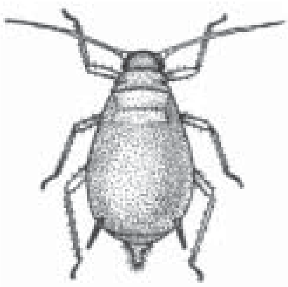
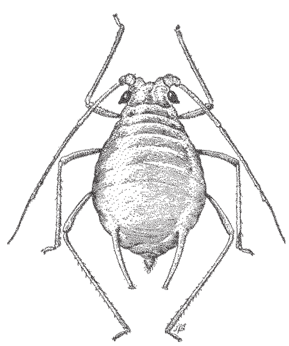
APHIDS. There are five species of aphids commonly found on apples: apple grain aphid, rosy apple aphid (shown below), apple aphid (shown on left), spirea aphid and the woolly apple aphid. The aphid species can be identified by their color, the time of year when they are present and by differences in the cornicles, which are small paired projections from the rear of aphids. Aphids feed on foliage using needlelike mouthparts to suck out plant juices. When present in high numbers, certain species may reduce tree growth and vigor.



Aphids overwinter in the egg stage on twigs, around buds or in bark crevices. **Apple grain aphid** eggs begin to hatch when apple buds are in the green tip stage. This aphid can be identified by its green color, with a darker green stripe on its back. The apple grain aphid can become very abundant on the buds in early spring, but it causes no damage to apples, and it soon migrates to grain crops and grasses for the summer.

Rosy apple aphid eggs complete hatch soon after half-inch green. The adults are pinkish grey, and acquire a powdery white covering. Rosy apple aphids have longer cornicles ("tail-pipes") than apple aphid. Rosy apple aphids feed on fruit and leaf buds, crawling inside the leaf clusters as the buds unfold. Feeding causes leaf curling which begins to show around petal fall. They prefer fruit clusters, and feeding there causes small distorted fruits and sooty mold growth on excreted honeydew. By the time their presence is obvious, they are protected by curled leaves from contact-type insecticide spray. After three generations on apple, they move to a summer host. Narrow-leaved plantain is a key alternate host.



A cool wet spring increases the chance of a rosy apple aphid problem. To monitor rosy apple aphid, check 10 interior fruit clusters per tree on 10 trees per block between bud break and first cover.

Unlike most pest monitoring which is based on random samples, when choosing clusters to check for rosy apple aphid, give preference to clusters that look like they might be infested. Treatment is advised if 1 or more of the 100 clusters are infested. Research indicates that insecticidal control with Lorsban or Vydate is more effective at pink than with later application of Vydate at petal fall or first cover, probably because good coverage is needed for control. **Note that Lorsban is not longer labeled for foliar use after bloom.**

Application of Provado at petal fall has also provided excellent rosy apple aphid control. Cortland, Golden Delicious, Idared, Gravenstein, Jonagold, and possibly Red Delicious, are more prone to rosy apple aphid damage.

Apple aphid eggs complete hatch soon after half-inch green. The nymphs and adults are light green with black cornicles. Usually, they do not become abundant until July, and are found primarily on the succulent foliage of water sprouts and growing terminals. If abundant, they produce large amount of honeydew which falls onto foliage and fruit. The honeydew serves as an excellent growth medium for black sooty mold fungus, which can mar and discolor the fruit surface. Aphid honeydew is relatively easy to wash off.

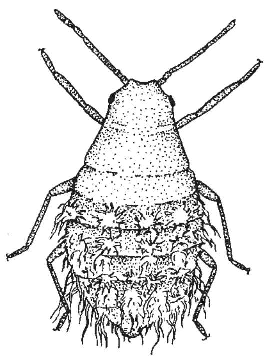
Commercial orchards can tolerate small to moderate populations of the apple aphid, thus there is considerable potential for integrated management of this pest. Excessive and prolonged vegetative growth can lead to an apple aphid problem. Limit nitrogen fertilization to the level necessary for optimum tree growth. Summer pruning to remove water sprouts can also prevent or reduce problems with apple aphids. Several predators destroy apple aphid colonies. Where beneficial species are accounted for in spray decisions, predators typically eliminate the need for chemical control. Syrphid and cecidomyiid fly larvae are the most common aphid predators in New England orchards.

If biocontrol fails, the recommended treatment threshold is if checking at least 10 terminals per tree and 10 trees per block reveals that 50% of vegetative terminals are infested AND less than 20% of the infested terminals have biocontrol agents present. Water sprouts should be included in the sampling in proportion to their presence in the canopy.

Another treatment threshold is if 10% of the fruit show staining from aphid excrement (honeydew). While easily washed off, honeydew can lead to growth of sooty mold fungus and interfere with harvest and pick-your-own marketing.

Spirea aphids are similar in appearance and life cycle to apple aphids, but they may remain active later into the summer, and may have different susceptibility to specific insecticides.

Woolly apple aphids have a complex life cycle that can involve overwintering either on apple or elm. Once on apple, they move to feeding sites on the roots or above ground. Root feeding produces knotty galls, and extensive feeding severely taxes the root system. Unfortunately, the above-ground woolly apple aphid population is not a reliable indication of the root-feeding population. Above ground, the crawlers settle in bark crevices, pruning cuts, wounds, leaf axils, and occasionally the stem or calyx of fruit.

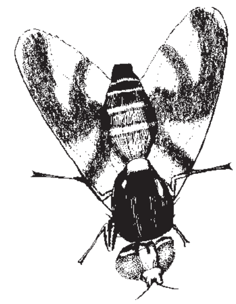


Larger nymphs have a purplish body, concealed by tufts of "wool," which are actually fine wax strands. Wooly apple aphid populations are usually most noticeable in late summer Because of poor correlation of above and below ground populations, there is only a tentative treatment threshold of 50% of pruning wounds or leaf axils infested. A treatment decision should be based on sampling 10 possible infestation sites per tree on at least 10 trees per block.

Provado and endosulfan (Thiodan, Thionex, Phaser) are options for chemical control. As with the other aphids, biocontrol (especially a tiny wasp) plays a key role in keeping populations of this insect below pest status. Insecticide use may result in an increase in woolly aphid numbers. The Malling Merton rootstock series was bred specifically for woolly aphid resistance. MM106 is the most resistant of these.

APPLE MAGGOT (AM)

The first emergence of apple maggot flies ranges from the second week in June to the first week in July. Emergence peaks in mid-July to early August. Red ball sticky traps indicate the timing and degree of apple maggot fly immigration. Use at least three traps per monitored block, starting in early July. For cultivars harvested before and with McIntosh, monitoring can discontinue August 31. For later harvested cultivars, continue monitoring into September.



The recommended treatment threshold is an average of 5 AM flies per odor-baited trap within a two-week period. For unbaited traps, the threshold is an average of 2 AM flies per trap. After treatment, ignore trap captures until insecticide residue is expected to begin losing effectiveness (10–14 days after a full rate application, or two inches of rain). Then clean the flies off the traps and begin counting from zero to see if the threshold is reached again, indicating the need for another treatment.

The life span of a female apple maggot fly is about 30 days. They mate and begin laying eggs beneath apple skin 7–10 days after emergence. The survival rate of the eggs and larvae is low in immature fruit. As apples approach maturity, the survival rate of newly laid eggs and larvae increases greatly. After tunneling for 2-4 weeks, larvae leave the dropped fruit and pupate in the soil.

AM control measures are aimed at the adult flies, because eggs and larvae are protected against pesticide sprays. The adults are active and spend much of their time on leaves and fruit where they feed on honeydew. This characteristic makes AM relatively easy to control with insecticide. Guthion and Imidan kill AM at 1/2 to 1/4 the full label rate. At an even lower rate, Guthion still effectively deters AM egglaying. Reducing the dosage will also reduce the length of residual protection, though not necessarily in direct proportion to the dosage.

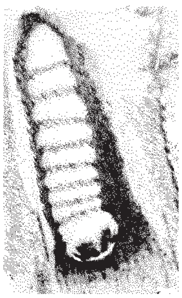
Removing unsprayed apple, crabapple, and hawthorn trees that are near the orchard can help to reduce the local AM fly population.

A trap-out strategy using sticky traps on every perimeter row tree can provide adequate control, but is labor intensive. Trials with insecticide impregnated spheres that greatly reduce the labor requirement for a trap-out strategy have shown promising results.

APPLE PITH MOTH overwinters as a partially grown caterpillar in a small chamber excavated beneath the bark of apple twigs. When growth resumes in the spring, the caterpillar bores into a young shoot, causing it to wilt. The pinkish caterpillar is nearly 1/2 inch long

when fully grown. It pupates inside the twig or shriveled shoot. Occasionally the caterpillars bore into fruit. Adult moths fly in June and July, and lay eggs on new shoots. The newly-hatched caterpillars quickly bore into twigs. They are vulnerable to insecticide at two times: prebloom and late July – early August.

BORERS. There are several species of borers that attack apple trees (especially young trees) in New England. Borers are not normally a problem in orchards where orchard grass and weed growth near the tree trunks is kept in check, close-fitting plastic spiral vole guards are removed at petal fall, and summer insecticide sprays are made for other pests. If there is need, an application of Lorsban applied to the trunk and lower limbs between half-inch green and petal-fall should provide control of the dogwood borer. If fresh borer activity is noted in July, follow up with one additional spray of Lorsban in July or two of Thiodan (early July and early August). Post-bloom applications of Lorsban are described on the supplemental label which must be in the possession of the user at time of application."



Roundheaded apple tree borers (RAB) are striped beetles about 5/8" long that emerge in the month after petal fall. Most egglaying occurs from late June to early August, and usually within a couple hundred yards of the tree from which the female beetles emerged. If possible, remove alternate hosts (wild and crab apple, choke cherry, hawthorn, mountain ash, shadbush) within 100 yards of the orchard.

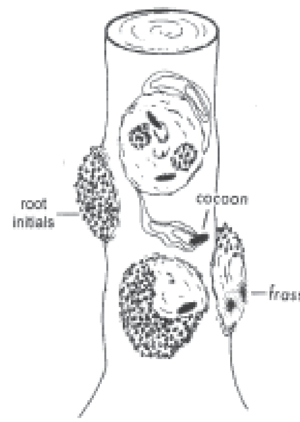
Insecticide sprays made against plum curculio and apple maggot also help control adult RAB as they feed on apple foliage. July and August applications that reach trunks not shielded by vegetation or guards also help control hatching RAB larvae. Without summer insecticide coverage there is increased risk of RAB attack, especially to trees less than 10 years old. Larval tunnelling occurs in the trunk from about 4 inches below ground up to one or two feet above the ground.

Brushing diluted white latex paint onto the lower trunk may deter egglaying. A white coating makes it easier to detect larval tunnels. If feasible, another way to prevent damage is to ring the lower trunk with a loose fitting barrier (mosquito netting, hardware cloth, several layers of newspaper). The barrier should be closed at the bottom with mounded soil, and tied with a cord around the top. Remove barriers after harvest.

September, and again in the spring, are the best times to check trunks above and below the soil line for small pinholes exuding reddish sawdust or dark, sunken areas indicating the presence of boring larvae. Shallow larvae may be dug out with a knife. Larvae in deeper tunnels may be killed with a wire or by injecting a suitable insecticide with a grease gun. Check with Extension for registered materials.

If not removed, or eaten by woodpeckers, larvae tunnel through the trunk until completing the 2–3 year life cycle. Affected trees have poor growth or yellow foliage, and may break off at the soil line. Trees injured beyond recovery should be removed and burned, and nearby trees checked for infestation.

Dogwood borer and **apple bark borer** are both small wasp-like moths that lay eggs in bark crevices, primarily in burr knots and callus tissue around graft unions. The caterpillars are usually less than 3/4 inches long, with an orange tinge. They bore in the bark, not the wood. Reddish frass on the surface indicates infestation. Adults fly from mid-June through late-August, but most activity is usually in July. The life cycle takes one year.

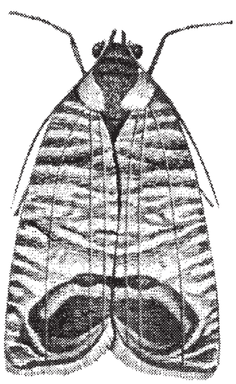


Trees with many burr knots (such as M9) are most heavily infested. Controlling burr knots helps prevent problems with these borers. Plant trees with the graft union not more than 1 to 2 inches above ground. Be careful not to bury scion wood. If trees are already in the ground, soil may be mounded around the trunk in a wide mound (not a narrow cone which may increase winter injury). Avoid shading and increased humidity at the trunk due to weeds, sucker growth, opaque vole guards, or debris trapped in vole guards. Diluted latex paint applied to the lower trunk before egglaying may be an effective deterrent.

Flat-headed apple tree borer adults are dark brown beetles about 1/2 inch long with a metallic luster. They are primarily active in June and July, on the sunny sides of trees. Eggs are laid in bark crevices. The sinuous trails in the bark are visible without cutting into the tree. Eventually, the grubs bore into the wood, leaving tunnels that are oval in cross-section. The grubs are legless, with a broad, flattened head end, and a cylindrical body. Weakened, stressed or strongly leaning young trees are most frequently attacked.

The **leopard moth** lays eggs in bark crevices in July and early August. The larvae bore into the bark and quickly move into the wood. They are usually first noticed because of the moist, fibrous droppings that are pushed out of the tunnel. The caterpillars are white or pink, with a dark head and up to 2 inches long. The life cycle is 2 to 3 years.

CODLING MOTH first generation flight begins around petal fall. Peak flight can be from 1 to 3 weeks after petal fall. First generation eggs begin hatching about the same time as peak flight. Larvae search out fruit and chew through the skin. They either feed briefly beneath the fruit surface or tunnel directly to the core and feed on developing seeds. Considerable frass (excrement) is normally associated with entry holes, which are often near the calyx end. Larval "stings" are shallow holes caused by a codling moth larva taking a few bites but not burrowing. A "sting" causes a surface blemish but does not result in interior breakdown of the fruit. Tunneled fruits usually fall with the "June drop." Upon completing their development in the fruit, some larvae enter hibernation while others pupate and emerge as second generation adults from the latter half of July into September.



Second generation codling moth larvae cause more damage than first generation. However, some damage attributed to second generation codling moth might actually be caused by oriental fruit moth (OFM), lesser appleworm (LAW), redbanded leafroller (RBLR) or obliquebanded leafroller (OBLR).

OFM larvae bore into fruit and may feed near the seed cavity but usually do not consume the seeds. OFM feed more randomly in the fruit than codling moth, which usually tunnel directly to the core and feed directly on the seeds. OFM are more likely to be abundant if there are nearby peach trees. In addition to fruit injury, OFM attack growing shoots as a twig borer, especially on vigorous young trees. It is difficult to distinguish codling moth from OFM and LAW larvae without a microscope. Due to differences in generational timing, insecticidal control that is effective for codling moth can be ineffective for OFM. When this happens, a perceived codling moth problem may actually be caused by OFM. See OFM section for more information.

LAW usually feed less than 1/4" under the skin of the calyx or stem end, and occasionally on the sides of fruit. LAW feeding leaves the skin intact. LAW do not deposit frass at the entrance hole like codling moth. Like OFM, LAW can also feed inside succulent twigs causing leaves on the twig to die and turn brown.

RBLR and OBLR are like LAW in that they feed superficially, and do not tunnel into fruit like codling moth. Unlike LAW, RBLR and OBLR consume the skin, and their feeding damage more frequently occurs on the sides of the apple.

Codling moths usually are infrequent pests in New England because the adults and larvae usually are killed by insecticide sprays made for other pests. Where specific codling moth treatments are needed, insecticide applied when egg hatch begins is the most effective strategy.

Optimum spray timing can be estimated by setting up pheromone traps during bloom to detect the beginning of adult emergence as a starting point (biofix) for degree day accumulation to track egg development. Use at least 2 traps checked twice a week. For best accuracy, check daily and increase the number of traps to 5, with one at each block corner and one in the middle. Hang traps as high as practical in the outer canopy, at 6–8 feet is best, and at least 30 feet way from other pheromone traps. Give preference to the southeast quadrant of the canopy and make sure that the trap entrance is not blocked by foliage.

A trap threshold to indicate need for treatment is not available because there is poor correlation between the number of male moths captured and the number of egglaying females. Guidelines used in other eastern states recommend control if more than 5–14 codling moths are captured per trap per week.

Where a single treatment per generation is sufficient, optimum timing is 360 DD base 50°F after the biofix for first generation, and 1460 DD past the biofix for second generation. If two treatments are needed for first generation, time the first application for 250 DD, with a second application 3 weeks later. Begin second generation control at 1260 DD, with a follow-up treatment 3 weeks later.

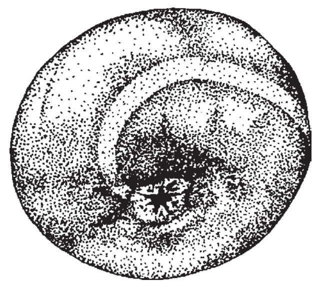
Selective insecticides such as Bt products, Confirm, Esteem and Intrepid may be slightly less effective against codling moth than broad spectrum organophosphate insecticides such as Guthion and Imidan. However, it is likely that these selective materials applied 2–3 times per generation, will provide adequate control in commercial apple orchards that are not located adjacent to abandoned orchards or extensive acreages of unsprayed apple trees. However, since some of these materials have limited contact activity against young codling moth larvae, and are only effective when ingested, they may be more effective if they are applied 5–7 days earlier (i.e. begin at 150 DD past biofix for first generation) than the estimated first optimum application date estimated by the developmental model for each codling moth generation, and using a shorter 10–15 day interval before subsequent applications.

Starting earlier or using a shorter re-spray interval may require a third spray per generation to cover the whole control period. The advantage of the adjusted timing is to ensure that eggs are deposited on relatively fresh spray residues so that hatching larvae are more likely to ingest a lethal dose of the material before entering the fruit.

Removal of unsprayed host trees (wild or abandoned apple or pear, hawthorn, stone fruit and quince trees) within 50 (preferably 100) meters of the orchard, will reduce codling moth immigration. These wild hosts are most easily located around apple bloom time, when they are also in bloom.

CUTWORMS are infrequent pests that can begin feeding on small apple trees as early as bud break. The dull gray or brown smooth-bodied caterpillars often have stripes, spots or splotches of other muted colors. Cutworms typically feed at night and hide in the turf during the day. When disturbed the larvae typically curl up into a ball. Closely mowing groundcover around young trees may reduce the chance of a cutworm problem. Cutworms can remove green tissue as fast as it emerges. They are likely to only reach pest status on young trees that receiving no insecticide coverage. Cutworms can also be a problem on foliage and fruit in late summer, especially where there is high broadleaf weed growth. Endosulfan (Thiodan, Thionex, Phaser) and Bt products are control options.

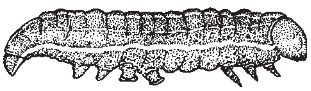
EUROPEAN APPLE SAWFLY (EAS) overwinters as a larva in the soil. It pupates in the spring, and adults emerge during late pink and bloom. Eggs are laid during bloom, at the calyx end of the fruit. Young larvae feed along the surface of the fruit and leave a curved feeding scar, while older larvae bore deep inside the fruit. Mature larvae drop to the soil. Insecticides applied at pink and/or petal fall control this pest. White sticky traps placed before bloom can help determine the need for EAS treatment at petal fall. Traps should be placed near blossoms at head height on the south side of at least one tree per 3 acres. If more than an average of 6 to 9 EAS per trap are captured by petal fall in a block that received prebloom insecticide (or 4 to 5 in a block that did not receive prebloom insecticide), then the cost of a petal fall insecticide is likely to be justified by improved EAS control alone.



Prebloom treatment for EAS is not needed except possibly for blocks where petal fall treatment has historically not given satisfactory control. This could be due to an unusually large EAS population where there is a mixture of early and late blooming cultivars in the block.

EUROPEAN CORN BORER larvae sometimes tunnel in current year's shoots, causing them to wilt. The caterpillars, which are light colored with a dark brown head, have also occasionally been found in the fruit. Typically, this occurs on lower limbs near groundcover, and in blocks near cornfields. Keeping groundcover mowed helps prevent damage.

GREEN FRUITWORMS (GFW). Several species of caterpillars are called by this one name because of their similar appearance, habits and damage to deciduous fruits. *Orthosia hibisci* moth flight peaks around tight cluster. GFW larvae are green with narrow white stripes and speckles along the body. They hatch between tight cluster and pink, and begin feeding on leaves and flowers. Fruit feeding is most likely when the fruit is 6–20 mm diameter. Buds, blossoms, and fruit that are fed upon before petal fall abort. Damaged fruit that remain have deep corky scars and indentations at harvest. There is one generation per year.

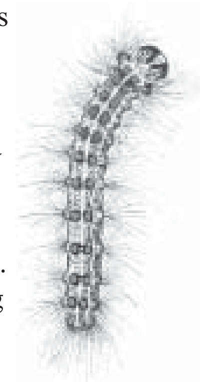


Pink and petal fall sprays directed at other apple pests should also control GFW. Cases of GFW tolerance or resistance to organophosphate insecticides have been reported.

Research indicates that a single petal fall spray provides comparable control to a two spray program at pink and petal fall. Unless extraordinarily abundant, GFW larvae detected prebloom can be left for control at petal fall. An economic threshold is not available, but finding more than one GFW larva per semi-dwarf tree at petal fall, or an average of 0.3 – 0.5 GFW larva per tree in high density plantings (> 140 trees per acre) may be indication that the cost of treatment will be matched by the benefit of damage prevention.

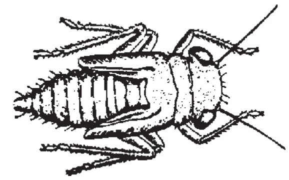
GREEN PUG MOTH (GPM) is a European species common in Nova Scotia, that has now been found in all of the New England states. The yellowish-orange eggs hatch just after bud break. The yellow-green larvae are inchworms that bore into blossom buds to feed, preferring flower anthers. One larva can damage several flowers and where numerous can significantly reduce fruit set. Most larvae finish feeding by petal fall, by which time they usually have a dark red-brown stripe along the back. The moths fly in June and July. Nova Scotia recommends organophosphate insecticide at tight cluster – early pink if there are 6 or more GPM larvae per 100 fruit clusters.

GYPSY MOTH larvae are infrequent apple pests, but can cause harmful defoliation on young trees in the absence of insecticide coverage. Gypsy moth larvae blow into the orchard from nearby infested hardwood trees. Larval feeding first appears as small holes in leaves during bloom, and may cause fruit to have small holes just after petal fall. Larger larvae eat whole leaves, leaving only veins. If abundant, gypsy moth larvae can denude young apple trees of all green tissue in just a few days. Infestation is typically noticed during bloom. If trees are blooming, Bt products can provide gypsy moth larva control without risk to pollinating bees.



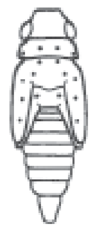
JAPANESE BEETLES overwinter as white grubs in the soil, complete their feeding on grass roots in the spring, and pupate. The first adults typically appear in late June or early July. Sometimes the beetles do enough leaf skeletonizing to cause concern, especially on young trees. Control by Sevin XLR Plus at 8–10 ozs./100 gallons dilute was rated “Excellent” in a West Virginia trial. Some growers have seen woolly aphid outbreaks after using Sevin on Japanese beetles. Lannate 90SP at 4 ozs./100 gals. was rated “Good”. Organic growers have had good results with Surround. Imidan or Guthion applied for apple maggot will control Japanese beetles. However, regardless of what insecticide is used, Japanese beetles are highly mobile and re-infestation can occur.

LEAFHOPPERS: White Apple Leafhopper (WAL). Adult WAL are pale yellowish-white and are about 1/ 8 inch long. They lay the overwintering eggs just beneath the bark surface on 1 to 5-year-old wood. Hatching begins around late pink and is completed by petal fall. The pale white nymphs complete their development on the under surface of older leaves. WAL nymph feeding removes sap from leaves, causing stippling that may coalesce into silvery white patches. Early in the season, extensive leaf damage may affect bud formation. Adult WAL spend less time feeding, and do not probe as deeply into leaf tissue, thus adult feeding is considered less important. Feeding by second generation nymphs and



adults in August and September can cause poor fruit color and preharvest drop. Their excreted honeydew may drop onto fruit and appear as dark colored spots that are difficult to remove. If adult WAL are numerous at harvest, they can be a nuisance to pickers.

Rose Leafhopper (RLH). Some “white apple leafhopper” populations may actually be another species, the rose leafhopper. It is difficult to distinguish between the two species. RLH nymphs have rows of small dark spots on their backs. A magnifying lens may be necessary to see the spots. The spots are easier to see on older nymphs. WAL nymphs lack these spots.



Timing can also be used to distinguish the species. Leafhoppers found during petal fall are most likely WAL. Adults found during late June and July could be either species, (or PLH). Nymphs found in late June and July are likely to be RLH (or PLH). Second generation WAL nymphs are found in August.

RLH have three distinct generations in New England. Many plants in the rose family are summer hosts, including apple, pear, quince, hawthorn, peach, plum, cherry, blackberry, and raspberry. Plants in other families are also hosts, but it seems that RLH overwinters only on *Rosa* species, such as cultivated and multiflora rose. Preliminary research in Massachusetts shows that removal of multiflora rose within 100 yards of an orchard block could reduce the influx of rose leafhoppers by 60–70%.

First generation RLH adults migrate into orchards form nearby multiflora rose bushes in early to mid-June. Second generation adults, present in July and August, confine egglaying largely to orchards. Third-generation adults, present in September and sometimes in very large numbers, can cause extensive excrement spotting of fruit and be a nuisance to pickers before emigrating to rose bushes to lay overwintering eggs.

Potato Leafhopper (PLH) nymphs and adults are pale green. When disturbed, nymphs move rapidly, in a sideways fashion. In contrast, nymphs of the WAL and RLH move slowly and usually straight ahead. Another difference is that unlike WAL and RLH that tend to feed on fruit cluster leaves in inner part of the tree canopy, PLH feed primarily on immature leaves of actively growing shoots in the outer part of the canopy. Leaves injured by PLH feeding turn yellow on the edges, cup upward, and later turn brown or scorched (“hopper burn”).

PLH damage is sometimes misidentified as herbicide injury, nutrient deficiency, or the effect of overfertilizing. PLH feeding can also cause terminal growth cessation or excessive branching around the feeding point. On mature trees, PLH damage may not be significant, but heavily infested young trees can end the season with less than half their expected growth.

PLH overwinter as adults in the southern states and move northward in summer air masses. It is a sporadic pest and its time of occurrence may vary from year to year. PLH has usually been found by mid-June in southern New England.

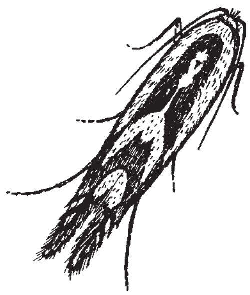
Leafhopper monitoring and control.
WAL and PLH have developed resistance to several organophosphate insecticides. Insecticides are most effective against first-generation young nymphs. Older nymphs and adults are usually less easily killed. Agri-Mek or Provado applied within the first few weeks after petal fall against leafminers will also give prolonged control of WAL and RLH. Sevin or Thiodan is effective for control of young WAL in the first 2 weeks after petal fall, and would control RLH adults and PLH if either species were present.

To monitor first generation WAL, check 10 interior fruit cluster leaves per tree on 10 trees per block. Research in WA and VA showed that an average of 3 first generation WAL nymphs per leaf did not cause a crop effect. This is the basis for a tentative treatment threshold of 3 WAL or RLH nymphs per leaf in June.

However, growers who have had troublesome leafhopper populations at harvest in PYO or other blocks, may want to use a lower threshold of 25 WAL or RLH nymphs per 100 leaves in June. To monitor second generation WAL nymphs and RLH, repeat sampling in early August, using the same tentative thresholds.

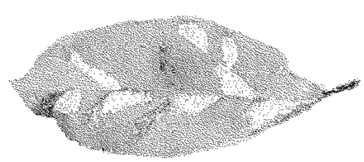
For PLH, sample the youngest shoot leaves in the outer canopy. New York researchers suggest a tentative threshold of an average of one PLH nymph or adult per leaf. There is an exception to this guideline if fire blight is a concern. Unlike white apple and rose leafhoppers, potato leafhoppers do seem to be able to spread fire blight bacteria. If active fire blight infections are present, there should be a very low tolerance for potato leafhoppers.

LEAFMINERS. Two major species of leafminers are commonly found in New England apple orchards: apple blotch leafminer (ABLM) and spotted tentiform leafminer (STLM). For many years ABLM was the dominant species present in commercial orchards in New England, while STLM was found predominantly in commercial orchards to the west and north, and on unsprayed trees. In the past 5 years, many orchards have experienced a marked and rapid shift in leafminer species composition, with STLM apparently displacing ABLM.



Apple Blotch and Spotted Tentiform Leafminers
Both species overwinter as pupae within mines in fallen leaves. Adult moths emerge from the leaf litter and move into tree canopies to mate, generally when trees reach half-inch green to pink. Adult flight and mating activity are most evident on warm, calm evenings when the temperature exceeds 48°F. Adults are primarily active at night. Wind and temperature affect mating and egglaying. Eggs are deposited on the undersides of leaves and hatch 5–16 days later. Egg development varies with temperature, requiring accumulation of about 172 DD base 36.5°F to hatch.

Newly hatched larvae cut their way between leaf layers and feed on foliar fluids, creating sap-feeding mines. The sap-feeding mines appear as small whitish patches on the undersides of leaves.



Fourth and fifth-instar larvae use their chewing mouthparts to bite divots of foliar tissue from inside the mine, resulting in the easily-recognized spotted appearance of tissue-feeding mines.

Both ABLM and STLM usually complete 3 generations per year. First-generation larvae are active from petal fall through June, second-generation larvae from mid-July to mid-August, and third-generation larvae from mid-August through October. Because of the tendency for egglaying and subsequent development of each leafminer generation to stretch out over several weeks, it is often difficult to distinguish between broods. Populations of both species vary greatly between generations, though STLM has shown a tendency in recent years toward more explosive population growth.

Monitoring: ABLM and STLM respond differently to traps and exhibit slightly different timing of emergence and adult flight. If ABLM is the dominant species in the orchard, red sticky rectangle traps offer a reasonable (roughly 80% accuracy) estimate of the orchard population. Thresholds associated with captures on trunk traps can be used to determine whether there is need for first-generation leafminer treatment at tight cluster (TC), pink, and in the first two weeks after petal fall. Red sticky traps should be stapled to the southern side of the trunk, no higher than knee height. For most reliable monitoring, traps should be placed at silver tip (ST), using no less than 4 traps per block. Current ABLM trap-capture thresholds (developed under Massachusetts growing conditions) are as follows:

	Cumulative LM per trap	
Cultivar	**S T to T C**	**ST to Pink**
McIntosh	4	9
Non-McIntosh	8	21

If the orchard has a mixed, unknown, or STLM-dominated population, the red sticky traps may not provide reliable information.

Visual inspection of fruit cluster leaves for presence of sap-feeding mines is a reliable tool for both species. Leaf inspection will indicate if first-generation treatment is warranted and identify proper timing. Early-instar mines are difficult to detect before petal fall, and treatments triggered by accumulation of sap-feeding mines are confined to insecticides labeled for use after petal fall.

Scouting for first-generation sap-feeding mines should begin soon after petal fall. A magnifying lens is helpful as the sap-feeding mines are light colored and can be difficult to see, especially in the early stages. Sample 5 mid-cluster leaves per tree (i.e. neither the oldest or youngest leaves in the cluster), and 20 trees per block, for a total of 100 leaves. Sample leaves should be taken from within 1 meter of the trunk, no higher than chest level, and from different quadrants of the canopy.

The recommended treatment thresholds for first-generation sap-feeding mines in southern New England are 7 mines per 100 leaves for McIntosh, and 14 mines per 100 leaves for non-McIntosh. First-generation mines exceeding these densities are likely to give rise to damaging second and third-generation leafminer populations.

To sample second-generation leafminer, select mid-terminal leaves from both interior and outer portions of the canopy, taking leaves from different quadrants of the canopy. Do not count first-generation tissue-feeding mines when sampling second-generation sap-feeders.

The optimum time to begin sampling second generation STLM mines is 690 DD Base 43°F after the start of the second moth flight. The flight date in your area can be identified by pheromone traps. Use at least two traps set shortly after petal fall. Record trap captures twice a week to insure accurate determination. If flight and degree day information is lacking, consult state newsletter for begin sampling date (typically in mid-late July).

Because second generation is spread out, sampling should be repeated at 150 DD intervals (5–7 days) until 1150 DD have accumulated since the start of second generation moth flight. Three sampling sessions are usually required. The third session can be eliminated if the second session finds very low numbers of mines (see chart).

If second-generation mines exceed 2 per terminal leaf (200 mines per 100 leaves), then treatment is advised. For varieties susceptible to late-season drop or trees under other environmental stress (such as mite pressure, drought stress, foliar burn, or trunk injury), a lower second generation treatment threshold of 1 mine per leaf is recommended.

The following sequential sampling scheme is extrapolated from Cornell University guidelines. It saves time by allowing you to reach a treatment decision before completing a full 100 leaf sample.

If monitoring indicates that the leafminer population poses a threat, it is far more effective to treat against first- or second-generation mines. Treatments against third-generation mines are usually ineffective due to high late-season foliar density (reducing necessary coverage), strung-out leafminer development (reducing the portion of the leafminer population susceptible to treatment on any given day), and negative impacts on building parasitoid populations (reducing biological control).

Spotted Tentiform and Apple Blotch Leafminer Suppression

Naturally occurring biological control agents play a major role in keeping leafminer populations below economic significance. Maintenance of these biocontrol agents through insecticide selection and minimization is an important component of leafminer management. When biocontrol fails, there are numerous pesticide options for leafminer control, falling into three basic strategies: Prebloom treatments, First-generation mine treatments, and Second-generation mine treatments.

Ambush, Asana, Pounce, Thiodan (Thionex), and Vydate can be applied prebloom, targeting eggs and egglaying adults. Intrepid targets the immature stages, and is applied at pink or petal fall. Assail, Provado, Agri-mek, SpinTor or Lannate can be applied from petal fall until sap-feeding mines transition to the tissue-feeding stage. Assail, Intrepid, Lannate, Provado, SpinTor or Vydate can also be used in July, targeting second-generation sap-feeding miners.

Each of these materials has advantages and disadvantages. Growers should cautiously approach the decision to select a prebloom leafminer treatment. Although all of the materials labeled for prebloom use are relatively inexpensive and effective against both leafminer adults and eggs, each of these materials is notoriously hard on beneficial insect and mite species. In addition, the decision to make a prebloom treatment may need to be made before the leafminer situation has fully developed.

Provado, SpinTor, or Agri-Mek application after Petal Fall should provide adequate leafminer control. Agri-Mek and SpinTor require combination

Second generation leafminer sampling

Number of leaves examined	Below threshold, but repeat 2nd or 3rd sample in 5–7 days if # of mines is < or =	Above threshold if # of mines is = or >
For 1 mine per leaf threshold		
30	15	47
40	20	58
50	29 (0)	64
60	51 (1)	64
70	70 (2)	71
For 2 mines per leaf threshold		
30	32	92
40	41	114
50	59 (1)	126
60	103 (2)	127
70	140 (4)	141

If number of mines is equal or below the value in parentheses on the second sample date, then the third sample can be skipped.

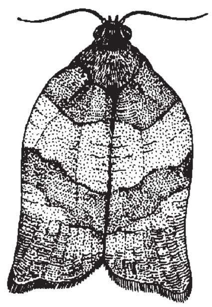
with a penetrating adjuvant for leafminer control. Repeated use of a single material could hasten resistance development in the leafminer population. Lannate is more harmful to beneficial species that the previously listed materials.

For maximum effectiveness with any of these materials, treatment decisions should be based on monitoring of mine density and developmental stage. The best timing for control of first or second generation mines is when sap-feeding mines are visible but before more than 10% of the mines progress to the tissue-feeding stage (when mines become visible on the top surface of the leaf).

Apple Leafminer (ALM). Female moths oviposit in tender new foliage by piercing the undersides of leaves and depositing single eggs inside the leaf tissue. The hatched larvae form serpentine mines, which are visible as wavy brown lines on the tops of the leaves. As the larvae grow, they enlarge their mines into brown blotches. Unlike the other leafminers found on apples, ALM is characterized by frass (small black pellets) that is expelled on a silken thread from the mine by the feeding larvae. Just prior to pupation, larvae spin cocoons, which are suspended by threads and resemble a hammock. ALM has 4 to 6 generations per year in New England.

ALM damage is confined to the youngest foliage, particularly terminal leaves of vigorously growing shoots. Severely mined leaves turn brown, die and may drop prematurely. The potential for damage is greater in young orchards than in mature ones, and vigorous trees sustain higher infestations than do less vigorous trees. Populations normally do not achieve high abundance or cause critical damage until the beginning of the harvest period of our earliest apple cultivars. Insecticidal control at this time may not be a reasonable tactic because of the preharvest interval of most materials. Fortunately, infestations are not known to cause premature fruit drop. ALM do not seem to be controlled by organophosphate insecticides, but apparently are susceptible to the same materials effective against ABLM and STLM. Sprays against ALM may be needed only on non-bearing trees where vigor is essential or on bearing trees that had high infestations the previous season.

LEAFROLLERS. The most common leafrollers found in New England orchards are the oblique banded leafroller (OBLR), and the redbanded leafroller (RBLR). These insects are not usually major pests, but they do cause serious fruit injury in some locations, and may become a problem in low-spray blocks.



Leafrollers are named because of the larval habit of rolling, folding or attaching leaves together.

In New England, leafrollers are usually controlled by insecticides directed at other pests such as plum curculio and apple maggot. Leafroller problems may increase with reduced summer spraying or with pesticide resistance in leafroller populations. See second paragraph of codling moth section for comparison of summer fruit damage caused by leafrollers and other caterpillars.

Adult RBLR emerge in the spring before or soon after green tip, and continue to fly until around bloom. By petal fall, young green or pale yellow larvae begin feeding on the underside of leaves within a web; later they are more likely to move about and feed on fruit. Second flight adults emerge in mid-June to mid-July, with larvae feeding in July and August. There may be a partial third generation in early fall.

RBLR damage on leaves is not significant except as evidence that larval feeding is occurring. RBLR larvae produce a skeletonized band near the leaf midrib or veins. First brood larvae may also web two apples together, causing deep, corked-over scars and deformed fruit. Later broods of RBLR tend to tie a leaf to an apple and feed on the apple under its protection, in a shallow irregular pattern. Damage by the summer broods can be late enough in the season that corking may not occur, leaving exposed tissue which will result in the fruit being discarded.

Yellowish-green OBLR larvae emerge and begin feeding on fruit and leaf buds around early tight cluster. Larvae continue to feed and grow through petal fall. First generation moth flight begins about 3 weeks after petal fall, and second generation eggs appear shortly afterward. Eggs appear as greenish-yellow masses laid on the upper surfaces of leaves, measuring about 1/4 by 1/2 inches. Second generation larvae feed on tender terminal growth, water sprouts or developing fruit. As the larvae grow, they are more likely to damage fruit.

Monitor first generation OBLR larvae during bloom. The optimum time to begin scouting for second generation OBLR larvae is about 600 DD base 43 after the beginning of first generation moth flight. To identify timing for beginning of the moth flight, set at least two OBLR pheromone traps about a week or two after petal fall. Place traps at least 30 feet away from other pheromone traps, and check them at least twice a week. The second generation larvae sampling date is typically about 6 weeks after petal fall, but varies with temperature.

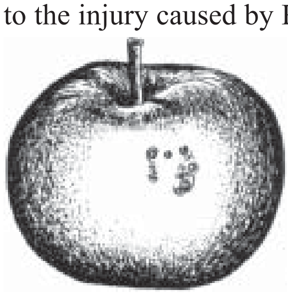
There is no trap catch threshold available for RBLR or OBLR. Larval sampling method and threshold are the same for both generations. Since 1st generation larvae are likely to be controlled by a petal fall insecticide, second generation larvae are a higher priority for monitoring. Check for live leafroller larvae on 10 fruit clusters or vegetative shoots per tree, on 10 trees per block (100 total samples). On trees over 10 feet tall, include some samples from the upper canopy. Include water sprouts as sample terminals. Count the number of infested clusters/shoots, not the number of larvae.

Number of clusters and shoots checked	Below threshold	Above threshold
60	0	3
100	3	4

If the number of infested samples is equal or less than the “below threshold” value, or equal or greater than the “above threshold” value, then a decision has been reached.

If the population is below threshold, a second check is made 3–5 days (100 DD base 43°F) later. This threshold is from New York and has not been tested in New England.

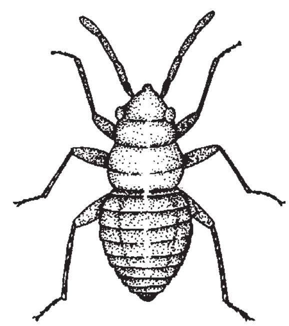
Foliar feeding by OBLR is characterized by rolled leaves with feeding evident on surrounding foliage. Early-season fruit injury usually causes the fruit to abort, but those that remain will have deep corky scars and severe fruit deformation, similar to green fruitworm injury. Later-season injury is similar to the injury caused by RBLR, but is generally deeper and smoother. OBLR has developed resistance to insecticides in NY and elsewhere, and has become a major pest in areas where it has done so. Trees purchased fromm nurseries in states having insecticide-resistant OBLR may be a vehicle for introduction of insecticides resistant OBLR in New England orchards.



Second generation OBLR moth flight begins in August. Late season larvae feed on leaves and occasionally fruit before seeking overwintering sites.

LESSER APPLEWORM (LAW) is a fruit-feeding caterpillar that causes damage similar that of codling moth and oriental fruit moth. See codling moth and oriental fruit moth sections for comparative damage and moth descriptions. Timing of LAW moth flights and larval development are very similar to those of codling moth. Thus, insecticide applications that control codling moth are also well-timed for lesser appleworm.

MULLEIN BUG (MB). Small, green, fast-moving MB nymphs emerge during or shortly after bloom. Red Delicious, Northern Spy, and Golden Delicious are more commonly damaged by MB than McIntosh. Damage is sporadic, but can be extensive when it does occur. The difference in cultivar frequency of damage apparently may be related to synchrony between fruit bud development and hatch date of MB nymphs, and not to a physiological difference in the way cultivars respond to damage. MB damage is more common during unusually warm spring weather that has a relatively greater effect on accelerating MPB hatch than on fruit development. That is, damage is more likely when MB hatch occurs early (during bloom) relative to fruit initiation.



Damage appears shortly after petal fall as small depressed corky areas, raised dark pimples or misshapen fruit. MPB damage can be distinguished from tarnished plant bug injury by being more cultivar-specific, and resulting in multiple wounds per fruit, raised bumps, and less of a conical dimple.

Knowing block history is a key factor in managing MB. Damage in the block last year is cause to be concerned this year. A high aphid population during the previous late summer and fall, and the presence of numerous mullein plants near the orchard, are two factors that may increase the local MB population. Research in NY has found correlation between fall pheromone trap captures of MB adults with nymphal populations the following spring. This research may lead to a fall trapping threshold that identifies which blocks are likely to have a threatening MB population the following spring, in which case a pink insecticide application would be advised.

Part of the difficulty in predicting MB hazard is that in addition to population density, spring weather conditions seem to play a role in whether or not this species reaches pest status.

MB may not be killed by the insecticides usually used at petal fall: Imidan or azinphosmethyl (Guthion). Where there is risk of MB damage, monitoring is advised and must be done in a timely manner. When MB hatch coincides with high fruit vulnerability, there can be only a few days to assess MPB abundance before damage accumulates.

A limb-tap sample taken just before the petal fall spray may be late enough for most of the MB nymphs to have emerged (and late enough so that the number of petals falling onto the collection sheet will be minimized), yet early enough so that, if necessary, MB can be factored into the petal fall spray decision. Where MB are over threshold, a delay in the petal fall spray is not recommended because additional damage may accumulate with each day of delay. As fruit diameter expands after petal fall, control to prevent more MB damage may not be that advantageous as the fruit may be growing beyond the susceptible stage anyway.

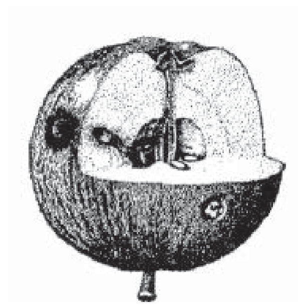
One optimum sampling date estimate is at 275 degree days, base 50°F from March 1, but has not been validated in New England. With cool weather, the optimum sample date may occur well after petal fall. This may suggest a lesser MB threat in that year due to lack of synchrony between MB hatch and fruit initiation, though this relationship is only speculative.

The limb-tap sample method is to jar a **minimum** of 20 limbs per block over a tapping tray. A piece of cloth, two feet on a side with cuffs in the corners, can be spread by two crossed wood slats to make a light and portable tapping tray. Trays are available from IPM suppliers. The MB nymphs are roughly the same size, shape and color as green apple aphid and apple sucker, but MB are much more mobile than these species. MB can be distinguished from aphids with a hand lens by looking for the wing pads and four-jointed antennae which MB have but aphids do not.

The action threshold used in Nova Scotia (where MB, and brown apple bug are more regular pests) is 8 MB nymphs dislodged per 20 limbs tapped. It is not possible to directly translate this threshold for New England because of the need for plum curculio control (which is not a regular problem in Nova Scotia). The choice in New England is likely to be about which insecticide to use at petal fall.

Provado, Lannate, dimethoate (Digon), and Asana are reported by various sources to effectively control MPB. (NH growers note that labels for these products do not name mullein plant bug as a target pest). Of these choices, Lorsban may be the best choice for controlling both MPB and plum curculio with the minimum detriment to beneficial insects and mites.

Where MPB is a threat, application timing is critical for damage prevention regardless of which insecticide is chosen. Ironically, MPB is a beneficial mite and aphid predator during late spring and summer.



ORIENTAL FRUIT MOTH, (OFM) has recently become more important as a pest of apples in eastern North America, particularly from late season infestations. The causes for this are not known, but could involve increased frequency of OFM populations resistant to commonly-used organophosphate and carbamate insecticides, or OFM buildup in orchards receiving fewer insecticide treatments under IPM.

First generation larvae bore into apple shoots, much as they do into peach terminals. Second and third-generation OFM larvae bore into fruit.

Fruit injury appears very similar to that of injury caused by the closely related codling moth and lesser appleworm. OFM larvae consume fruit flesh near the surface. Unlike lesser appleworm, but like codling moth, OFM larvae bore toward the center of the fruit, leaving a brown tunnel in their wake. See the codling moth section for diagnostic comparisons of summer fruit damage caused by various caterpillars.

The only way to distinguish between OFM and codling moth larvae is to use a magnifying lens to look for an anal comb on mature larvae. OFM and lesser appleworm larvae have an anal comb, codling moth larvae do not. The comb is a small dark fringed appendage on the bottom side of the last abdominal segment.

The timing of moth flights and egg hatch for OFM generations are different than codling moth, and require different timing for optimum control. First generation OFM adult emergence typically begins in late-April or early-May and peaks around pink bud stage. If no prebloom insecticide is used, early hatching OFM larvae may have escaped control by the time insecticide is applied at petal fall. The second generation OFM flight typically starts in early July, and 2-3 weeks earlier than the start of second generation codling moth flight. Thus, second generation OFM larvae may hatch in a low-insecticide period after depletion of protection against plum curculio and before sprays for apple maggot. Third generation OFM flight typically does not start until mid-August, and generally peaks in late-August into September, about two weeks later than the peak of the second generation codling moth flight. As with the previous OFM generations, the timing for third generation OFM can also result in larvae hatching when late season insecticide coverage is depleted.

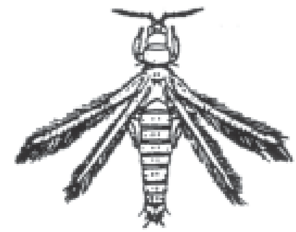
Harvest sample surveys of internal caterpillar in other eastern states have found that OFM are frequently more prevalent than codling moth.

Optimum timing for OFM control can be determined with OFM pheromone traps. Use at least 2 traps per orchard, hung at 6–7 feet high in the northern or eastern quadrant of the tree canopy. If insecticide application targeted against OFM is needed, optimum timing is 200 DD base 45°F after the start of each generation's flight, with a follow-up treatment another 200 DD after the first.

Block history is the best guide to determine need for control. A treatment threshold based on pheromone trap catches is not available for New England apples. Based on guidelines from other eastern states, catching more than 6–14 OFM per trap per week is a tentative "level of concern".

OFM pheromone traps may also catch closely related lesser appleworm moths. OFM and lesser appleworm moths are both about 1/4" long, but OFM are slightly bigger, with slate-gray mottled wing colors. Lesser appleworm moths are dark with gold patches on the wings and head.

PEAR THRIPS are only rarely noticeable as an apple pest, but when numerous, their feeding on apple blossom clusters can cause decrease in fruit set. Adults begin feeding inside buds around the green tip stage as buds open. Adults are about 1 mm long, slender and brown with fringed wings. They look like little pencil marks that wiggle.



As leaves peel back from the thrips-damaged buds, they may be misshapen or brown at the tips. During tight cluster thrips adults are able to enter the flower buds, where they begin to feed on petal tissue and the fruit calyx. This is the most commonly seen and generally most severe injury. As soon as the pink tissue starts to unfold, damage is seen as shriveling and discoloration of petal tissue, which has two effects: damaging the fruitlets directly and reducing the overall quality of the flower, so that it is no longer attractive to pollinating insects. Damaged flower buds are shriveled or browned, and may fall off.

To monitor thrips, cut open buds from green tip through early pink. Prompt treatment is recommended if you find 3 or more thrips per bud. A green tip oil application suppresses egglaying adults, and pear thrips are susceptible to most prebloom insecticide applications.

PLUM CURCULIO (PC) weevils are about 3/16 inch long with a long snout. They are dark brown-black with flecks of grey on a bumpy back. The adults overwinter in leaf debris in nearby woods and hedgerows, and in the orchard. PC begin migrating to apple trees during bloom, but peak migration usually occurs from petal fall to 14 days after petal fall. Egglaying and feeding damage can occur as soon as the fruit begins to form, continuing until the apples are about 1.5 inches in diameter. Most infested fruits drop in June. Fully grown larvae leave fruit and enter soil to a depth of 1 inch and pupate. Adults of the next generation emerge about 50 days after the eggs were laid in June. The adults feed on maturing apples until they seek hibernation sites.

PC move down to the orchard floor during the day and during cool, windy weather. Thus, limb tapping that finds no weevils does not guarantee that they are not present. To monitor the

beginning and continuation of PC egglaying activity, check fruit on border row trees (especially near woods) for fresh damage. Damage appears as small crescent-shaped egglaying cuts and small hollowed-out feeding cavities. Fresh scars show no shriveling of the skin edges, no browning of the flesh at the cut, and no crusty exudate.

Search as high as is practical in the tree. Damage may be heavier in trees pruned in April or May, compared to trees pruned earlier or not at all. Removing unsprayed plum, hawthorn, and native crabapple trees from near the orchard will reduce the threat of PC damage, especially the threat of egglaying damage 3 weeks or more after petal fall.

Insecticide for PC control is typically applied at petal fall, first cover, and (depending on block history, scouting, and weather) second cover. Research on whether adding an insecticide application at pink stage reduced PC fruit damage as compared to the normal postbloom-only treatments found mixed results. Pink application may be worthwhile in blocks with a history of early PC damage due to mixed cultivars that reach petal fall at different times, making prompt petal treatment for the earliest blooming cultivars difficult.

Surround (kaolin clay) appears moderately effective against plum curculio when applied with excellent coverage on a weekly basis to the whole block. See notes on insecticides and miticides.

If populations of other pests at petal fall are below threshold, and if there is not a history of PC damage, it may be possible to delay the first postbloom spray. Unusually cool weather during bloom and petal fall can delay the peak threat from plum curculio, and extend the duration of the threat. Not using a petal fall spray requires careful daily monitoring of plum curculio activity and attention to forecast weather. Plum curculio damage to fruit can begin abruptly, and extensive damage can occur in a single night. If the temperature exceeds 70^{o}F for 2 days before petal fall, females may be ready to lay eggs at petal fall. Humid, calm, warm evenings (especially if the temperature is above 70^{o}F), pose the greatest risk. The risk of plum curculio damage increases after there have been 3–4 days of average temperature of 55–60^{o}F, or 2 days with maximum temperatures above 75^{o}F, after petal fall.

The most conservative approach is 2–3 full block applications. An intermediate approach is to start with a full block insecticide application right at petal fall, and then continue with border row treatments as needed to maintain effective residue on trees at risk of attack. The border row treatment(s) should include two rows around the perimeter of the block, and spraying into end row trees as far as possible from one side of the sprayer.

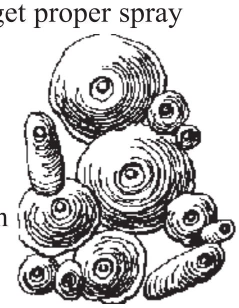
Where the PC threat is low, if weather at petal fall is not conducive for PC activity, a border treatment might suffice for the first application, with the decision of full-block or border-row for subsequent applications depending on weather and block history.

The choice of border row-only protection for any PC treatments has to consider need for full block coverage for other concurrent pests, such as European apple sawfly and codling moth.

Research in New York found that degree day (DD) accumulation is a useful predictor of how long protection is needed against plum curculio. The model is based on field trials that found negligible plum curculio egglaying damage where insecticide protection was maintained from petal fall until 340 DD base 50^{o}F (Baskerville-Emin method) had accumulated after petal fall.

The DD model gives growers a guideline for making decisions about a final insecticide spray for plum curculio protection. It is important to note that this model assumes that all PC that immigrated prior to the 340 DD point have been killed by earlier insecticide coverage. Thus, combining the DD model with border row-only treatments could result in an unacceptable level of damage. Unless there is virtually no history of significant PC damage in the block, at least one full block application is recommended before basing final PC spray timing on the DD model.

SAN JOSE SCALE (SJS) is most commonly a problem on trees which do not get proper spray coverage. SJS overwinter under protective scales on twigs and branches. At bloom, the males emerge and fly to the females, which remain immobile. Tiny bright yellow oval crawlers hatch roughly 3 to 5 weeks after petal fall. (300–350 DD base 50°F after first catch of SJS in pheromone trap.)

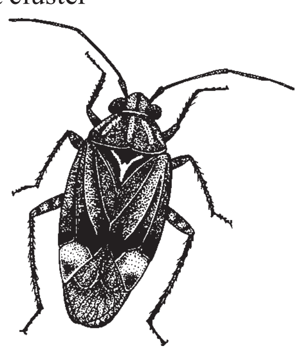


There are 2 or 3 generations a year. SJS infestations are easily detected by examining the fruit at harvest. SJS on the fruit are surrounded by reddish rings. Heavy infestation can stress the tree, causing thin foliage, dying branches, and eventually tree death. Esteem can be effective as a delayed dormant treatment, and applying it with oil may improve effectiveness. Alternatively, oil can be applied at half inch green, and an insecticide directed against postbloom crawlers. Esteem, Guthion (azinphosmethyl), Imidan and Provado are effective against SJS crawlers. Distance can be used on non-bearing trees. Black tape, wrapped around infested limbs (sticky side out, or covered with a thin layer of Vaseline) is an effective tool for monitoring SJS crawler activity.

STINKBUGS There are several species of stinkbugs that feed on apples in New England, but brown stinkbug may be the most common. Adults and late instar nymphs are nearly 1/2 inch long. Stinkbugs seem to be late summer pests. The long piercing-sucking mouthparts make deep punctures that create corky flesh under the surface. The puncture is difficult to see, even with a lens. Usually each puncture is surrounded by a small greenish area that is slightly sunken. This injury should not be confused with cork spot, which usually occurs around the calyx end.

TARNISHED PLANT BUG (TPB) overwinters as an adult and becomes active as the weather warms in the spring. Adults feed on apple fruit buds or fruit from the time of bud swell until about petal fall, but fruit dimpling and scabbing is caused primarily from tight cluster to petal fall. Feeding before tight cluster causes flower bud abscission.

TPB populations vary considerably between blocks. White sticky traps placed at silver tip can help determine the need for prebloom TPB treatment. Traps should be stapled to stakes or hung on low branches at no higher than knee height near the orchard perimeter. Use at least one trap per 3 acres, with at least 3 traps per monitored block.



Cumulative TPB per trap thresholds

	Silvertip to Tight Cluster	ST to Pink
Wholesale	3	5
Retail	5	8

Control may be enhanced by applying insecticide on a warm, sunny, calm day when TPB are most active.

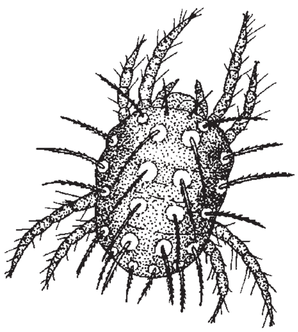
Destroying broad leaf weed hosts (such as mullein, pigweed, and golden rod) in and around the orchard in the fall may decrease the overwintering TPB population. To improve TPB control, avoid mowing or using herbicide between pink and petal fall because disturbance of alternate hosts in the groundcover may cause TPB to move up into apple trees. If dandelion removal before bloom is necessary, applying insecticide application at pink immediately before the dandelion removal may effectively control TPB that are flushed up into the trees.

A non-pyrethroid insecticide rated as poor for TPB control may nevertheless provide adequate control of a moderate TPB population. Pyrethroids are rated as good for TPB control, but pyrethroid use is likely to have a long-lasting devastating effect on mite predators. The eventual disadvantage in terms of mite outbreaks can be greater than the benefit from improved TPB control. For this reason, use of pyrethroid insecticides in apple orchards is discouraged.

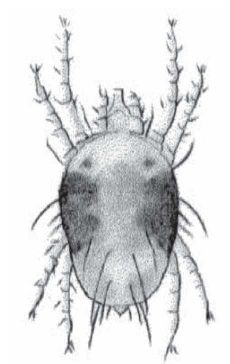
Apparently because of local systemic activity, dimethoate applied at half-inch green or tight cluster provides better control than other organophosphates, and can be an effective control where TPB damage has repeatedly been a significant problem.

MITE PESTS

EUROPEAN RED MITE (ERM) overwinter as eggs on rough bark areas of small limbs and fruit spurs. Egg hatch begins at tight cluster, is about half complete by pink, and is complete by petal fall.



TWOSPOTTED SPIDER MITES (TSM) overwinter as mature females on the lower portion of the tree trunks or in orchard groundcover. First immature stages of each species have only 6 legs, but all other stages are 8-legged. TSM become active before bloom but usually remain on bindweed and other weed hosts beneath the trees into June. As the TSM population increases and host plant quality declines or is disrupted by groundcover management, TSM begin moving into apple trees.



There are multiple ERM and TSM generations per year. The number within a season varies with temperatures. ERM require 40 days to complete a generation at an average temperature of 55^{o}F, but only 10 days at 75^{o}F.

Both ERM and TSM are indirect pests that feed by extracting leaf sap. A severe infestation can cause leaf bronzing, reduced photosynthesis, fruit size reduction, preharvest drop, poor fruit coloring, and reduced crop potential for the next year.

There are many beneficial insect and mite species that prey on pest mites (see Table 8). Because ERM and TSM are foliar feeders and do not damage fruit directly, low populations can be tolerated. This creates an opportunity to benefit from biological control, and to limit miticide use to situations where ERM or TSM have become too numerous for timely control by their natural enemies.

Minimizing the use of pesticides that are harmful to mite predators is critically important in order to conserve and benefit from biological mite control. Until research demonstrates the efficacy of mite predators purchased for release, it is recommended that growers rely only on naturally occurring populations.

MITE THRESHOLDS: Mite injury is most likely to be significant in the weeks following petal fall. It is critical that mites not be allowed to build up during May and June, when the trees are most sensitive to even relatively low numbers of mites (2 to 5 per leaf). Thorough application of prebloom oil, Apollo, or Savey should keep mites below damaging levels during this critical period.

From July on, apple trees can withstand much higher levels of mite activity. Accumulations of 500 to 750 mite days (1 mite day = 1 mite per leaf for 1 day) have not caused any apparent damage to fruit in field experiments. This would be the equivalent of 5 mites per leaf for 100 days or 20 mites per leaf for 25 days. In many cases, this summer injury threshold will not be reached. It may be best to wait until it is clear that withholding a miticide will result in a buildup of mites over the injury threshold before taking action. Often, mite predators or rainy cool weather will help keep mite populations below the injury threshold.

Consult your state Extension guidelines on mite monitoring and action thresholds. If the threshold is reached, but there are more eggs than active mites present, it may be better to delay application until 50% of the eggs have hatched. Miticide application is more effective if most of the mites are in the immature nymph stage. Adults and eggs are harder to kill. In addition to assessing the need for treatment, regular mite monitoring can help determine the timing for optimum control.

MITE MANAGEMENT

Biological control of mites via predators is the best long-term solution to mite management. Unsprayed apple trees rarely have problems with pest mites due to the presence of a complex of predators that achieve biocontrol. Mite problems in commercial orchards arise from the use of insecticides, fungicides or miticides that disrupt biocontrol, either by killing predators outright or adversely affecting some aspect of predator physiology, such as their ability to reproduce. Growers who adjust pesticide selection to maximize the potential for mite predator buildup may find they no longer need to use any miticide beyond prebloom oil sprays.

Amblyseius fallacis is a predatory mite that is widespread in New England. Unfortunately, cold winter weather usually takes a heavy toll on *A. fallacis*, reducing it to low numbers by spring. *A. fallacis* populations build slowly until late July. However, in orchards not receiving predator-harmful insecticides or fungicides, *A. fallacis* often controls mites well from mid-summer onward.

Presently, some New England orchards have significant numbers of the predatory mite *Typhlodromus pyri*, which is capable of providing excellent season-long biocontrol of pest mites, even during spring and early summer. The major obstacle to establishment and spread of released *T. pyri* is use of pesticides having adverse effects. Synthetic pyrethroid insecticides in particular have prolonged adverse effects. EBDC fungicides and ziram prevent hatch of *T. pyri* eggs. Because *T. pyri* lay few eggs before bloom, it is safe to use EBDC or ziram fungicide before first bloom. With established populations of *T. pyri*, there is no evidence that EBDC use leads to mite outbreaks; however, it has not been possible to establish a self-sustaining *T. pyri* population where EBDCs are used after bloom.

T. pyri are able to survive periods of fairly low ERM populations by feeding on alternative foods such as pollen. From this population stability, *T. pyri* can prevent ERM population outbreaks from developing.

Where a natural population is not present, *T. pyri* can be introduced to orchards by four methods: 1) transfer winter prunings 2) transfer flower clusters at pink or bloom 3) transfer leaves or fresh summer prunings 4) transfer burlap-lined tree bands. In the last method, bands are placed on donor trees in early September, removed in early December and specially stored, then placed on inoculation trees in the spring. Details on these methods are available in Cornell IPM publication #215.

Populations of generalist insect predators such as ladybird beetles, lacewings, minute pirate bugs and other species also contribute to pest mite biocontrol. Populations of these species are reduced by orchard pesticide applications. Some materials are much more harmful than others in this regard. See Table 17 – Pesticide Toxicity to Selected Predator Species.

Early Season Miticides
(Green Tip to Second Cover)

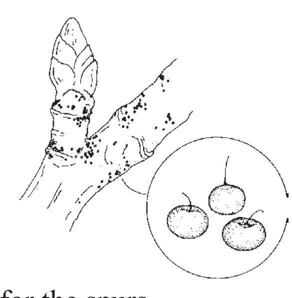
While progress is being made in biocontrol, at present growers still have to rely on some form of pesticide application (even if just oil) to prevent pest mites from reaching damaging numbers. Where insecticides or postbloom fungicides deleterious to mite predators are not used, and where the number of overwintering European red mite eggs is moderate, a prebloom double oil program alone may provide sufficient mite suppression until biocontrol agents exert their influence. Each of the two applications in a double oil program should be made at a rate effective at that bud stage (i.e. 2–3 gals. oil/100 gals. dilute at Half-Inch Green, 1–2 gals. oil/100 at Tight Cluster, 1 gal. oil/100 at early Pink).

Regardless of what subsequent tactics are used, prebloom oil application reduces the overwintering European red mite population, thus increasing the prospects for prolonged suppression below threshold. By reducing the number of mites exposed to a chemical challenge, preceding miticide with oil should also help delay resistance development. Prebloom oil also provides some control of other pests such as San Jose scale and rosy apple aphid.

Ideally, a decision on whether to apply Apollo, Savey or Agri-Mek would be made in conjunction with sampling information on the mite population density. However, it is very difficult to obtain a reliable estimate of mite population density when they average less than 1 per leaf from prebloom to petal fall. Populations reaching or exceeding 1 per leaf during this time merit strong consideration for treatment with Apollo, Savey or Agri-Mek.

A sampling system to evaluate density of overwintering European red mite egg (ERM) density is used in Nova Scotia. The sample unit is 3 cm of two-year-old spur wood that is at least 2 cm diameter. Minimum sample size is 30 spurs. Each spur is scored according to the number of ERM eggs present. Careful inspection is required when eggs are not plentiful.

Number of ERM eggs on 3 cm of spur wood	**Score**
0	***0***
1–10	***1***
11–50	***2***
51–100	***3***
> 100	***4***



Calculate the average score for the spurs. Prebloom suppression is advised for if the average score of 0.1 or more. An average score of 1–2 is transitional. Suppression in addition to prebloom oil is advised if the average score is 2.0 or more. This system has not been evaluated in New England.

If it appears from previous-year's experience, early-season sampling, or plans to use pesticides detrimental to predators, that some miticide in addition to prebloom oil will be needed, then the following options will provide best mite control with least adverse effects on predators:

– Apollo or Savey with or without oil at tight cluster or pink stage;

– Apollo, Savey or Agri-Mek with oil (or another suitable adjuvant) in the first two weeks after petal fall.

These options are about equal in effectiveness, providing control at least through mid-July. None of them appears effective against apple rust mites. Agri-Mek controls leafminers and leafhoppers in addition to mites. Timing Apollo or Savey application after bloom will likely provide control later into the summer than prebloom timing. Carzol is another option until Petal Fall, although it will not provide prolonged suppression, is more detrimental to beneficials, and European red mites in some orchards are resistant.

Postbloom mite monitoring

Postbloom mite thresholds increase as the season progresses. Mite feeding is most damaging, and thresholds are lowest, early in the postbloom period when next year's fruit buds are developing. Also, as days-to-harvest decreases, it takes a higher mite density to reach the same total seasonal mite-days (average number of mites per leaf X number of days) that determines the degree of damage to foliage.

Mite thresholds recommended in MA and ME vary slightly, but the differences are negligible. Both are adapted from Cornell guidelines:

MA mite thresholds	
May 15 – May 31	30%
June 1 – June 15	45%
June 16 – June 30	55%
July 1 – July 15	65%
July 16 – August 15	80%

ME mite thresholds:	
Petal Fall – June 15	30%, or 1 mite/leaf average
June 16 – July 15	54%, or 2.5 mites per leaf
July 16 – August 15	73%, or 5 mites per leaf
August 16 – 31	83%, or 7.5 mites per leaf

The following sequential sampling scheme to allow reaching a monitoring decision without having to take a full 100 leaf sample is also adapted from Cornell recommendations.

	Number of leaves with mites		
Number of leaves examined	column 1 **Far Below threshold**	column 2 **Below threshold**	column 3 **Above threshold**
Threshold points for 30% threshold (1 per leaf)			
40	—	5	23
50	—	7	26
60	—	10	30
70	—	12	30
80	—	16	30
90	—	19	30
100	—	30	30
Threshold points for 54% threshold (2.5 per leaf)			
40	8	16	31
50	12	21	37
60	15	26	43
70	19	31	50
80	23	37	55
90	26	42	55
100	36	54	55
Threshold points for 73% threshold (5 per leaf)			
40	13	25	37
50	19	32	45
60	24	39	54
70	29	46	62
80	34	53	70
90	39	60	74
100	52	73	74
Threshold points for 83% threshold (7.5 per leaf)			
40	18	29	40
50	25	37	49
60	31	45	58
70	37	53	67
80	44	62	84
90	50	70	84
100	63	83	84

Interpretation:

column 1 – If the number of infested leaves is less than or equal to the number in column 1, the mites are below threshold and resampling can wait for 11-16 days (depending on temperatures).

between columns 1 and 2 – If the number of infested leaves is greater than column 1, but less than or equal to the value in column 2, the mites are below threshold now but need to be resampled in 6–10 days (depending on temperatures).

between columns 2 and 3 – If the number of infested leaves is greater than column 2 and less than column 3, more leaves must be examined to decide if the mites are above or below threshold. A decision is always reached if sample size reaches 100 leaves.

column 3 – If the number of infested leaves is equal to or greater than the value in column 3, mites are above threshold for this time of year and prompt treatment is recommended.

Postbloom mite suppression tactics

A succession of two or three summer oil sprays beginning at petal fall may give reasonable season-long suppression if the mite population is not too large at petal fall and if the mite predator population has not been decimated by pesticide sprays.

Acramite and Pyramite are best reserved for use as rescue materials to reduce an over-threshold European red mite (ERM) population in late June, July or August. Pyramite is less effective on twospotted spider mites (TSM). Vendex and Kelthane are other options for summer treatments for ERM and TSM suppression. Vydate is not as effective on ERM as the other materials mentioned above, but paired Vydate applications may provide suppression, and would also control leafminer. In recent tests, Vendex, Agri-Mek and Vydate gave good TSM control. However, consideration of Vydate has to include its greater negative impact on beneficial species than other miticide options and its potential to thin fruit if used within 30 days of petal fall. Agri-Mek applied more than 6 weeks after Petal Fall is much less likely to offer prolonged control.

Conserving beneficial arthropods

Prebloom oil, Apollo, and Savey do not cause substantial negative effects on mite predators. Agri-Mek and summer oil have moderate impact on predatory mites. Pyramite at field use rates has low impact on *T. pyri.* Pyramite adversely affects insect predators of mites, but not to the extent that their populations cannot rebound. Kelthane and Vendex are less detrimental to predatory insect and mite species than Pyramite. Vydate has the most detrimental impact of the summer miticide options.

Preventing resistance

Pest mites can develop resistance to all currently registered miticides, except possibly oil. Growers can reduce the chance of resistance in their blocks by conserving biological control species, using miticide only when the economic threshold is exceeded, and by switching to a different miticide for each application.

Preserving the susceptibility of pest mites to the available miticide options is an essential part of a mite management strategy. Apollo and Savey have similar modes of action and should be considered interchangeable in trying to prevent resistance development. Reports from other countries show that resistance has occurred after only 3 consecutive years of using Apollo or Savey, and after only 4 consecutive years of Pyramite use. The situation with Agri-Mek is less clear, but it is reasonable to assume that mites can develop resistance to it also.

Poor results from Vendex in some locations are assumed to be caused by cross-resistance caused by previous frequent use of cyhexatin (Plictran), a chemically-related material. Pest mites in some New England orchards have developed reduced susceptibility to Kelthane. There are no known cases of mite resistance to oil. With any of these materials, proper dosage and thorough coverage with high water volume application are required for best effect.

All miticides (except oil) should be rotated to minimize the frequency of use for each material. For Apollo and Savey in particular, it is highly recommended that growers alternate with other strategies so that a member of this pair is used no more frequently than once every other year in the same block. Experimental evidence suggests that resistance to Kelthane is not stable, and that susceptibility returns to a European red mite population if it is not exposed more frequently than once every 4 years.

Strategy. A successful mite management strategy is based on multiple tactics.

- Maximize benefit from early season suppression. Apply oil as close to dilute as feasible. Use prebloom chemical miticide as needed.
- Maintain groundcover, tree, and fruit condition to reduce susceptibility to the negative effects of mite feeding on foliage.
- Make use of available cultural and biological controls for orchard pests. Restrict pesticide applications to situations where scouting observations or other information indicates need. Use spot or border treatments whenever possible.
- Use frequent and structured mite scouting to detect a mite problem as it is developing. Frequent scouting allows treatment before the majority of pest mites become fully mature and less susceptible, and before they can lay a full batch of eggs for the next generation
- Give preference to materials with low hazard to beneficial species when pesticide is needed.
- Apply miticide when needed in a manner that maximizes the likelihood of successful mite suppression. Specifically, use high volume/low concentrate sprays (1X–3X spray concentration) from accurately calibrated equipment, proper dosage, and appropriate adjuvants, during good application weather, and drive at atractor speed that favors good coverage. It is also important to pay attention to potential effects on miticide performance of other materials in the tank .