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Nantucket Pine Tip Moth

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The Nantucket pine tip moth, *Rhyacionia frustrana* (Scudder in Comstock), is a common insect pest of young pine stands in the eastern and southern United States (Figure 1). It was first reported as a pest in 1879 and its life history was described in 1883. Its native range extends from Massachusetts south to northern Florida and west to eastern Texas (Figure 2). There are also disjunctive populations in New Mexico, Arizona, and southern California, where it was accidently introduced via nursery stock imported from Georgia. This species has also been reported from Mexico, Guatemala, Nicaragua, Cuba, Jamaica, and the Dominican Republic.

The natural range of Nantucket pine tip moth overlaps with several other pine tip moths, including the pitch pine tip moth (*R. rigidana* [Fernald]), the subtropical pine tip moth (*R. subtropica* Miller), and the European pine shoot moth (*R. buoliana* [Denis & Schiffermüller]). The pitch pine tip moth and Nantucket pine tip moth look similar and can often be found infesting the same tree, even though Nantucket pine tip moths tend to be more abundant where the two species co-occur. The European pine shoot moth is an introduced species that overlaps with the Nantucket pine tip moth in much of the eastern U.S.; however, the European pine shoot moth is larger in size, has a different color pattern, and the pupae are larger with more pronounced spines.

Figure 1. A Nantucket pine tip moth adult.

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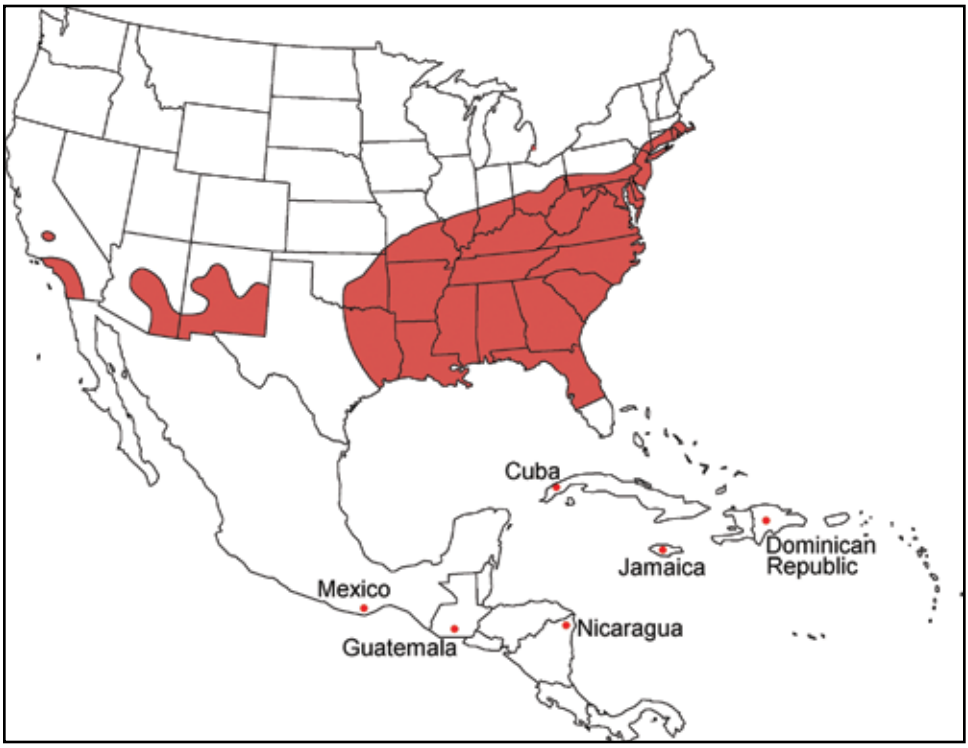

Figure 2. Current distribution of the Nantucket pine tip moth. Red shaded area is known range and red dots denote isolated records of occurrence. No information is available for northern Mexico or western Texas.

Loblolly, shortleaf and Virginia pines are preferred hosts in the southeastern U.S. Slash, longleaf and Eastern white pines can also be infested, but are considered more resistant than the species listed above. In the northeastern U.S., preferred hosts include Scots, pitch, and red pines, while ponderosa and Monterey pines are common hosts in the western U.S.

Life Stages and Life History

Newly emerged adults have gray-white scales covering their heads, and their orange-red wings have white bands. Male moths emerge before females and are later attracted to a sex pheromone produced by the female moth. After mating occurs, eggs are laid singly on newly produced buds or needles. The slightly convex eggs are yellow to orange and are less than 0.1 inches in length (Figure 3). After hatching, the first instar larvae mine into needles, causing necrotic areas, and then move out of the needles and begin feeding on buds and shoots. Larvae go through

Figure 3. Pine tip moth eggs; Eggs depicted are R. rigidana *eggs.* Rhyacionia frustrana *eggs are similar in appearance, but are laid singly. Black colored eggs are parasitized by* Trichogramma *and yellow colored are unparasitized.*

5 instars. Young larvae are cream colored with black heads, while later instars are yellow to orange and can measure up to 0.5 inches in length (Figure 4). Pupation occurs in shoots killed by larval feeding. Pupae are light to dark brown and are about 0.3 inches in length (Figure 5). There are 2-5 generations per year, with the number dependent on climate and the growth flushes of the host tree. They overwinter as pupae.

Figure 4. Nantucket pine tip moth larvae.

Figure 5. Nantucket pine tip moth pupae.

Damage

Nantucket pine tip moths primarily infest seedlings and saplings up to 5 or 6 years old, thus are particularly problematic in young pine plantations. Damage to trees is caused by larval feeding in the buds and tips of pine shoots (Figure 6). Early feeding is indicated by a protective, resin-soaked web of silk found between the needles and bud axils. As the larvae continue to feed in the buds and shoots, the webs become more prominent as resin and frass accumulate (Figure 7). Their feeding severs the shoots' vascular system and causes the infested shoots, buds and associated needles to turn brown. The length of damage on the shoots is generally proportional to the number of larvae feeding within individual shoots.

Economic Impacts

Typically, Nantucket pine tip moth infestation causes little or no pine mortality. Severe infestations typically occur during the first few years of plantation establishment, when tip moth damage has the greatest influence on main stem volume. Damage tends to be concentrated along the terminal leader and top whorl of young pines, frequently leading to increased compression wood and deformity of the main stem. Moderate to heavy infestations can reduce tree height and stem volume. Repeated and severe infestations can kill seedlings and cause older trees to become forked and deformed. Nantucket pine tip moth can also infest conelets and reduce subsequent cone crops.

The primary economic impact is delayed growth, particularly in intensively managed plantations where rotation lengths may be extended by several years as a result of shoot mortality. It has been suggested

Figure 6. Damaged caused by the Nantucket pine tip moth on loblolly pine.

that pine trees can 'catch up' from growth losses early in the rotation, but evidence suggests that while this is sometimes true for height, it is generally not the case for total stem volume. In intensively managed plantations, foresters try to achieve merchantable growth of pines in less time. This push for shorter rotation times results in tip moth becoming a problem during a larger proportion of the rotation, particularly in stands grown for sawtimber. Due to the ubiquitous nature of this pest, it is likely that growth loss in intensively managed loblolly pine across the southeastern U.S. is quite substantial and greatly underestimated. Recent work suggests that control of even low-level tip moth populations can yield significant economic gains in intensively managed plantations.

One of the primary difficulties in tip moth management has been the establishment of a damage threshold, above which chemical control becomes economically feasible. The determination of this threshold is confounded by many factors including multiple tip moth generations over multiple years, significant fluctuations in tip moth populations between generations and years, local site and stand conditions (soils, site index, tree growth rates, etc.), and management practices (site preparation, chemical weed control, etc.). Furthermore, rotation times of 18 years or longer for most pine plantations dictate that one must either conduct research over an extended time frame, or use growth and yield models combined with a series of economic assumptions to project future losses based on short term growth impacts. Not surprisingly, both strategies have been attempted and have produced highly variable results. The resulting uncertainty has been a primary reason for the forest industry's reluctance to apply control methods.

Figure 7. Feeding site of the Nantucket pine tip moth larvae on loblolly pine including discarded pupal case.

Management

Chemical. Control of tip moth infestations with contact insecticides (e.g., pyrethroids) applied directly to the foliage is effective if properly timed to target susceptible life stages. Spraying at about 30-80% egg hatch generally maximizes control and corresponds with an abundance of early instar larvae in the field, which are most vulnerable due to their small size and level of exposure. Several spray timing models, based on degree-day accumulations that predict the presence of early instar larvae, have been published for areas where three and four tip moth generations occur annually. This encompasses most of the Piedmont and Coastal Plain of the southeastern U.S. where the majority of tip moth damage occurs. Generally, one chemical application is carefully timed to target each generation. Some research suggests that spraying only the first tip moth generation or perhaps the first two generations annually may be enough to significantly reduce populations. Insecticides are most commonly used to protect high-valued stands such as Christmas tree plantations, seed orchards, progeny tests, and intensively managed plantations.

Two systemic insecticides have also been recently registered for tip moth control. The first has the active ingredient fipronil and is applied as a liquid, while the second contains imidacloprid and is applied in tablet form. These systemic treatments are designed to be applied once at the time of tree planting; however, if control is desired after the first two years, then traditional contact insecticides may be the better option. Preliminary research has demonstrated effective control of all generations during the first two years of growth. This development will likely reduce or eliminate the need to apply insecticides using traditional sprays and spray schedules during the first years following stand establishment. Proper timing to adequately control later tip moth generations (third or beyond) with insecticide sprays has always been problematic. Furthermore, climatic variation may adversely affect the usefulness of published spray dates based on historical temperature regimes. The development of affordable systemic insecticides that protect trees during the first two years following planting with only one application can help circumvent these issues and should make chemical control a more predictable, cost effective, environmentally safe, and operationally feasible practice.

Natural Enemies. The Nantucket pine tip moth is attacked by a variety of natural enemies. Relatively little work has been done on pathogens and parasites associated with tip moths, but there is evidence that applications of codling moth granulosis virus can reduce tip moth populations. The nematode DD-136 can also cause tip moth mortality, but probably does not provide sufficient control for use as a pest management strategy. There is little evidence that pathogenic fungi cause significant tip moth mortality. Numerous arthropod predators have been associated with tip moths, including clerid beetles in the genus *Phyllobaenus* (Figure 8), various web-building and hunting spiders, and predatory wasps such as the eumenid *Zethus spinipes* Say. However,

Figure 8. A Nantucket pine tip moth predator, Phyllobaenus *spp.*

little is known about the impact that these predators have on tip moth populations and their potential role in population regulation.

Most work on tip moth natural enemies has focused on parasitoids, and over 60 species of parasitoids have been associated with tip moths. Tip moth larval/pupal parasitism rates in excess of 40% have been reported. The ichneumonid *Campoplex frustranae* Cushman (Figure 9) and the tachinid *Lixophaga mediocris* Aldrich (Figure 10) are consistently among the most abundant tip moth parasitoids, although *C. frustranae* was absent in a survey of tip moth parasitoids in the Georgia Coastal Plain. There is evidence that certain insecticides (including acephate, spinosad, permethrin and lambda-cyhalothrin) used for tip moth control can have adverse effects on parasitoids. Egg parasitoids in the genus *Trichogramma* can cause high tip moth egg mortality, with documented mortality rates of over 60% (Figure 3). Experimental inundative releases of *Trichogramma exiguum* Pinto & Platner against tip moths initially showed potential for increasing egg parasitism and decreasing shoot damage, but predation on capsules containing *Trichogramma* wasps, and low *Trichogramma* emergence rates due to microclimatic conditions appear to be significant roadblocks to the use of these parasitoids for tip moth control.

Figure 9. A Nantucket pine tip moth parasitoid, Campoplex *spp.*

Figure 10. A Nantucket pine tip moth parasitoid, Lixophaga mediocris.

Silviculture. Nantucket pine tip moth populations and damage levels can vary in relation to site and stand characteristics, such as soil type, vegetative competition, and nutrient availability. Infestation levels are higher in planted stands versus naturally regenerated stands, and it is commonly believed that intensive forest management practices such as weed control and fertilization can exacerbate tree damage. Although study results testing this hypothesis are mixed, the totality of the data

indicate that tip moth populations are less stable and fluctuate more drastically in plantations where competing herbaceous vegetation has been controlled through herbicide applications or mechanical site preparation. Research on the effects of fertilization on tip moth damage levels has yielded confounding results. Still, it is recommended that chemical control of tip moth populations be considered in plantations that are managed intensively due to the higher potential for loss of investment caused by growth losses and the potential for severe damage levels in areas with competing vegetation control. Furthermore, longleaf pine is considered resistant to this insect and can be planted in lieu of other southern pine species on appropriate sites.

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Photo Credits

Figures 2, 6, & 7 – Christopher Asaro (VA Dept. of Forestry, Charlottesville, VA); Figures 4, 5, 8, 9, & 10 – Katja Seltmann (NC State University, Raleigh NC); Figure 3 – photographer unknown.

Additional Information

Private landowners can get more information from County Extension Agents, State Forestry Departments, or State Agriculture Departments. Federal resource managers should contact USFS Forest Health Protection (www.fs.fed.us/foresthealth/). This publication and other Forest Insect and Disease Leaflets can be found at www.fs.fed.us/r6/nr/fid/wo-fidls/.

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