survey.

In 2016 acres defoliated increased a whopping 480% to 226,800 acres! This includes acres that may have been defoliated by Forest Tent Caterpillar (FTC), another caterpillar that was abundant in the spring of 2016. As both GM & FTC were present during the same timeframe, and since they prefer similar host tree species, it isn't possible to differentiate defoliations caused by each defoliator.

However, based on field observations and historic distribution data it can be deduced that defoliation caused by GM & FTC combined accounted for approximately 85,000 acres. Therefore, for reporting purposes each caterpillar is attributed 50% of the defoliation of that acreage. The extent and intensity of the defoliation was captured by USDA Forest Service “Forewarn” satellite imagery which detects and quantifies (relatively) changes in the density of forest canopy (Figure 6).

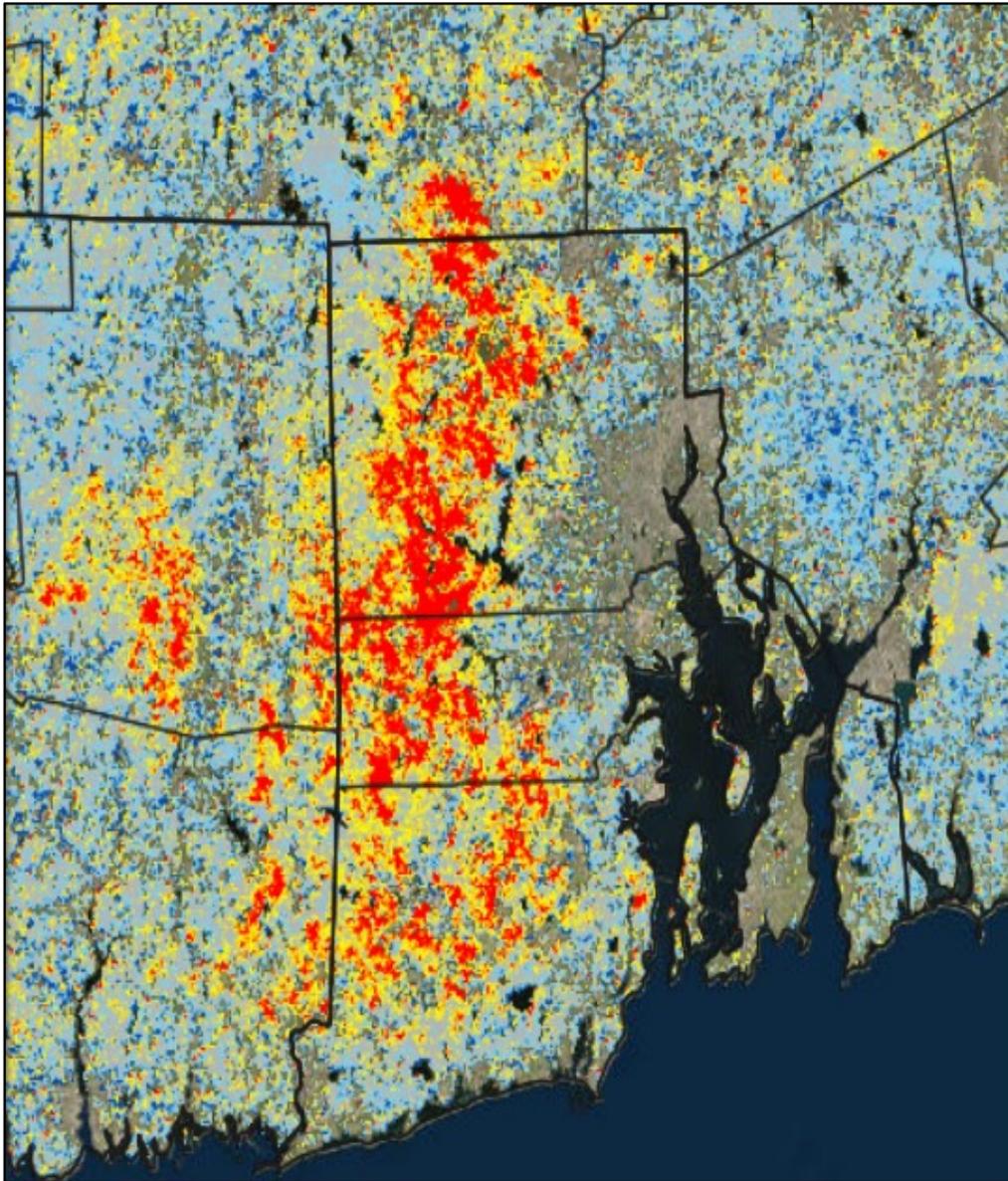


Figure 6. Area of forest canopy affected by forest defoliators, May 2016. As colors deepen from yellow to red, the intensity of canopy change (defoliation) increases. Source: USDA Forest Service Forewarn satellite imagery.

When viewed from an aircraft an observer gets a deeper appreciation of the scope and intensity of the defoliation (Figure 7).



Figure 7. Photo taken during aerial detection survey indicating the expanse of canopy defoliation. Scituate, looking westward. SR-102 north of SR-14 can be seen in mid-photo. (Photo: P. Ricard).

Discussion.

Caution should be exercised in the interpretation of the results of the DEM survey and monitoring efforts. The method used for the egg mass survey is a variation of a methodology developed to survey much smaller tracts (on the order of 1,000’s of acres). To my knowledge our “variant” has not been peer reviewed/accepted for use at the scale for which it has been applied here. Each sample plot is 1/40 of an acre, and the *total* area surveyed equates to only 3.5 acres, or .001% of our roughly 369,800 acres of forestland (USDA Forest Service, 2015 FIA data).

Consider also that in the field there is a high egg mass count variability within any given acre, and that egg masses laid in the upper reaches of trees are more difficult to spot. Also, observers are instructed to cease counting the number of egg masses on a tree once the count reaches 200 masses. In plots in the most heavily infested areas it can be easy to reach this threshold, and within those plots oftentimes multiple trees will reach the peak tally, skewing results low for that plot.

When conducting the aerial detection survey (ADS), the flight lines, elevation and aircraft speed are theoretically designed to provide the observer with the opportunity to undertake a complete visual surveillance of the state’s forested canopy, and to map forest canopy anomalies. In actuality ideal conditions are rarely maintained and circumstances such as cloud cover, shadows, mapping errors, observer experience, and flight path deviations affect the overall accuracy of the survey, especially as affected canopy areas become extensive and/or affect the canopy at the furthest extent of the observer’s line of sight. Also, smaller areas of light or widely scattered defoliations (of which there are likely to be many) are easily missed.

Despite the limitations of the aerial and ground surveys, the results are useful to provide relative distribution and intensity information, as demonstrated by the correlation between satellite imagery, mapped polygons of defoliation, and egg mass counts. So while the actual numbers may be debatable there is no question that we are in the third year of a widespread and intense gypsy moth outbreak.

Analysis of the data from the 2016 egg mass count, average and maximum statewide estimates of the number of eggs (and therefore the potential number of larvae) hatching in spring, 2017 can be derived (Table 2).

Table 2. Estimates of the potential number of gypsy moth larvae hatching in 2017 as determined by analysis of 2016 egg mass survey tallies from 142 plots.

Average # egg masses/acre	11,458
x assumed #eggs/mass (400) =	4,583,200
less assumed egg parasitism (30%) =	1,374,960
= est. avg. # of larvae/acre	3,208,240
Total # of larvae in forested land	1,283,296,000,000
Greatest # egg masses/acre	60,891
x assumed #eggs/mass (200) =	12,178,200
less assumed egg parasitism (50%) =	6,089,100
= Greatest # of larvae/acre	6,089,100

The differences in assumed average numbers of egg/egg mass, and parasitism rate is because in situations where there is a high density of adult moths, females create smaller egg masses (less eggs/mass) which provides greater opportunity for parasitism. Because of survey bias those staggering numbers should not be applied to every acre of land in the state. Remember plot size was small, plots were located in suitable habitat with host species present, and acreage values used in the calculations included totally unsuitable habitats such as farmland, and waterways/waterbodies. So the average and maximum numbers would apply only to acres of suitable habitat.

The observations from the supplemental survey indicate that gypsy moth can now be found in nearly every community in the state. The fact that “few” egg masses were found in multiple sites should be of little comfort as before the beginning of the current outbreak, nearly 96% of the plots sampled for egg masses in 2014 had no egg masses discovered at all. The significance of these findings is also important in that a greater number of people will be affected than in 2016, and that the focus of concern for the public will shift more to “shade” and “street” trees, rather than forestlands.

The 2015 ADS was undertaken in good environmental conditions for flight and mapping. The entire state was flown and the discreet areas of defoliation were fairly easy to map and analyze. In 2016 conditions were different.

First, a new mapping device (tablet) was introduced to replace the aerial sketch-mapping device used previously. Not only was the hardware different but the two devices used completely different software as well. While the state had possession of the tablet early in 2016, training in its use did not occur until days before the first ADS of the season, leaving little time to become familiarized with the device’s operations.

Secondly, during the ADS a thick fog bank moved in, obscuring visibility during the survey of Newport County. Within Newport County only the municipalities of Tiverton and Little Compton have large areas of forestland with gypsy moth preferred host species. Those areas were later surveyed via visual observation from automobile. Despite mapping defoliation caused in those communities caused by gypsy moth in 2015, no defoliation was observed there in 2016 using that survey method.

So then, taking into consideration the data collected, what is the forecast for 2017? Before that question can be answered, we must consider the circumstances in non-outbreak conditions, and how the gypsy moth population is kept under control then.

Environmental conditions and naturally occurring biological agents keep gypsy moth numbers in check in non-outbreak periods. These “bio-controls” include predators of the gypsy moth larvae including small mammals and birds, parasitoids of the gypsy moth eggs and larvae, of which there are several wasps and flies, and a naturally occurring fungus (*Entomophaga maimaiga*) and virus, the Nucleopolyhedrosis virus (NPV).

While *Entomophaga* can infect 78 species of Lepidoptera, infection rates in the wild of species other than gypsy moth are so unlikely that *Entomophaga* is considered “highly host specific”. NPV is a specific pathogen of gypsy moth and does not infect other Lepidoptera. When commercially produced, NPV is known by its trade name “Gypcheck” which is the sole property of the US Forest Service.

Gypcheck is not available to the commercial market, but is available to the Forest Service’s state partners, but must be ordered well in advance so that sufficient time can be provided for its production.

Like other fungi, *Entomophaga* requires periodic sustained rainfall in order to reproduce and spread. The timing of the rainfall events (April-June) is critical for the reproduction and efficient transmission of the fungus to the larvae. In the most recent past *Entomophaga* has been able to prevent gypsy moth populations from attaining outbreak status.

As depicted in Figure 8, Rhode Island had below average precipitation during that critical time (weeks 3-7), which created unsuitable conditions for the development and spread of *Entomophaga*. The result was greater survival of gypsy moth larvae to adulthood, and greater egg mass numbers each successive year.

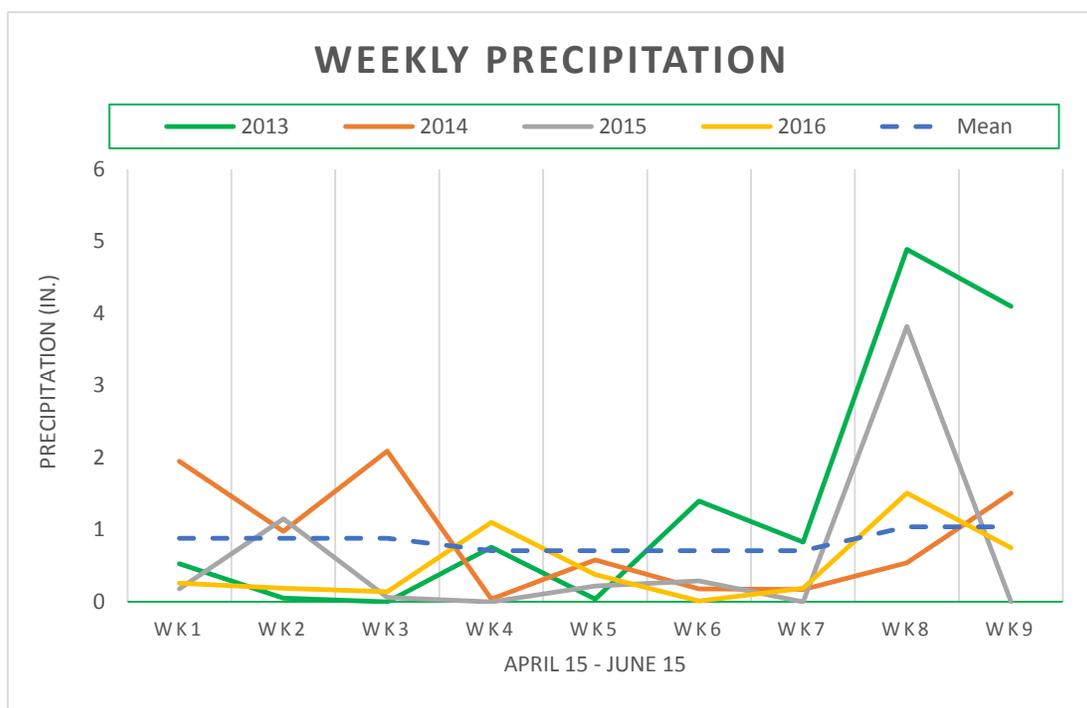


Figure 8. Deviation of precipitation from the 10-yr. mean during the months critical for the reproduction and spread of the *Entomophaga maimaiga* fungus.

NPV plays a significant role in gypsy moth population control when larval numbers and densities are high, such as during an outbreak when more suitable conditions exist for caterpillar to caterpillar transmission. During an outbreak, NPV can cause an “epizootic” episode (massive die-off). Unfortunately this usually doesn’t occur until the late stages of the defoliation event.

The Connecticut Agricultural Experiment Station (CAES) analyzed samples taken from gypsy moth caterpillars collected in Connecticut in 2015 and 2016 to determine the presence/absence/relative abundance of *Entomophaga* and NPV in the environment. Little to no inoculum of *Entomophaga* was detected in 2015 or 2016; no NPV was detected in 2015, and only little was detected in 2016. However, given proper conditions (sufficient rainfall & caterpillar density), each of these pathogens can multiply

rapidly and cause mass mortality. While no such sampling occurred in Rhode Island it is not unreasonable to assume a similar situation exists here.

With the substantial number of gypsy moth larvae, insufficient rainfall, and lack of pathogens in the environment, it is no wonder that 226,800 acres of defoliation attributed to gypsy moth larval feeding behavior was delineated during the ADS in 2016. Forest Tent Caterpillar (FTC), which hatched concurrently with gypsy moth in southern and south-central Rhode Island, fed alongside gypsy moth, contributing to the defoliation of approximately 80,000 of those acres.

It would be easy to look back to the duration of previous infestations and conclude that since historically most infestations last from 2-3 years, this infestation will end within the next 1-2 years. Unfortunately some infestations have lasted ten years or longer.

It is generally accepted that once an outbreak of the extent that we are currently experiencing occurs, only natural events/conditions can bring about its end. As there are so many variables involved in gypsy moth population cycles, it is not possible to predict with any degree of certainty when this outbreak will end.

Conclusion.

The substantial number of egg masses tallied in the 2016 egg mass survey and the number and distribution of egg masses observed in the supplemental visual survey, together with the scarcity of natural pathogens, suggest that there is a high probability for another significant defoliation event this coming season (April – July, 2017). While last year's defoliation event affected nearly one-quarter of the State's terrestrial land mass, the more or less statewide distribution of egg masses indicates that the area affected in 2017 will be larger, and will expand into the previously unscathed suburban and urban areas and east bay communities. Areas heavily defoliated in 2016 can expect a similar defoliation in 2017, while trees in areas with moderate to no defoliation in 2016 can expect increased defoliation.

We should remember that trees are generally resilient, and can tolerate some defoliation. However, even healthy trees can only survive a limited number of defoliations before they succumb, having used up their energy stores re-foliating after the initial defoliations. Due to how they store their energy, hardwood trees are more likely to survive defoliations than evergreens which may die from a single defoliation event.

When trees are stressed by other factors such as drought, exposure, or poor growing condition, their likelihood of survival decreases. As some parts of the state have already experienced two years of defoliation, we should expect to observe measurable tree mortality beginning in 2017.

Until conditions (i.e. periodic consistent rainfall from late April to mid- June) are such that the naturally occurring bio-controls can regain the upper hand on the gypsy moth, the outbreak will continue. Even if spring weather conditions are perfect for the pathogens of gypsy moth to spread, because of the method of transmission and dispersal of *Entomophaga* and NPV, we are still likely to experience a significant defoliation event in 2017. A high rate of larval mortality in 2017 can prevent or minimize defoliation for 2018.