MID ATLANTIC APPLE PEST MANAGEMENT STRATEGIC PLAN - 2003

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MID ATLANTIC APPLE
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Dr. Jim Kotcon - Nematology

Mr. Bill Grafton – Wildlife Management

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EXECUTIVE SUMMARY

Pest Management Strategic Plan Priorities

	RESEARCH
1	Evaluate new products for pests where effective and/or economical options are lacking or threatened.
2	Improve and validate disease prediction models for the mid-Atlantic region.
3	Develop and evaluate tactics to manage deer.
4	Conduct studies on biology, monitoring, and management of emerging pests, including mullein bug, European apple sawfly, borers, and stink bugs.
5	Develop economically viable alternatives to 2,4-D for broadleaf weed control.
6	Determine efficacy, use protocols, and economics of pheromone mating disruption technology for lepidopteran pests.
7	Study role of biocontrol agents and evaluate new products for impact on predators and parasites.
8	Develop resistance management strategies.
9	Develop and test new chemistries and refine use of existing chemistries as alternatives to products at risk of resistance and/or potentially limited by regulatory concerns.
10	Monitor fungicide resistance and improve resistance management strategies for apple scab, rots, and fire blight.
11	Evaluate relative susceptibility of new apple varieties and rootstocks with the goal of improved disease and insect resistance in horticulturally attractive varieties.
12	Study weed population shifts and resistance.
13	Develop and evaluate cultural practices for the reduction of disease inoculum, especially for apple scab and rot diseases.
14	Develop alternatives to methyl bromide.
15	Develop effective perennial weed management programs.
	REGULATORY
1	Register new products identified as efficacious for key pests.
2	Address internal worm tolerance issue.
3	Enact legislation to address abandoned orchards.
4	Enact legislation for more effective deer management.
5	Update export protocols to reflect current pesticide registrations.
6	Register fluazinam for summer disease control (registered on peanuts but not for apples) - IR4 request is in but not from mid-Atlantic region.
7	Provide clarification of label language between State regulatory agencies and EPA. For example, enclosed cab statement, ASAE standards.
8	Register alternatives to methyl bromide.
9	Adopt proposed changes and adjust endangered species part of Section 18 applications so that it doesn't have to be resubmitted each year.

EDUCATION	
1	Train growers, consultants, agents, and industry field reps on identification and biology of pests and natural enemies, and use of new monitoring and management strategies.
2	Make available in a timely manner monitoring and modeling information for key pests.
3	Provide instruction on application technology that addresses important issues including drift, label restrictions, etc.

BACKGROUND

Production Information

- Apple production in the mid-Atlantic region (MD, NJ, PA, VA, WV) has averaged 946 million pounds (22.5 million bushels), with an average value of 102.5 million dollar, over the past three years.
- Apples are produced on approximately 48,866 acres in the mid-Atlantic region.
- Approximately 60-75 percent of the crop is marketed for processing and 25-40 percent as fresh fruit.
- Increased planting of trees on size-controlling rootstocks, especially dwarfs, has occurred in recent years.
- Apple production areas are facing increased pressure from urbanization.

Critical Pest Information

- Apples produced in the mid-Atlantic region are susceptible to a complex of over two dozen insects and a dozen diseases that injure/damage the fruit, foliage and woody parts of trees.
- Rigorous pest monitoring and management programs are required throughout the season for crop protection.
- Weeds and nematodes can affect tree vigor and productivity, whereas voles and rabbits can result in tree death, especially in young orchards.
- Deer have become a major problem, severely inhibiting orchard establishment and productivity.

Insects and Mites

- **Rosy apple aphid, *Dysaphis plantaginea* (Passerini)** is the most serious of the aphid species found on apple, and is the most important prebloom insect pest. Feeding causes leaf curling and dwarfed and deformed fruit, and up to 50% fruit injury can occur in severe outbreaks. Fruit injury can be prevented by 1-2 insecticide applications during the prebloom period (green tip to pink). If control is not achieved during the prebloom period a rescue treatment is usually applied at petal fall, however, some fruit injury may still result.

- **Spirea aphid, *Aphis spiraecola* Patch and apple aphid, *Aphis pomi* DeGeer** feed on the youngest leaves on terminals and watersprouts. Low to moderate populations can usually be tolerated without detrimental effects, however, high populations can result in discoloration of fruit from sooty mold growth on honeydew deposits. Control, if needed, usually consists of a single insecticide application about 4-6 weeks after petal fall. Biological control by adults and larvae of ladybird beetles, and larvae of syrphid flies, aphid midges and green lacewings is likely to occur if greater than 20% of the aphid colonies have predators. Populations can be reduced in the center of trees by removal of watersprouts.

- **Woolly apple aphid, *Eriosoma lanigerum* (Hausmann)** has become more problematic over the past few years due to the cancellation of methyl parathion and postbloom use of chlorpyrifos, and increased use of pyrethroids (do not provide control and are toxic to predators and parasites). Above-ground feeding occurs primarily on pruning cuts and in the leaf axils on terminals. Root-feeding results in the most important injury, consisting of galls which inhibit water and nutrient movement. Outbreaks can be minimized by limiting use of methomyl and pyrethroids. There are currently no insecticides which provide excellent control.

- **European red mite, *Panonychus ulmi* (Koch)** is a major foliage-feeding pest that can be difficult to control, especially on susceptible cultivars such as Delicious and York. This pest has 8-10 generations per year and is more problematic in hot, dry seasons. Moderate to high populations can reduce fruit size and result in the production of fewer and less vigorous fruit buds for the following season. High populations late in the season can result in the indirect downgrading of fruit by depositing overwintering eggs in the calyx end of fruits. Control is achieved by acaricide applications targeted at the overwintering egg stage during the prebloom period (green tip to pink) and/or the motile and egg stages during the postbloom period. The need for postbloom control is determined by monitoring motile stages, and is based on specific action thresholds as a function of crop load (bushels/acre) and time of season. Biological control by a black ladybird beetle, *Stethorus punctum* (Leconte), and various predaceous mite species is usually very successful if not disrupted by application of toxic pesticides.

- **Twospotted spider mite, *Tetranychus urticae* Koch** can be problematic, but is usually of secondary importance to European red mite in the mid-Atlantic region. Females that overwinter in the orchard ground cover move into the tree canopy during late spring and summer resulting in multiple generations per year. Because foliage feeding has a greater impact on leaf function than European red mite, control must be implemented at lower thresholds to prevent reduction in fruit size and return bloom. Control, if needed, is accomplished with a summer acaricide application or by various predatory insects and mites.

- **San Jose scale, *Quadraspidiotus perniciosus* (Comstock)** has recently increased in importance in some mid-Atlantic orchards due to the cancellation of methyl parathion and postbloom use of chlorpyrifos. Outbreaks typically occur in large, poorly pruned standard-sized trees that do not receive adequate spray coverage. Bark infestations can result in a decline in tree vigor and productivity and eventual limb death. Feeding directly on fruit results in a reddish-purple spotting. Control is achieved with a single insecticide application at the green tip to tight cluster stage against the overwintering immature scale and multiple applications against the nymphal (crawler) stage during the postbloom period. Crawler sprays can be timed with degree-days and the use of tape traps. Annual dormant pruning, especially of large trees, improves spray coverage and reduces the severity of this pest.

- **Tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois)** overwinters in woods, hedgerows and rock breaks, and moves into apple orchards early in the prebloom period. Most of the feeding at this time results in early fruit bud abscission and is rarely a problem. Feeding after fruit set typically results in the formation of a dimple (sunken conical area) in the side or calyx end of the fruit. Populations may be monitored with a white visual trap, with threshold-based application of insecticides for control during the tight cluster to pink stage and at petal fall.

- **Mullein plant bug, *Campylomma verbasci* (Meyer)** is a recent pest in mid-Atlantic apple orchards. Nymphs feed on flower parts and developing fruitlets from just before to shortly after bloom. Fruit injury consists of dark, raised, corky warts, typically near the calyx end. Feeding punctures may occur individually or in clusters, which may cause some fruit deformity. Nymphs may be sampled with a beating tray from pink to petal fall in order to make management decisions. Insecticide application must be timed during the pink to early petal fall period to prevent fruit injury.

- **Plum curculio, *Conotrachelus nenuphar* (Herbst)** is a sporadic pest in mid-Atlantic apple orchards, with most fruit injury occurring in those orchards that are adjacent to hedgerows and woodlots. Overwintering adults move from these sites into orchards during bloom and cause oviposition and some feeding injury on developing fruitlets. Injury is typically worse in orchards of multiple varieties with different bloom periods, with injury occurring on varieties that have completed bloom while waiting for later blooming varieties to reach petal fall in order to apply insecticides. Control can usually be achieved with a single insecticide application at petal fall. In higher pressure situations, or under cooler early season conditions, a second application may be needed in 10-14 days.

- **European apple sawfly, *Hoplocampa testudinea* (Klug)** is a newer pest in mid-Atlantic apple orchards, having recently moved from Pennsylvania into more southern orchards in the region. Females deposit eggs in the developing fruit around the bloom period. The young larva mines just under the skin of the apple, creating a large russeted circular scar originating from the calyx. An older larva will typically leave the first fruit and tunnel to the core of a second fruit, which is likely to abscise during the summer. Adults may be monitored with white visual traps, with insecticides applied for control at pink or petal fall if trap thresholds are reached.

- **Green fruitworm, *Lithophane antennata* (Walker); speckled green fruitworm, *Orthosia hibisci* (Guenée); humped green fruitworm, *Amphipyra pyramidoides* Guenée** are early season pests that injure foliage and developing fruit. Injured fruit may abscise early or remain until harvest with deep russeted sunken areas. Larvae are controlled with insecticide application at pink and/or petal fall to prevent fruit injury.

- **White apple leafhopper, *Typhlocyba pomaria* McAtee and Rose leafhopper, *Edwardsiana rosae* (Linnaeus)** are foliage-feeding insects that can be tolerated at low populations. Moderate to high populations can cause indirect damage to fruit in the form of black speckling (sooty mold) which grows on honeydew deposits. An abundance of adult leafhoppers at harvest can also be a nuisance to pickers. The need for insecticide application to control each of two generations on apple is based on an action threshold averaging 1-3 nymphs per leaf.

- **Potato leafhopper, *Empoasca fabae* Harris** is primarily a pest of younger apple trees. Feeding on the younger leaves of terminals causes them to curl downward and become yellow and necrotic (“hopperburn”). Foliage injury may be severe enough to stop tree growth. Overwintering occurs in the Gulf Coast states, with adults arriving on wind currents in late spring in the mid-Atlantic region where multiple generations are produced. Insecticides are applied for control when damaging populations are detected, especially on young trees.

- **Codling moth, *Cydia pomonella* (Linnaeus)** is a direct pest that tunnels through the fruit. Populations have increased in some orchards over the past few years due to an increase in adjacent abandoned orchards, FQPA cancellations and restrictions of organophosphate insecticides, and use of more selective chemistries for leafrollers that are less efficacious against codling moth. Insecticide applications (1-2 per generation) are timed with degree days to coincide with egg hatch in those orchards where the pheromone trap capture exceeds 5 moths per trap per week. Pheromone mating disruption is also a control option that has had mixed results. Use has been limited because of cost and variable control, which is influenced by the presence of wild hosts and abandoned orchards. Presence of worms in harvested fruit has resulted in load rejections by processors.

- **Oriental fruit moth, *Grapholita molesta* (Busck)** has historically been a major pest of peach in the mid-Atlantic region. Increased injury (similar to codling moth) has recently occurred in apple, especially where adjacent to peach. Possible factors for increased injury on apple include: 1) specific timing of insecticide applications (based on degree days) for codling moth and leafrollers may be permitting survival of oriental fruit moth, which had been previously controlled by calendar-type applications; 2) elimination of some insecticide applications, which may have contributed to control, because of below threshold populations of codling moth; 3) use of more selective chemistries for leafrollers which are not as efficacious against oriental fruit moth; 4) shift in host preference for apple; and 5) insecticide resistance. Control is achieved with insecticide applications (1-2 per generation) timed with degree days to coincide with egg hatch where pheromone trap thresholds (30 for first generation, 10 for subsequent generations) are exceeded. Pheromone mating disruption has also been a successful control option. Presence of worms in harvested fruit has resulted in load rejections by processors.

- **Borers (dogwood borer, *Synanthedon scitula* (Harris); american plum borer, *Euzophera semifuneralis* (Walker); apple bark borer, *Synanthedon pyri* (Harris)** infest burr knots (adventitious root primordia), located primarily near the graft union but also higher on the trunk and scaffold limbs of dwarfing rootstocks. Injury can result in reduced vigor, and tree girdling and death. Dogwood borer is the major species in most orchards, whereas american plum borer is a greater threat in apples adjacent to stone fruit orchards. Pheromone traps may be used to time 1-2 insecticide applications. Cultural practices which reduce burr knot development and the level of borer infestation include: 1) deeper planting of trees or mounding to cover the burr knots, 2) removal of spiral-wrap tree guards which can also inhibit spray coverage, and 3) weed control around the trunk.

- **Spotted tentiform leafminer, *Phyllonorycter blancardella* (Fabr.)** occurs throughout the mid-Atlantic region, but does not become a significant pest problem in most orchards. Low levels of injury can be tolerated without economic impact. An average mine density in excess of two per leaf can reduce fruit quality and quantity, decrease size, cause premature leaf and fruit drop, and reduce fruit set the following year. Insecticide applications are typically targeted against spring brood adults and first and/or second generation sap-feeding larvae. A sequential sampling scheme can be used to assess mine density to determine the need for spray applications. A complex of predators and parasitoids maintain the population below economic injury levels in most orchards.

- **Redbanded leafroller, *Argyrotaenia velutinana* Walker** was once the most important leafroller in the eastern U.S., reaching its greatest severity in the mid-Atlantic region. Larval injury consists of shallow feeding on the fruit surface. Except for localized problem orchards where insecticide resistance is likely, the three generations are generally controlled effectively with organophosphate-based spray programs. Pheromone mating disruption has also recently shown promise as a management strategy.

- **Tufted apple bud moth, *Platynota idaeusalis* (Walker) and variegated leafroller, *Platynota flavedana* Clemens** are closely related species that cause similar “pin-hole” type and shallow surface injury on fruit. Tufted apple bud moth has been a far more widespread and serious pest, causing the most direct injury of apple in the mid-Atlantic region until the late 1990s. Variegated leafroller has been more of a localized and sporadic problem in the southern and western areas of the mid-Atlantic. Development of resistance to organophosphate and carbamate insecticides was a major factor contributing to the severity of tufted apple bud moth. This pest is generally well managed with newer, more selective chemistries that are timed with degree days to coincide with the egg hatch of two generations per year.

- **Oblique-banded leafroller, *Choristoneura rosaceana* (Harris)** is an important species in the northern part of the mid-Atlantic, where larvae can cause deep scarring of fruit, and shallow surface and “pin-hole” type injuries, depending upon when the feeding occurs. This insect has become problematic due primarily to the development of resistance to organophosphate insecticides. Control is generally achieved today with applications of newer, selective chemistries timed with degree days to coincide with egg hatch.

- **Apple maggot, *Rhagoletis pomonella* (Walsh)** is not a resident pest in most commercial orchards in the mid-Atlantic, but enters from adjacent abandoned orchards to cause fruit injury. Populations can be monitored with baited yellow panel and red sphere traps to properly time highly effective applications of organophosphate insecticides. Border sprays may be sufficient to provide control of flies entering from abandoned sites. Additional urbanization is likely to increase the threat from this pest.

- **Japanese beetle, *Popillia japonica* Newman** causes foliage injury ("skeletonizing") and occasional injury to mature or previously injured fruit. Mature semi-dwarf and standard size trees can tolerate significant foliage injury without economic impact, but younger and dwarf trees must be treated more conservatively because of the reduced canopy volume. Insecticides are applied for control when foliage injury becomes significant.

- **Stink bugs (brown stink bug, *Euschistus servus* (Say); dusky stink bug, *Euschistus tristigmus* (Say); green stink bug, *Acrosternum hilare* (Say))** have historically been major pests of peach, but have recently been shown to cause mid to late season injury on apple that resembles, and may be misdiagnosed as, corkspot or bitter pit. The shift away from organophosphates to more selective and efficacious chemistries for leafrollers may be contributing to increased incidence and potential for injury from these pests. Pyrethroids have demonstrated effective control, but use is likely to lead to mite outbreaks because of toxicity to predators. Effective monitoring methods are needed for proper timing of spray applications.

Diseases

- **Apple scab, caused by *Venturia inaequalis*,** is one of the most important apple diseases in the Mid-Atlantic region. Losses result directly from fruit or pedicel infections, or indirectly from repeated defoliation, which can reduce tree growth and yield. The disease reduces fruit yield and fruit size and causes cracked and misshapen fruit. Infected fruit have dark brown to black lesions that make them unmarketable. The fungus overwinters in fallen leaves on the ground. Ascospores, the cause of primary infections, are released from fallen leaves when they become wet during spring rains. The critical period for ascospore release is from the time green tissue is first visible through second cover. One hundred percent of apple acreage is potentially affected by the disease.

- **Powdery mildew, caused by *Podosphaera leucotricha***, overwinters as mycelia in the terminal buds of apple trees. Although the disease is present every year, it is more prevalent during years when weather is dry. Control usually begins at the pre-pink stage because mycelium becomes active early in the season. Fruit infection occurs at pink stage. Regular sprays are required through the third cover spray. The disease causes whitish lesions, curled and folded leaves, stunted gray twig growth, and fruit russeting. Effects of the disease include blossom abortion, reduced return bloom and yield the following season, and stunted growth. Mildew severity and the need for and intensity of control measures are related to cultivar susceptibility and intended fruit market. Approximately 40% of current acreage is planted to susceptible cultivars.

- **Cedar-apple rust, caused by *Gymnosporangium juniperi-virginianae*,** overwinters as galls on cedar trees. During the early spring, wetting of the cedar galls produces spore horns bearing teliospores, which give rise to basidiospores. Given the proper conditions of wetting and temperature, basidiospores are carried to apple trees where they infect leaves and fruit. Fruit lesions appear bright orange to brown, and may crack as the fruit matures. The cedar-apple rust gall produces spores for only one season; therefore there is only one disease cycle per year. Rust infections can occur between the pre-bloom pink bud stage through mid June. The disease can affect most commercial cultivars, but 'Red Delicious' cultivars are almost immune. Because of the abundance of cedar trees in the Mid-Atlantic region, the disease is regularly managed from the pink bud stage through first cover. Quince rust, caused by *C. clavipes*, is more damaging to fruit and is prevalent in years that have favorable conditions for blossom infection during pink to petal fall.

- **Fire blight, caused by *Erwinia amylovora***, is a bacterial disease that can be highly destructive when it occurs on susceptible varieties and under the right conditions. The pathogen overwinters in cankers on limbs that were infected during the previous season. As temperatures warm in the spring, bacteria multiply and produce bacterial ooze on the canker margins. Insects that are attracted to the ooze carry and spread the bacteria through the orchard. Under suitable wetting conditions, infections are readily established on open flowers, causing blossom blight. Winds and rain can help further establish the disease in shoot blight and canker blight phases. The disease is erratic, and may occur in only a few areas during some seasons, but may kill half an orchard during another season. Varieties that are most susceptible include Rome, Jonathan, Jonagold, Idared, Gala, Fuji, Braeburn, Mutsu, and Paula Red. The most critical time to control the disease is during bloom. Streptomycin or coppers can also be applied at any time that infections are known to occur, given the proper environmental and infection conditions. Coppers applied at the 1/2" green stage are thought to be helpful in reducing the levels of exposed inoculum present. Predictive models can also help identify infection periods, and improve application timing.

- **Brooks spot, caused by *Mycosphaerella pomi*,** is a sporadic disease that in some years has caused considerable losses in the Mid-Atlantic region.

Ascospores that are discharged from overwintered leaves infect both leaves and fruit during the late spring to early summer. Infections do not become visible until late summer. Fruit infections usually show up in late July to August, with foliar infections showing up slightly later. Fruit symptoms start as sunken dark green lesions near the calyx end, and progress to dark red or purple on red fruit, but remaining dark green on yellow fruit. There is a very shallow flesh browning under the lesion. Those cultivars that are most susceptible to the disease in the Mid-Atlantic region include Jonathan, Golden Delicious, Stayman, Winesap, and Rome. Up to 30-40% of the crop has been infected during some years. Depending on the severity, symptoms may be able to be peeled by the processor. If quality demands are high, then infected fruit is culled for both processing and fresh markets, and only marketable for juice.

- **Bitter rot, caused by *Glomerella cingulata, Glomerella acutatum, Colletotrichum gloeosporioides, Colletotrichum acutatum***, pathogens are widespread and infect many other hosts, including grape, pear, peach and nectarine. Prolonged periods of hot, moist weather are favorable for disease infection. Although infection may occur early in the season, bitter rot is usually thought of as a late season disease, with symptoms visible from July through August. Lesions start as small light brown circular spots. They enlarge to a round, sunken depression, often with concentric rings where fruiting bodies appear in pink to cream-colored masses. The rot often forms a perfect "V" – shape when sliced through the lesion. Rotted fruit are complete culls, and if left on the tree, may overwinter there as a mummy. All apple varieties are susceptible, but the disease is sporadic and highly dependent upon environmental conditions. The disease may be present on 100% of acreage, but causes sporadic problems. Some Mid-Atlantic region orchards have experienced 30 - 40% crop loss during certain years.

- **White rot, caused by *Botryosphaeria dothidea***, is widespread, and the fungus also is found on birch, chestnut, peach, and blueberry. White rot can be a serious disease causing considerable crop loss. Up to 50% crop losses have been reported from individual orchards in the mid-Atlantic region. The disease involves both wood and fruit tissue, but not the foliage. Fruit infection may occur at any time, although some literature suggests that infection only occurs during the last six to eight weeks of the season. Drought stress and winter injury can augment the disease and increase canker growth. Wood infections and cankers are similar in appearance to black rot. Fruit infections start as small sunken brown spots with a red halo. In warm weather, they progress to a light watery appearance, soft to the touch. Cankers can girdle branches, leading to defoliation and crop loss. The disease may be present on 100% of acreage, but causes sporadic problems.

- **Black rot, caused by *Botryosphaeria obtusa*,** occurs as a fruit rot, a leaf spot (frogeye leaf spot), and a limb canker. Limb cankers can girdle and kill entire branches. Excessive leaf spotting can lead to partial defoliation, whereas fruit lesions render the infected fruit unmarketable. Fruit infections vary in appearance, but usually appear as a firm, dark brown to black rot with concentric rings starting from the calyx end of the fruit. The fungus overwinters in cankers, in mummified fruit, or on dead bark. Ascospores may be produced during petal fall and the early part of the season, whereas conidia may be produced during rainy periods throughout the season. Infections occur through fruit and leaf stomata, whereas later season fruit infections occur through lenticels, cracks and wound areas. The disease may be present on 100% of acreage, but causes sporadic problems.

- **Sooty blotch, caused by a complex of fungal pathogens, including *Peltaster fructicola, Geastrumia polystigmatus, Leptodontium elatus*, and flyspeck, caused by *Zygophiala jamaicensis***, cause surface blemishes that usually appear together on the same fruit. The fungi are found on the waxy surfaces of many plants and may overwinter on woody apple tissues, and can infect apples as early as two to three weeks after petal fall. The diseases do not become visible until July or later, and are commonly thought of as late season diseases. Favorable infection periods include frequent rains with slow drying conditions. Environmental models based on accumulated wetting hours are available that help predict favorable disease conditions and may time fungicide applications for pre-symptom disease suppression. Sooty blotch infections appear like sooty or olive green smudges on the fruit surface. Flyspeck lesions consist of 10 to 50 black specks clustered in 5/16 to 1-inch-diameter colonies. The fruit does not rot from either infection, but their presence can degrade the fruit surface, leading to water loss in storage and a downgrading from fresh market to process grade. The disease is more pronounced on light skinned fruit, especially yellow and green cultivars. The disease may be present on 100% of acreage, but causes sporadic problems. Depending on the quality demands from processors, it usually more of an issue with only fresh market fruit. During wet growing seasons, losses of 25 % or more are commonly found, even in orchards treated with fungicides.

- **Alternaria Leaf Blotch, caused by *Alternaria mali***, was first recognized as a serious problem in North Carolina in the 1980's. By 1993, it had been identified by growers in nine counties in southern and central Virginia, some with as much as 50 to 60% defoliation of Red Delicious trees. Although leaf blotch severity may vary from year to year there are strong indications that it could become a problem in more northern areas of the mid-Atlantic region. Lesions first appear on leaves in late spring or early summer as small, round purplish or blackish spots, gradually enlarging to 1.5-5 mm in diameter, with a brownish purple border. Lesions may coalesce and become irregular and much darker acquiring a "frogeye" appearance. If lesions occur on petioles, 50 percent or more defoliation may occur. Severe defoliation leads to premature fruit drop. The fungus can overwinter on dead leaves on the orchard, in mechanical injuries in twigs, or in dormant buds. Primary infection takes occurs about a month after petal fall. The disease advances rapidly in the optimum temperature range of 77 to 86F, and with secondary cycles occurring in a few days The fungus produces a toxin which increases the severity of the disease on susceptible cultivars. Strains of Delicious and Empire are very susceptible. Golden Delicious is moderately resistant but becomes infected when planted as a pollenizer in orchards of Delicious. Fuji, Mutsu, Jonagold, and Jonathan are also susceptible. Kresoxim-methyl (Sovran) is the only effective fungicide currently registered for Alternaria leaf blotch and there is a concern about development of resistance to this and other strobilurin fungicides. Sanitation is important in control of the disease. Leaves in infected orchards should be removed by raking, or leaves on trees should be sprayed with urea in the late fall to promote their rapid breakdown. Because disease severity is aggravated by severe mite infestations, maintaining mites below 10 per leaf is an important factor in preventing severe defoliation.

- **Phytophthora root, crown, and collar rot, caused by *Phytophthora cactorum* and other *Phytophthora* species**, is usually seen in trees planted in low areas, or on poorly drained soils. It is particularly troublesome in trees grown on M104 and M106 rootstocks, but can infect most rootstocks. The pathogens can last several years in the soil, or on dead roots and plant tissue. Prolonged periods with cool wet soils favor infection. The period between the pink stage of bloom to the beginning of shoot growth is when most new infections take place. Infections may also take place in the fall, or at other times when the proper conditions exist. Infected trees will exhibit delayed bud break, leaf discoloration and twig dieback. Fruit may remain undersized color prematurely. Leaves can prematurely color and drop in the fall. While a large mature tree may survive for several years, it will steadily decline and eventually die. While either the collar (scion) portion of the tree, the crown (rootstock) portion may be involved. A necrotic area marked with a distinct margin that is orange to reddish-brown to dark brown will be present at the affected site. While the disease usually works its way from the roots (crown rot), the tree is not killed until the entire crown is completely girdled. The disease is sporadic, depending on prolonged weather conditions, and affects about 5 - 10% of acreage.

- **Blue mold, caused by *Penicillium expansum***, is the most important postharvest decay of stored apples in the United States. The losses from this disease can be significant but can be substantially reduced by following proper sanitation and control measures. The fungus not only causes fruit decay but also produces the carcinogenic mycotoxin patulin. This toxin may rise to unacceptable levels in fruit destined for processing and may also result in off flavors. The appearance of the decay caused by most species of Penicillium is very similar. The rotted areas are soft, watery and light brown in color. The surface of older lesions may be covered by bluish-green spores that initially are nearly snow white in color. The blue mold spores are long-lived and may easily survive from season to season on contaminated bins, where the fungus can grow and produce copious amounts of spores. Contamination with these spores may come from various other sources including orchard soil carried on bins from the orchard, decaying fruit or air. Inoculation of the fruit going into storage is believed to occur mainly from the diphenylamine (DPA) drenching solution used for protection against superficial scald, where the spore concentrations increase with each successively drenched bin and may reach high levels if solutions are not changed regularly. Inoculation can also occur during fruit handling in water contaminated with the fungus in packinghouses. A single decayed fruit may contain enough spores to contaminate water on the entire packing line. Postharvest treatment of fruit with fungicides has been traditionally the most common method of combating blue mold. However, this decay can be reduced by a variety of methods and procedures and many of them can be combined for overall improvement, including sanitation, avoiding injuries to fruit, calcium chloride, and biological control organisms.

Nematodes

- Lesion Nematode (*Pratylenchus penetrans*) and Dagger Nematodes (*Xiphinema americanum* and *X. rivesi*) are both widespread in Mid-Atlantic orchards, occurring in 50-70 % of sites, but only 10-20 % orchards have population densities sufficient to cause economic losses. For both nematodes, long term management over the life of the orchard is important and the best time to start managing is before the orchard is planted.

Weeds

- In apple orchards, weeds are considered important pests. They compete with the crop for nutrients, water, light, and space. Weed competition in orchards less than four years of age is capable of causing permanent yield reductions.

- There are limited alternatives for herbicides to manage weeds in apple production. Herbicides available currently are used well to manage weeds in orchards.

- The safety of the alternatives and the potential to cause tree injury are not well known. Herbicides not registered yet but considered to be effective for weed management in apple include clopyralid, triclopyr, fluroxypyr, thiazopyr, halosulfuron, sulfentrazone, and flumioxazin.

- Testing and registration of potential herbicides like clopyralid, fluroxypyr, and sulfentrazone may help better manage perennial broadleaf weeds.

Vertebrates

- Deer population management is best accomplished through utilizing the legal hunting seasons or deer damage permits. When shooting is unfeasible or undesirable, exclusion utilizing fences has proven to be the best option. Fencing should be built by integrating modifications that will also control access of other animals, such as, rabbits and woodchucks.

- Voles populations are usually controlled by cultural modification to the habitat, toxicants, exclusion, trapping, or repellents. These can be tailored to the population density of voles, value of crops, and costs.

- Cottontails rabbits are classified as game animals and are protected by laws throughout our region. Legal hunting, exclusion, habitat modification, trapping and repellents are options to manage rabbit populations.

- Woodchucks seldom build up is large numbers and do not cause major damage created by high populations of other animals. Hunting, fumigants, trapping, and exclusion are the most common control methods with woodchucks.

- Beaver population can be best controlled by exclusion, cultural methods, and trapping. These methods work well as part of an integrated system for controlling access by several other animals, such as rabbits and woodchucks that can be excluded by similar fences and techniques.

Critical pesticide information

- Organophosphate insecticides remain the foundation of insect pest management programs and their use is critical for key pests such as plum curculio, apple maggot, codling moth, oriental fruit moth, dogwood borer and woolly apple aphid.

- Cancellation of methyl parathion and postbloom foliar uses of chlorpyrifos have contributed to increased levels of San Jose scale and woolly apple aphid.

- Use of newer, selective chemistries have significantly improved control of leafrollers, and some have the potential as OP replacements to control other pests, but at a substantial increase in pest management costs.

- The availability of fungicides with broad-spectrum activity against a variety of pathogens is of major importance for the management of fruit tree diseases because producers contend with a diversity of pathogens simultaneously.

- Newer fungicides with site-specific modes of action, such as the SI's and strobilurins, while highly effective, are at risk for the development of resistant pathogen populations. Availability of a diverse array of fungicides with differing modes of action is critical for the management of pathogen resistance to fungicides. This is especially a critical issue for management of apple scab and powdery mildew.

- Because of the diversity of pathogens and concerns about resistance to fungicides, there is a need for products with non site-specific modes of action, such as EBDC's, captan and ziram. These chemistries provide protection against a diversity of pathogens, are at minimal risk for pathogen resistance, and when used properly in combination or alternation with SI's and strobilurins, can help delay the onset of pathogen resistance.

- Streptomycin is the only effective bactericide for management of fire blight blossom infections. There are no effective alternatives available at this time and genetically engineered host resistance will not be available in the near future. Bacteria resistant to streptomycin are widespread in many locations and it is only a matter of time before resistance occurs in the mid-Atlantic region. Registration of effective products with differing modes of action from streptomycin is necessary for resistance management.

IPM issues

- Growers are making increased use of IPM methods (scouting, pheromone traps, degree days) to justify and properly time pest management practices.

- Increased use of pyrethroids, for more economical pest control, has been detrimental to IPM programs and led to increased outbreaks of mites and woolly apple aphids.

- Pheromone mating disruption and newer, selective chemistries have demonstrated effective control of target pests, but adoption has been slowed by increased costs.

- Development of IPM methods for disease management is difficult due to the inherent unpredictability of pathogen populations and their potential impact on crop quality and yield. Nevertheless, some progress has been made on monitoring for apple scab ascospores and predicting the economic threshold for implementing sanitation measures, prediction of fire blight blossom infection, and appearance of sooty blotch symptoms.

- Development of host plant resistance to multiple pathogens incorporated into desirable apple cultivars and rootstocks, developed by either conventional or engineered genetic methods, is highly desirable.

- Site-specific regional weather forecasting shows promise for improving disease management.

Resistance management issues

- Resistance of rosy apple aphid to organophosphates and pyrethroids will necessitate a shift to newer, more selective and more expensive chemistries in order to maintain effective control.

- Extensive use of a limited selection of chemistries for effective leafroller control increases the potential for future resistance.

- There is increased potential for mites to develop resistance to a very limited selection of effective acaricides for summer application.

- Resistance of the apple scab pathogen to SI's and strobilurins will necessitate a shift to newer and more expensive chemistries in order to maintain effective control.

- Resistance of the fire blight pathogen to streptomycin could lead to extensive crop losses and threatens the economic viability of apple production in the mid-Atlantic region. Reliance on a single effective chemistry for disease control increases the potential for future resistance.

Consumer education issues

- Educate consumers on growers' use of safer, more environmentally and ecologically friendly pest management programs and the associated increased costs.

- Educate consumers on how the low tolerance for internal worms in processed product drives pest management programs and pesticide use.

- Educate consumers on the influence of abandoned orchards on disease management and pesticide use.

Export/import issues

- Export protocols need to be updated to reflect current pesticide registrations.

OUTLINE OF PLAN

Pest-by-pest management information by apple phenology

Information outlined in this section includes target pests (Insects and diseases), current and potential control options, pesticide efficacy, re-entry interval (REI), and post harvest interval (PHI). Also noted are other control options, chemical and non-chemical, unregistered chemicals, and a “TO DO” list of research, regulatory and educational needs.

Dormant

<u>Diseases</u>

TARGET DISEASE	MANAGEMENT OPTIONS	Efficacy*	REI (hrs)	PHI (days)
Fire blight	**CHEMICAL OPTIONS**			
	Copper	V		
	CULTURAL OPTIONS			
	Remove cankers	V		
	Reduce nitrogen	G		

Notes: Suggested where fire blight was difficult to control in the previous year or on young blocks of susceptible cultivars such as York Imperial, Jonathan, Rome Beauty, Idared, Gala, and crabapple pollinizers and orchards planted on M.9, M.26 and Mark rootstock. Do not apply copper after foliage appears because of potential for fruit russeting. Where there is less economic risk due to russeting as in fruit grown for processing, copper sprays applied from silver tip to half-inch green will protect against an early scab infection period. 75% of susceptible acreage is sprayed delayed-dormant. Bacterial population growth in blossoms of resistant cultivars and subsequent movement to susceptible ones suggests that the copper applications should include entire orchards, not just susceptible cultivars. Copper applied too early may not be present in sufficient amounts when needed due to weathering and wash-off. Weathering and wash-off are related to environment and time from application to first bloom, both of which are variable, therefore efficacy of copper at this time is listed as variable.

The primary purpose of this treatment is not to kill bacteria in the cankers or even to kill the bacteria as they ooze out of overwintering cankers. Even where copper residue covers the canker surface, the ooze is forced out in droplets or strands that "poke through" that residue exposing many live bacteria for dispersal in the orchard. The real role for copper in controlling fire blight is to provide an inhibitory barrier over all bark and bud surfaces in the orchard that will prevent the bacteria from colonizing these areas. Recommendations for the use of copper materials at green tip, therefore, are to interfere with the widespread colonization of bark and bud surfaces throughout the orchard. For this to be effective, coverage must be thorough so a high volume spray is needed to completely wet all exposed surfaces in the orchard. In addition, because the dispersal and colonization of the bacteria is random and independent from the resistance or susceptibility of the trees, all of the trees in a treated block must be sprayed, not just those of susceptible varieties. Failure to also spray the normally fire blight resistant Red Delicious trees in an orchard interplanted with fire blight susceptible varieties provides a safe harbor for the bacteria to colonize and later be dispersed by honey bees to open flowers on all varieties, reducing if not totally negating the value of the treatment.

Copper application may have more utility in an integrated program when used at the green tip or quarter-inch green stage. Sprays at green tip with copper for fire blight may control apple scab more cost effectively than sanitation for large growers.

"TO DO" list

Regulatory: None.

Research: None.

Education: None.

Scab	**CULTURAL OPTIONS**			
	Shred leaf litter	depends on amount of overwintering inoculum; in spring		
	Apply urea	depends on amount of overwintering inoculum, apply to leaves before they abscise.		
	Implement other inoculum reduction practices (leaf blowing, dropped fruit removal)			

Notes: Sanitation practices are not worthwhile in terms of cost of implementation and future fungicide savings if overwintering levels of scab are moderate to high. Sanitation practices also are used for inoculum reduction of the Alternaria leaf blotch fungus in southern Virginia.

Sprays at green tip with copper for fire blight controls apple scab more cost effectively than sanitation for large growers.

Regulatory: None.

Research: Use of plastic mulches for inoculum reduction; demonstrations of the concept locally, more research on cultural practices to reduce inoculum, develop knowledge to build trust in the practice, 2-4D applications in spring can reduce ascospore discharge.

Education: Overview of the practices to reduce inoculum.

*E = excellent efficacy; G = good; F = fair; P = poor, V = variable
$ = significantly more expensive than other chemical options, but disease complex controlled needs to be considered.

(I) = See label
(II) = See label. Restricted-entry interval may be more restrictive than days-to-harvest limitations.
(III) = Maximum 24 oz. per acre/per season

Silver tip – ½ inch green

Insects and mites

Target Insect/Mite	MANAGEMENT OPTIONS	Efficacy*	REI (hrs)	PHI (days)
Rosy apple aphid (RAA)	**CHEMICAL OPTIONS**			
	Organophosphates			
	Chlorpyrifos (Lorsban 4E)	G	96	28 (I)
	Methidathion (Supracide)	G	48	(II)
	Pyrethroids			
	Cyhalothrin (Warrior)	G	24	21
	Esfenvalerate (Asana)	G	12	21
	Fenpropathrin (Danitol)	P$	24	14
	Permethrin (Pounce, Ambush)	G	12	(III)
	Other chemicals			
	Azadirachtin (Aza-Direct)	G$	4	0
	Pyriproxyfen (Esteem)	G$	12	45
	Oil	F-G	12	0
	Unregistered chemicals			
	None identified			
	NON-CHEMICAL OPTIONS			
	None identified			

Notes: Most orchards receive a prebloom insecticide application for control of this pest. Localized resistance exists to chlorpyrifos, esfenvalerate and permethrin. Pyrethroid use may upset mite management programs by destroying predator mites/insects, but application at this time is less deleterious than later. Azadirachtin is OMRI certified for organic production. Depending upon rate, fenpropathrin can be more expensive than esfenvalerate and permethrin. This insect can also be controlled at the tight cluster to pink stage.

"TO DO" list

Regulatory: None.

Research: Fund and conduct research to better identify biology and life cycle. Determine economics of various management options. Determine how late control can be implemented without effecting fruit yields/quality.

Education: Explain monitoring techniques, use of economic thresholds, and proper timing of spray applications.

Target Insect/Mite	CHEMICAL OPTIONS	Efficacy*	REI (hrs)	PHI (days)
San Jose scale (SJS)	**Organophosphates**			
	Chlorpyrifos (Lorsban)	E	96	28 (I)
	Methidathion (Supracide)	E	48	(II)
	Other chemicals			
	Oil	E	12	0
	Pyriproxyfen (Esteem)	E$	12	45
	Unregistered chemicals			

	None identified			
	NON-CHEMICAL OPTIONS			
	Prune out early infestations	G		

Notes: This insect is a sporadic problem that is increasing in severity with the cancellation of methyl parathion and postbloom use of chlorpyrifos. High volume sprays will improve control.

"TO DO" list

Regulatory: Register promising new chemicals that are identified as efficacious.

Research: Evaluate alternative chemicals. Identify importance of natural enemies and toxicity of chemicals.

Education: Train growers on importance of high volume spray applications.

European red mite (ERM)	**CHEMICAL OPTIONS**			
	Other chemicals			
	Oil	E	12	0

Notes: Control should be considered at this stage if overwintering eggs are abundant.

"TO DO" list

Regulatory: None.

Research: Evaluate importance of temperature in oil efficacy and phytotoxicity. Determine if there are any predators effective at this stage.

Education: None.

*E = excellent; G = good; F = fair; P = poor efficacy.
$ = significantly more expensive than other chemical options, but pest complex controlled needs to be considered.

(I) = Registered for dormant or delayed-dormant foliar application.
(II) = See label.
(III) = Apply no later than petal fall.

Silver tip – ½ inch green

Diseases

TARGET DISEASE	MANAGEMENT OPTIONS	Efficacy*	REI (hrs)	PHI (days)
Scab	**CHEMICAL OPTIONS**			
	Dodine (Syllit)	E	48	7
	Captan	G	96	(II)
	Fenarimol (Rubigan) + Captan	E	12 / 96	30 / (II)
	Fenarimol (Rubigan) + Dodine (Syllit)	E	12 / 48	30 / 7
	Fenarimol (Rubigan) + Mancozeb	E	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Metiram (Polyram)	E	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Ziram	E	12 / 48	30 / 14
	Myclobutanil (Nova) + Captan	E	24 / 96	14 / (II)
	Myclobutanil (Nova) + Dodine (Syllit)	E	24 / 48	14 / 7
	Myclobutanil (Nova) + Mancozeb	E	24 / 24	14 / (I)
	Myclobutanil (Nova) + Metiram (Polyram)	E	24 / 24	14 / (I)
	Myclobutanil (Nova) + Ziram	E	24 / 48	14 / 14
	Triflumizole (Procure) + Captan	E	12 / 96	14 / (II)
	Triflumizole (Procure) + Dodine (Syllit)	E	12 / 48	14 / 7
	Triflumizole (Procure) + Mancozeb	E	12 / 24	14 / (I)
	Triflumizole (Procure) + Metiram (Polyram)	E	12 / 24	14 / (I)
	Triflumizole (Procure) + Ziram	E	12 / 48	14 / 14
	Ziram	F-G	48	14
	Vangard + Mancozeb	G	12 / 24	7 / (I)
	Kresoxim-Methyl (Sovran)	E	12	30
	Trifloxystrobin (Flint)	E	12	14
	Sulfur	F	24	0
	Lime-sulfur	G	48 (I)	
	Copper	G		
	Ziram + Mancozeb	G	48 / 24	14 / (I)
	Ziram + Metiram (Polyram)	G	48 / 24	14 / (I)
	Captan + Mancozeb	G	96 / 24	(II) / (I)
	Captan + Metiram (Polyram)	G	96 / 24	(II) / (I)
	EBDC (high rate option)	G	24	(I)
	CULTURAL OPTIONS			
	Ascospore maturity monitoring	good for some early decision-making		

Notes: SI's not used at silver tip; Rubigan, Nova, Procure, Trifloxystrobin (Flint) Kresoxim-Methyl (Sovran), Vangard, Dodine (Syllit) are at risk for resistance development.
Captan is incompatible with oil; copper has potential to cause fruit russet; fruit for the processing market will tolerate more russet (except Golden Delicious).
Ratings are based on disease pressure, which takes into account disease history and prevailing weather patterns and specific weather parameters.
Combinations of SI's + EBDC's are used to combine the disease eradication activity of the SI with the disease protection activity of the EBDC.
Choice of fungicide at this early stage may be based on the occurrence of infection periods.
75% of acreage employs copper at this time.

Use of copper at this time may help in the management of resistance to Streptomycin (Agri-mycin 17) for fire blight control.

"TO DO" list

Regulatory: None.

Research: Assessment of the sensitivity of the scab fungus to the various classes of fungicides should be conducted periodically.

Education: Monitor infection periods and disseminate information to growers.

Fire blight	**CHEMICAL OPTIONS**			
	Copper	V		
	CULTURAL OPTIONS			
	Remove cankers	V		

Notes: Copper at this time also controls scab

"TO DO" list

Regulatory: None.

Research: None.

Education: None.

*E = excellent efficacy; G = good; F = fair; P = poor, V = variable.
$ = significantly more expensive than other chemical options, but disease complex controlled needs to be considered.

(I) = See label
(II) = See label. Restricted-entry interval may be more restrictive than days-to-harvest limitations.
(III) = Maximum 24 oz. per acre/per season.

Tight Cluster - Pink

Insects and mites

Target Insect/Mite	MANAGEMENT OPTIONS	Efficacy*	REI (hrs)	PHI (days)
Rosy apple aphid (RAA)	**CHEMICAL OPTIONS**			
	Organophosphates			
	Dimethoate (Cygon)	G	48	28
	Chlorpyrifos (Lorsban)	G	96	28 (I)
	Methidathion (Supracide)	G	48	(II)
	Carbamates			
	Oxamyl (Vydate)	F-G	48	14

	Pyrethroids			
	Cyhalothrin (Warrior)	G	24	21
	Esfenvalerate (Asana)	G	12	21
	Fenpropathrin (Danitol)	P$	24	14
	Permethrin (Pounce, Ambush)	G	12	(III)
	Other Chemicals			
	Acetamiprid (Assail)	E	12	7
	Endosulfan (Thionex)	F-G	24	21 or 30 (II)
	Thiamethoxam (Actara)	E	12	14 or 35 (II)
	Unregistered Chemicals			
	Thiacloprid (Calypso)	E		
	NON-CHEMICAL OPTIONS			
	None identified			

Notes: Thiamethoxam has been shown to affect bee pollination in the West if used too close to bloom. The second half of an alternate-row-middle application of an OP or pyrethroid may occur during this stage. Pyrethroid use at this stage is likely to disrupt mite management programs because of toxicity to predators.

"TO DO" list

Regulatory: None.

Research: Conduct resistance monitoring for various chemicals. Investigate bee effects of Actara in East.

Education: None.

Plant bugs (TPB, MB)	**CHEMICAL OPTIONS**	Efficacy*	REI (hrs)	PHI (days)
	Organophosphates			
	Chlorpyrifos (Lorsban)	F-G	96	28 (I)
	Dimethoate (Cygon)	G	48	28
	Pyrethroids			
	Cyhalothrin (Warrior)	E	24	21
	Esfenvalerate (Asana)	E	12	21
	Fenpropathrin (Danitol)	E	24	14
	Permethrin (Pounce, Ambush)	E	12	(III)
	Other Chemicals			
	Endosulfan (Thionex)	G-E	24	21 or 30 (II)
	Formetanate HCL (Carzol)	G-E$	(II)	(III)
	Indoxacarb (Avaunt)	G	12	28
	Thiamethoxam (Actara)	G	12	14 or 35 (II)
	Unregistered Chemicals			
	Thiacloprid (Calypso)	?		
	NON-CHEMICAL OPTIONS			
	Manage broadleaf weeds	E		

Notes: Mullein bug injury is a recent occurrence in the mid-Atlantic region.

"TO DO" list

Regulatory: None.

Research: Determine efficacy of new products against this group of pests. Conduct pheromone work for monitoring. Determine biology, monitoring procedures, economic thresholds, and impact of mullein bug in the East. Determine efficacy of other OPs at this stage. Investigate potential effect of Warrior on bees at this stage.

Education: Train growers in identification of and monitoring for MB injury.

Oblique-banded leafroller (OBLR)				

Notes: Typically controlled during postbloom, but occasionally appears and needs to be controlled during prebloom. A sporadic pest in mid-Atlantic region (primarily in PA), and need to control occurs on an individual orchard basis. (See OBLR under postbloom time period for specific management tools.) May need to be controlled during bloom with BT (E) or Intrepid (E).

"TO DO" list

Regulatory: None.

Research: Evaluate prebloom treatments. Conduct economic threshold studies.

Education: None.

Oriental fruit moth (OFM)	**CHEMICAL OPTIONS**	Efficacy *	REI (hrs)	PHI (days)
	Organophosphates			
	Azinphosmethyl (Guthion)	G-E	(IV)	14 (V)
	Chlorpyrifos (Lorsban)	G-E	96	28 (I)
	Phosmet (Imidan)	G-E	72	7
	Carbamates			
	Carbaryl (Sevin)	G	12	3
	Methomyl (Lannate)	G	72-96 (II)	14
	Pyrethroids			
	Cyhalothrin (Warrior)	E	24	21
	Esfenvalerate (Asana)	E	12	21
	Fenpropathrin (Danitol)	E	24	14
	Permethrin (Pounce, Ambush)	E	12	(III)
	Other Chemicals			
	Acetamiprid (Assail)	G	12	7
	Indoxacarb (Avaunt)	G	12	28
	Methoxyfenozide (Intrepid)	G	4	14
	Unregistered Chemicals			
	Thiacloprid (Calypso)	G		
	NON-CHEMICAL OPTIONS			
	Pheromone mating disruption	E	4 (VI)	0

Notes: Control is normally initiated at petal fall, but adults may be targeted at pink in high pressure situations. Pheromone mating disruption would not normally be initiated at this stage because of the complex of pests present that may be controlled with insecticide application.

"TO DO" list

Regulatory: None.

Research: Determine population level that justifies control at this stage.

Education: Instruct growers in determining if control is needed at this stage.

*E = excellent; G = good; F = fair; P = poor efficacy.
$ = significantly more expensive than other chemical options, but pest complex controlled needs to be considered.

(I) = Prebloom application.
(II) = See label.
(III) = Apply no later than petal fall.
(IV) = See label. Restricted-entry interval may be more restrictive than days-to-harvest limitations.
(V) = 21 days if over 2 lbs/acre.
(VI) = For sprayable formulation.

Tight Cluster - Pink

Diseases

TARGET DISEASE	MANAGEMENT OPTIONS	Efficacy*	REI (hrs)	PHI (days)
	CHEMICAL OPTIONS			
Scab	Dodine (Syllit)	Excellent (resistance may be present in some areas but in other areas may be useful for suppression of scab lesions)	48	7
	Captan	G	96	(II)
	Fenarimol (Rubigan) + Captan	E	12 / 96	30 / (II)
	Fenarimol (Rubigan) + Mancozeb	E	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Metiram (Polyram)	E	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Ziram	E	12 / 48	30 / 14
	Myclobutanil (Nova) + Captan	E	24 / 96	14 / (II)
	Myclobutanil (Nova) + Mancozeb	E	24 / 24	14 / (I)
	Myclobutanil (Nova) + Metiram (Polyram)	E	24 / 24	14 / (I)
	Myclobutanil (Nova) + Ziram	E	24 / 48	14 / 14
	Triflumizole (Procure) + Captan	E	12 / 96	14 / (II)
	Triflumizole (Procure) + Mancozeb	E	12 / 24	14 / (I)
	Triflumizole (Procure) + Metiram (Polyram)	E	12 / 24	14 / (I)
	Triflumizole (Procure) + Ziram	E	12 / 48	14 / 14
	Ziram	F-G	48	14
	Kresoxim-Methyl (Sovran)	E	12	30
	Trifloxystrobin (Flint)	E	12	14
	Sulfur	F	24	0

	Lime-sulfur	G	48 (I)	
	Ziram + Mancozeb	G	48 / 24	14 / (I)
	Ziram + Metiram (Polyram)	G	48 / 24	14 / (I)
	Captan + Mancozeb	G	96 / 24	(II) / (I)
	Captan + Metiram (Polyram)	G	96 / 24	(II) / (I)
	EBDC (high rate option)	G	24	(I)

Notes:
Rubigan, Nova, Procure; Trifloxystrobin (Flint) and Kresoxim-Methyl (Sovran); Vangard; and Dodine (Syllit) are different classes of fungicides and are all at risk for resistance development
Captan, sulfur are incompatible with oil;
Ratings are based on disease pressure, which takes into account disease history and prevailing weather patterns and specific weather parameters.
Combinations of SI's + EBDC's are used to combine the disease eradication activity of the SI with the disease protection activity of the EBDC.
Choice of fungicide at this early stage may be based on the occurrence of infection periods.
Sulfur and lime-sulfur would be used primarily by organic growers.
Lime-sulfur may cause phytotoxicity (yellowing of foliage, premature abscission).

"TO DO" list

Regulatory: None.

Research: Assessment of the sensitivity of the scab fungus to the various classes of fungicides should be conducted periodically; continue investigations on new materials for scab management; continue to examine new varieties for resistance to scab.

Education: Monitor infection periods and disseminate information to growers.

Powdery mildew	**CHEMICAL OPTIONS**			
	Fenarimol (Rubigan) + Captan	E	12 / 96	30 / (II)
	Fenarimol (Rubigan) + Mancozeb	E	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Metiram (Polyram)	E	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Ziram	E	12 / 48	30 / 14
	Myclobutanil (Nova) + Captan	E	24 / 96	14 / (II)
	Myclobutanil (Nova) + Mancozeb	E	24 / 24	14 / (I)
	Myclobutanil (Nova) + Metiram (Polyram)	E	24 / 24	14 / (I)
	Myclobutanil (Nova) + Ziram	E	24 / 48	14 / 14
	Triflumizole (Procure) + Captan	G	12 / 96	14 / (II)
	Triflumizole (Procure) + Mancozeb	G	12 / 24	14 / (I)
	Triflumizole (Procure) + Metiram (Polyram)	G	12 / 24	14 / (I)
	Triflumizole (Procure) + Ziram	G	12 / 48	14 / 14
	Kresoxim-Methyl (Sovran)	G - E	12	30
	Trifloxystrobin (Flint)	G - E	12	14
	Sulfur	F-G	24	0
	Lime-sulfur	G	48 (I)	(I)
	Triadimefon (Bayleton)	E	12	45 (III)
	JMS stylet oil	F-G	4	0
	CULTURAL OPTIONS			
	Remove infected terminals May be used in organic systems More effective if used at tight cluster stage	F		

Notes:

"TO DO" list

Regulatory: None.

Research: Continue investigations on new materials for mildew management; continue to examine new varieties for resistance to mildew; develop weather-based models for prediction of mildew incidence and severity.

Education: Make available new information on the disease susceptibility of new varieties

	CHEMICAL OPTIONS			
Rusts -	Fenarimol (Rubigan) + Mancozeb	E	12 / 24	30 / (I)
Cedar-apple rust	Fenarimol (Rubigan) + Metiram (Polyram)	E	12 / 24	30 / (I)
Quince rust	Fenarimol (Rubigan) + Ziram	E	12 / 48	30 / 14
	Myclobutanil (Nova) + Mancozeb	E	24 / 24	14 / (I)
	Myclobutanil (Nova) + Metiram (Polyram)	E	24 / 24	14 / (I)
	Myclobutanil (Nova) + Ziram	E	24 / 48	14 / 14
	Triflumizole (Procure) + Mancozeb	E	12 / 24	14 / (I)
	Triflumizole (Procure) + Metiram (Polyram)	E	12 / 24	14 / (I)
	Triflumizole (Procure) + Ziram	E	12 / 48	14 / 14
	Ziram	G	48	14
	Triadimefon (Bayleton)	E	12	45 (III)
	Kresoxim-Methyl (Sovran)	F-G	12	30
	Trifloxystrobin (Flint)	F-G	12	14
	CULTURAL			
	Remove infected cedars	V		

Notes: Combination of SI's with dithiocarbamate protectants are used for scab and mildew control

"TO DO" list

Regulatory: None.

Research: Continue to investigate the disease susceptibility of new varieties to rust pathogens.

Education: Make available new information on the disease susceptibility of new varieties.

*E = excellent efficacy; G = good; F = fair; P = poor, V = variable
$ = significantly more expensive than other chemical options, but disease complex controlled needs to be considered.

(I) = See label
(II) = See label. Restricted-entry interval may be more restrictive than days-to-harvest limitations.
(III) = Maximum 24 oz. per acre/per season

Bloom

Insects and mites

Target Insect/Mite	MANAGEMENT OPTIONS	Efficacy*	REI (hrs)	PHI (days)
Oriental fruit moth (OFM)	**CHEMICAL OPTIONS**			
	Other Chemicals			
	Acetamiprid (Assail)	G	12	7
	Indoxacarb (Avaunt)	G	12	28
	Methoxyfenozide (Intrepid)	G	4	14
	Unregistered Chemicals			
	Thiacloprid (Calypso)	G		
	NON-CHEMICAL OPTIONS			
	Pheromone mating disruption	E	4 (I)	0

Notes: Control is normally initiated at petal fall, but adults and early egg hatch may be targeted at bloom in high pressure situations. To avoid toxicity to bees, acetamiprid and indoxacarb should be applied at times when bees are not actively foraging with ample time allowed for spray to dry before bees become active. Pheromone mating disruption would normally not be used for first generation control, but if used would need to be initiated in the previous stage.

"TO DO" list

Regulatory: None.

Research: Determine population levels which justify control during bloom and compare efficacy of bloom versus pink control.

Education: Instruct growers in determining if control is needed at this stage.

Target Insect/Mite	MANAGEMENT OPTIONS	Efficacy*	REI (hrs)	PHI (days)
Codling moth (CM)	**NON-CHEMICAL OPTIONS**			
	Pheromone mating disruption	F-G$	4 (I)	0

Notes: Pheromone mating disruption must be initiated just prior to the beginning of moth flight. Differences in control exist for mating disruption options. It is costly and works better in larger orchards. It has been less effective in this region than in the Northwest due to orchard configuration (long and slender) and the influx of high numbers of CM from border areas (abandoned orchards and wild native hosts).

"TO DO" list

Regulatory: None.

Research: Continue to study pheromone mating disruption to include feasibility in the East, application methods, economics, and multiple-pest pheromone release systems.

Education: None.

*E = excellent; G = good; F = fair; P = poor efficacy.
$ = significantly more expensive than other chemical options.
(I) = For sprayable formulation.

Bloom

Diseases

TARGET DISEASE	MANAGEMENT OPTIONS	Efficacy*	REI (hrs)	PHI (days)
Scab	**CHEMICAL OPTIONS**			
	Dodine (Syllit)	Excellent (resistance may be present in some areas but in other areas may be useful for suppression of scab lesions)	48	7
	Captan	G	96	(II)
	Fenarimol (Rubigan) + Captan	E	12 / 96	30 / (II)
	Fenarimol (Rubigan) + Mancozeb	E	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Metiram (Polyram)	E	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Ziram	E	12 / 48	30 / 14
	Myclobutanil (Nova) + Captan	E	24 / 96	14 / (II)
	Myclobutanil (Nova) + Mancozeb	E	24 / 24	14 / (I)
	Myclobutanil (Nova) + Metiram (Polyram)	E	24 / 24	14 / (I)
	Myclobutanil (Nova) + Ziram	E	24 / 48	14 / 14
	Triflumizole (Procure) + Captan	E	12 / 96	14 / (II)
	Triflumizole (Procure) + Mancozeb	E	12 / 24	14 / (I)
	Triflumizole (Procure) + Metiram (Polyram)	E	12 / 24	14 / (I)
	Triflumizole (Procure) + Ziram	E	12 / 48	14 / 14
	Ziram	F-G	48	14
	Kresoxim-Methyl (Sovran)	E	12	30
	Trifloxystrobin (Flint)	E	12	14
	Sulfur	F	24	0
	Lime-sulfur	G	48 (I)	
	Ziram + Mancozeb	G	48 / 24	14 / (I)
	Ziram + Metiram (Polyram)	G	48 / 24	14 / (I)
	Captan + Mancozeb	G	96 / 24	(II) / (I)
	Captan + Metiram (Polyram)	G	96 / 24	(II) / (I)
	EBDC (high rate option)	G	24	(I)

Notes: Rubigan, Nova, Procure; Trifloxystrobin (Flint) and Kresoxim-Methyl (Sovran); Vangard; and Dodine (Syllit) are different classes of fungicides and are all at risk for resistance development.
Captan and sulfur are incompatible with oil.
Ratings are based on disease pressure, which takes into account disease history and prevailing weather patterns and specific weather parameters.
Combinations of SI's + EBDC's are used to combine the disease eradication activity of the SI with the disease protection activity of the EBDC.
Choice of fungicide at this early stage may be based on the occurrence of infection periods.
Sulfur and lime-sulfur would be used primarily by organic growers.
Lime-sulfur may cause phytotoxicity (yellowing of foliage, premature abscission).

"TO DO" list

Regulatory: None.

Research: None.

Education: Publication of regular bulletins during the season is important for decision-making. Monitor infection periods and disseminate information to growers.

Powdery mildew	Fenarimol (Rubigan) + Captan	E	12 / 96	30 / (II)
	Fenarimol (Rubigan) + Mancozeb	E	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Metiram (Polyram)	E	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Ziram	E	12 / 48	30 / 14
	Myclobutanil (Nova) + Captan	E	24 / 96	14 / (II)
	Myclobutanil (Nova) + Mancozeb	E	24 / 24	14 / (I)
	Myclobutanil (Nova) + Metiram (Polyram)	E	24 / 24	14 / (I)
	Myclobutanil (Nova) + Ziram	E	24 / 48	14 / 14
	Triflumizole (Procure) + Captan	G	12 / 96	14 / (II)
	Triflumizole (Procure) + Mancozeb	G	12 / 24	14 / (I)
	Triflumizole (Procure) + Metiram (Polyram)	G	12 / 24	14 / (I)
	Triflumizole (Procure) + Ziram	G	12 / 48	14 / 14
	Kresoxim-Methyl (Sovran)	G - E	12	30
	Trifloxystrobin (Flint)	G - E	12	14
	Sulfur	F- G	24	0
	Lime-sulfur	G	48 (I)	
	Triadimefon (Bayleton)	E	12	45 (III)
	JMS stylet oil	F-G	4	0
	Armicarb (eradicant, mildew only)	$ F-G	4	0
	BIOLOGICAL OPTIONS			
	AQ10 (mildew only)	F-G		
	CULTURAL OPTIONS			
	Remove infected terminals May be used in organic systems More effective if used at tight cluster stage	F		

Notes: Mildew control is achieved mostly with the SI portion of the combination.

"TO DO" list

Regulatory: None.

Research: None.

Education: None.

Rusts	**CHEMICAL OPTIONS**			
	Fenarimol (Rubigan) + Mancozeb	E	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Metiram (Polyram)	E	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Ziram	E	12 / 48	30 / 14
	Myclobutanil (Nova) + Mancozeb	E	24 / 24	14 / (I)
	Myclobutanil (Nova) + Metiram (Polyram)	E	24 / 24	14 / (I)
	Myclobutanil (Nova) + Ziram	E	24 / 48	14 / 14
	Triflumizole (Procure) + Mancozeb	E	12 / 24	14 / (I)
	Triflumizole (Procure) + Metiram (Polyram)	E	12 / 24	14 / (I)
	Triflumizole (Procure) + Ziram	E	12 / 48	14 / 14
	Ziram	G	48	14
	Triadimefon (Bayleton)	E	12	45 (III)
	Kresoxim-Methyl (Sovran)	F-G	12	30
	Trifloxystrobin (Flint)	F-G	12	14

	CULTURAL OPTIONS			
	Remove infected cedars	V		

Notes: Combination of SI's with dithiocarbamate protectants are used for scab control

"TO DO" list

Regulatory: None.

Research: None.

Education: None.

Fire blight	**CHEMICAL OPTIONS**			
	Streptomycin (Agri-mycin 17)	E	12	50
	Copper	F-G		
	Serenade	P-F	4	0
	Messenger	P	4	0
	Fosetyl-Al (Aliette)	P-F	12	(I)
	CULTURAL OPTIONS			
	BIOLOGICAL OPTIONS			
	BlightBan	F	4	

Notes: Effective fire blight management depends on use of predictive model such as Maryblyt or Cougarblight to predict infection periods and properly time Streptomycin (Agri-mycin 17) applications.
BlightBan seems to work more effectively on the west coast.
Percent of acres on which Streptomycin (Agri-mycin 17) is used for fire blight is 30 to 40% but is increasing as more susceptible cultivars and rootstocks are being planted.
In most seasons there can be two to four applications of streptomycin during the bloom period.
Copper applied at this stage can cause fruit russeting.

"TO DO" list

Regulatory: Streptomycin (Agri-mycin 17) is the only effective choice at this time. Mycoshield (not registered for this use) is fair against fire blight and could be used in a resistance management program to help maintain the effectiveness of streptomycin. Oxolinic acid (not registered for this use) has shown good control of fire blight in recent tests. Actigard (not registered for this use) is poor to fair against fire blight.

Research: Because of the potential for resistance to Streptomycin (Agri-mycin 17), evaluation of new materials should continue; continue to improve predictive models for fire blight; at what age do susceptible rootstocks become resistant; local evaluation of rootstocks for blight resistance.

Education: Monitor infection periods and make information available to growers and consultants.

*E = excellent efficacy; G = good; F = fair; P = poor, V = variable
$ = significantly more expensive than other chemical options, but disease complex controlled needs to be considered.

(I) = See label
(II) = See label. Restricted-entry interval may be more restrictive than days-to-harvest limitations.
(III) = Maximum 24 oz. per acre/per season

Petal fall

Insects and mites

Target Insect/Mite	MANAGEMENT OPTIONS	Efficacy*	REI (hrs)	PHI (days)
Plum curculio (PC)	**CHEMICAL OPTIONS**			
	Organophosphates			
	Azinphos-methyl (Guthion)	E	(I)	14 (II)
	Phosmet (Imidan)	E	72	7
	Carbamates			
	Carbaryl (Sevin)	G	12	3
	Pyrethroids			
	Cyhalothrin (Warrior)	G	24	21
	Esfenvalerate (Asana)	G	12	21
	Fenpropathrin (Danitol)	G	24	14
	Permethrin (Pounce, Ambush)	G	12	(III)
	Other Chemicals			
	Indoxacarb (Avaunt)	G$	12	28
	Kaolin (Surround)	F$	4	0
	Thiamethoxam (Actara)	G$	12	14 or 35 (IV)
	Acetamiprid (Assail)	G$	12	7
	NON-CHEMICAL OPTIONS			
	None identified			

Notes: There are no alternatives, either registered or unregistered, that provide as effective control as azinphos-methyl or phosmet. Higher rate of Imidan is needed to provide comparable control to Azinphos-methyl. Pyrethroids at this stage are likely to disrupt mite management programs for the entire season by destroying predators.

"TO DO" list

Regulatory: Address phenological issues related to trade barriers.

Research: Develop population monitoring tools/thresholds for spray timing. Validate degree day model for predicting end of oviposition. Improvement of pheromones for monitoring. Evaluate new compounds for efficacy. Conduct PHI and residue studies for use in mitigation strategies. Determine impact of bivoltine generation and northern/southern strain overlap. Determine role of ground cover in overwintering.

Education: New tools and pest management practices are needed before education can occur.

Target Insect/Mite	MANAGEMENT OPTIONS	Efficacy*	REI (hrs)	PHI (days)
Oriental fruit moth (OFM)	**NON-CHEMICAL OPTIONS**			
	Pheromone mating disruption	E	4 (V)	0

Notes: First generation is generally controlled with the petal fall spray for PC. Specific control is recommended at 350-375 degree days after biofix if the pheromone trap capture exceeds 30 moths per trap per week. Pheromone mating disruption is not practical at this stage because of the pest complex present that may be controlled with insecticide application.

	NON-CHEMICAL OPTIONS			

Codling moth (CM)	Pheromone mating disruption	F-G$	4 (V)	0

Notes: Pheromone mating disruption must be initiated just prior to the beginning of moth flight, which may occur during bloom. Differences in control exist for mating disruption options. It is costly and works better in larger orchards. It has been less effective in this region than in the Northwest due to orchard configuration (long and slender) and the influx of high numbers of CM from border areas (abandoned orchards and wild native hosts).

"TO DO" list

Regulatory: None.

Research: Continue to study pheromone mating disruption to include feasibility in the East, application methods, economics, and multiple-pest pheromone release systems.

Education: None.

European apple sawfly (EAS)	CHEMICAL OPTIONS	Efficacy*	REI (hr)	PHI (days)
	Organophosphates			
	Azinphos-methyl (Guthion)	E	(I)	14 (II)
	Phosmet (Imidan)	E	72	7
	Pyrethroids			
	Cyhalothrin (Warrior)	G-E	24	21
	Esfenvalerate (Asana)	G-E	12	21
	Fenpropathrin (Danitol)	G-E	24	14
	Permethrin (Pounce, Ambush)	G-E	12	(III)
	Other Chemicals			
	Indoxacarb (Avaunt)	G$	12	28
	Thiamethoxam (Actara)	G$	12	14 or 35 (IV)
	Acetamiprid (Assail)	G$	12	7
	Unregistered Chemicals			
	Thiacloprid (Calypso)	G		
	NON-CHEMICAL OPTIONS			
	None identified			

Notes: A relatively new pest to the mid-Atlantic region with serious potential. Populations are moving southerly. Late bloom to early petal fall timing is very important for control. Pyrethroids at this stage are likely to disrupt mite management programs for the entire season by destroying predators. Other chemicals have yet to be proven against this pest.

"TO DO" list

Regulatory: None.

Research: Conduct studies on pest distribution, biology, and behavior. Develop and evaluate monitoring techniques and thresholds. Screen for potential new management tools. Survey for natural enemies.

Education: Provide instruction on pest biology and behavior, and use of monitoring tools once developed.

Plant bugs (TPB, MB)	CHEMICAL OPTIONS	Efficacy *	REI (hrs)	PHI (days)
	Organophosphates			
	Azinphos-methyl (Guthion)	F-G	(I)	14 (II)

	Phosmet (Imidan)	F	72	7
	Carbamates			
	Methomyl (Lannate)	G	72	14
	Pyrethroids			
	Cyhalothrin (Warrior)	E	24	21
	Esfenvalerate (Asana)	E	12	21
	Fenpropathrin (Danitol)	E	24	14
	Permethrin (Pounce, Ambush)	E	12	(III)
	Other Chemicals			
	Endosulfan (Thionex)	G-E	24	21 or 30 (IV)
	Formetanate HCL (Carzol)	G-E	(IV)	(III)
	Indoxacarb (Avaunt)	G	12	28
	Thiamethoxam (Actara)	G	12	14 or 35 (IV)
	Unregistered Chemicals			
	Thiacloprid (Calypso)	?		
	NON-CHEMICAL OPTIONS			
	Manage broadleaf weeds	E		

Notes: Pyrethroids and methomyl are generally discouraged at this time because of toxicity to mite predators, resulting in mite increases.

"TO DO" list

Regulatory: None.

Research: Evaluate new materials. Conduct pheromone work for monitoring. Determine biology, impact and monitoring procedures for mullein bug in the East.

Education: Train growers in use of monitoring procedures.

Redbanded leafroller (RBLR)	**CHEMICAL OPTIONS**	Efficacy *	REI (hrs)	PHI (days)
	Organophosphates			
	Azinphos-methyl (Guthion)	G	(I)	14 (II)
	Phosmet (Imidan)	G	72	7
	Carbamates			
	Methomyl (Lannate)	E	72	14
	Carbaryl (Sevin)	F	12	3
	Pyrethroids			
	Cyhalothrin (Warrior)	E	24	21
	Esfenvalerate (Asana)	E	12	21
	Fenpropathrin (Danitol)	E	24	14
	Permethrin (Pounce, Ambush)	E	12	(III)
	Other Chemicals			
	BT	G-E	4	0
	Methoxyfenozide (Intrepid)	E	4	14
	Spinosad (SpinTor, Entrust)	E	4	7
	Unregistered Chemicals			
	Emamectin benzoate (Proclaim)	E		
	NON-CHEMICAL OPTIONS			
	Pheromone mating disruption	G-E$		

Notes: This insect has been problematic in a few mid-Atlantic orchards in recent years. Pyrethroids are generally discouraged at this time because of toxicity to mite predators, resulting in mite increases.

"TO DO" list

Regulatory: None.

Research: Evaluate pheromone mating disruption. Screen populations for insecticide resistance. Evaluate potential of new products as ovicides.

Education: None.

Green fruitworm (GFW)	**CHEMICAL OPTIONS**	Efficacy *	REI (hrs)	PHI (days)
	Organophosphates			
	Azinphos-methyl (Guthion)	G	(I)	14 (II)
	Phosmet (Imidan)	F	72	7
	Carbamates			
	Methomyl (Lannate)	G	72	14
	Carbaryl (Sevin)	F	12	3
	Pyrethroids			
	Cyhalothrin (Warrior)	G	24	21
	Esfenvalerate (Asana)	G	12	21
	Fenpropathrin (Danitol)	G	24	14
	Permethrin (Pounce, Ambush)	G	12	(III)
	Other Chemicals			
	BT	F-G	4	0
	Methoxyfenozide (Intrepid)	G-E	4	14
	NON-CHEMICAL OPTIONS			
	None identified			

Notes: Pyrethroids are generally discouraged at this time because of toxicity to mite predators, resulting in mite increases. This pest may be controlled with materials and timings for RBLR and OBLR.

"TO DO" list

Regulatory: None.

Research: Develop and screen new materials.

Education: None.

White apple leafhopper (WALH)	**CHEMICAL OPTIONS**	Efficacy *	REI (hrs)	PHI (days)
	Organophosphates			
	Dimethoate (Cygon)	G	48	28
	Carbamates			
	Carbaryl (Sevin)	G-E	12	3
	Methomyl (Lannate)	G	72	14
	Oxamyl (Vydate)	F-G	48	14
	Pyrethroids			
	Cyhalothrin (Warrior)	G	24	21
	Esfenvalerate (Asana)	G	12	21
	Fenpropathrin (Danitol)	G	24	14

	Permethrin (Pounce, Ambush)	G	12	(III)
	Other Chemicals			
	Acetamiprid (Assail)	E	12	7
	Avermectin (Agri-mek)	F-G$	12	28
	Endosulfan (Thionex)	G	24	21 or 30 (IV)
	Formetanate HCL (Carzol)	E	(IV)	(III)
	Imidacloprid (Provado)	E	12	7
	Indoxacarb (Avaunt)	F-G	12	28
	Kaolin (Surround)	F-G$	4	0
	Thiamethoxam (Actara)	E	12	14 or 35 (IV)
	Unregistered Chemicals			
	Thiacloprid (Calypso)	E		
	NON-CHEMICAL OPTIONS			
	Predators and parasites	F-G		

Notes: In many orchards, populations of first generation do not exceed threshold and treatment is not needed. Pyrethroids are generally discouraged at this time because of toxicity to mite predators, resulting in mite increases. Predators and parasites can aid in reducing leafhopper populations, but are generally not sufficient to provide complete control.

"TO DO" list

Regulatory: None.

Research: Identify impact of various predators in control.

Education: None.

European red mite (ERM)	**CHEMICAL OPTIONS**	Efficacy*	REI (hr)	PHI (days)
	Carbamates			
	Oxamyl (Vydate)	F-G	48	14
	Other Chemicals			
	Avermectin (Agri-mek)	E	12	28
	Clofentezine (Apollo)	E	12	45
	Hexythiazox (Savey)	E	12	28
	Oil	E	12	0
	Pyridaben (Pyramite)	E	12	25
	Bifenazate (Acramite)	G-E	12	7
	Unregistered Chemicals			
	None identified			
	NON-CHEMICAL OPTIONS			
	Predators	F		

Notes: Use of oil may result in compatibility problems when tank mixed with certain fungicides. Predators are not usually abundant enough this early in the season to provide sufficient biological control.
Pyramite and Acramite are not recommended at this stage, but should be reserved for summer use to avoid resistance problems.

"TO DO" list

Regulatory: None.

Research: None.

Education: Provide instruction in early season use of oil for mite management.

*E = excellent; G = good; F = fair; P = poor efficacy.
$ = significantly more expensive than other chemical options, but pest complex controlled needs to be considered.
(I) = See label. Restricted-entry interval may be more restrictive than days-to-harvest limitations.
(II) = 21 days if over 2 lbs/acre .
(III) = Apply no later than petal fall.
(IV) = See label.
(V) = For sprayable formulation

Petal Fall

Diseases

TARGET DISEASE	MANAGEMENT OPTIONS		Efficacy*	REI (hrs)	PHI (days)
	CHEMICAL OPTIONS				
Scab	Dodine (Syllit)	Excellent (resistance may be present in some areas but in other areas may be useful for suppression of scab lesions)		48	7
	Captan		G	96	U
	Fenarimol (Rubigan) + Captan		E	12 / 96	30 / (II)
	Fenarimol (Rubigan) + Mancozeb		E	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Metiram (Polyram)		E	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Ziram		E	12 / 48	30 / 14
	Myclobutanil (Nova) + Captan		E	24 / 96	14 / (II)
	Myclobutanil (Nova) + Mancozeb		E	24 / 24	14 / (I)
	Myclobutanil (Nova) + Metiram (Polyram)		E	24 / 24	14 / (I)
	Myclobutanil (Nova) + Ziram		E	24 / 48	14 / 14
	Triflumizole (Procure) + Captan		E	12 / 96	14 / (II)
	Triflumizole (Procure) + Mancozeb		E	12 / 24	14 / (I)
	Triflumizole (Procure) + Metiram (Polyram)		E	12 / 24	14 / (I)
	Triflumizole (Procure) + Ziram		E	12 / 48	14 / 14
	Ziram		F-G	48	14
	Kresoxim-Methyl (Sovran)		E	12	30
	Trifloxystrobin (Flint)		E	12	14
	Sulfur		F	24	0
	Lime-sulfur		G	48 (I)	
	Ziram + Mancozeb		G	48 / 24	14 / (I)
	Ziram + Metiram (Polyram)		G	48 / 24	14 / (I)
	Captan + Mancozeb		G	96 / 24	(II) / (I)
	Captan + Metiram (Polyram)		G	96 / 24	(II) / (I)
	EBDC (high rate option)		G	24	(I)

Notes:
Rubigan, Nova, Procure; Trifloxystrobin (Flint) and Kresoxim-Methyl (Sovran); Vangard; and Dodine (Syllit) are

different classes of fungicides and are all at risk for resistance development.
Captan, sulfur are incompatible with oil.
Ratings are based on disease pressure, which takes into account disease history and prevailing weather patterns and specific weather parameters.
Combinations of SI's + EBDC's are used to combine the disease eradication activity of the SI with the disease protection activity of the EBDC.
Choice of fungicide at this early stage may be based on the occurrence of infection periods.
Sulfur and lime-sulfur would be used primarily by organic growers.
Lime-sulfur may cause phytotoxicity (yellowing of foliage, premature abscission).

"TO DO" list

Regulatory: None.

Research: Assessment of the sensitivity of the scab fungus to the various classes of fungicides should be conducted periodically; continue investigations on new materials for scab management; continue to examine new varieties for resistance to scab.

Education: None.

Powdery mildew	**CHEMICAL OPTIONS**			
	Fenarimol (Rubigan) + Captan	E	12 / 96	30 / (II)
	Fenarimol (Rubigan) + Mancozeb	E	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Metiram (Polyram)	E	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Ziram	E	12 / 48	30 / 14
	Myclobutanil (Nova) + Captan	E	24 / 96	14 / (II)
	Myclobutanil (Nova) + Mancozeb	E	24 / 24	14 / (I)
	Myclobutanil (Nova) + Metiram (Polyram)	E	24 / 24	14 / (I)
	Myclobutanil (Nova) + Ziram	E	24 / 48	14 / 14
	Triflumizole (Procure) + Captan	G	12 / 96	14 / (II)
	Triflumizole (Procure) + Mancozeb	G	12 / 24	14 / (I)
	Triflumizole (Procure) + Metiram (Polyram)	G	12 / 24	14 / (I)
	Triflumizole (Procure) + Ziram	G	12 / 48	14 / 14
	Kresoxim-Methyl (Sovran)	G - E	12	30
	Trifloxystrobin (Flint)	G - E	12	14
	Sulfur	F-G	24	0
	Lime-sulfur	G	48 (I)	
	Triadimefon (Bayleton)	E	12	45 (III)
	JMS stylet oil	F-G	4	0
	Armicarb (eradicant, mildew only)	$ F-G	4	0
	BIOLOGICAL OPTIONS	F-G		
	AQ10 (mildew only)			
	CULTURAL OPTIONS			
	Remove infected terminals May be used in organic systems More effective if used at tight cluster stage	F		

Notes: Mildew control is achieved mostly with the SI portion of the combination.

"TO DO" list

Regulatory: None.

Research: Continue investigations on new materials for mildew management; continue to examine new varieties for resistance to mildew.

Education: Make available new information on the disease susceptibility of new varieties.

Rusts	**CHEMICAL OPTIONS**			
	Fenarimol (Rubigan) + Mancozeb	E	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Metiram (Polyram)	E	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Ziram	E	12 / 48	30 / 14
	Myclobutanil (Nova) + Mancozeb	E	24 / 24	14 / (I)
	Myclobutanil (Nova) + Metiram (Polyram)	E	24 / 24	14 / (I)
	Myclobutanil (Nova) + Ziram	E	24 / 48	14 / 14
	Triflumizole (Procure) + Mancozeb	E	12 / 24	14 / (I)
	Triflumizole (Procure) + Metiram (Polyram)	E	12 / 24	14 / (I)
	Triflumizole (Procure) + Ziram	E	12 / 48	14 / 14
	Ziram	G	48	14
	Triadimefon (Bayleton)	E	12	45 (III)
	Kresoxim-Methyl (Sovran)	F-G	12	30
	Trifloxystrobin (Flint)	F-G	12	14
	CULTURAL OPTIONS			
	Remove infected cedars	V		

Notes: Combination of SI's with dithiocarbamate protectants are used for scab control.

"TO DO" list

Regulatory: None.

Research: None.

Education: Make available new information on the disease susceptibility of new varieties.

Rots and frogeye leaf spot	**CHEMICAL OPTIONS**			
	Captan	G	96	U
	Fenarimol (Rubigan) + Captan	F	12 / 96	30 / (II)
	Fenarimol (Rubigan) + Mancozeb	F	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Metiram (Polyram)	F	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Ziram	F	12 / 48	30 / 14
	Myclobutanil (Nova) + Captan	F	24 / 96	14 / (II)
	Myclobutanil (Nova) + Mancozeb	F	24 / 24	14 / (I)
	Myclobutanil (Nova) + Metiram (Polyram)	F	24 / 24	14 / (I)
	Myclobutanil (Nova) + Ziram	F	24 / 48	14 / 14
	Ziram	G	48	14
	Kresoxim-Methyl (Sovran)	G	12	30
	Trifloxystrobin (Flint)	G	12	14
	Sulfur	P	24	0
	Lime-sulfur	P	48 (I)	(I)
	Copper	G	(I)	(I)
	Thiram	F	24	0
	Ziram + EBDC	G	48 / 24 (I)	14
	Captan + EBDC	G	96 / 24 (I)	(II)
	Trifloxystrobin (Flint) + Captan	G	12 / 96	14 / (II)
	CULTURAL OPTIONS			
	Remove inoculum sources			

Notes: When oil is used for thinning or mite control, use of Captan is incompatible.

Copper may cause phytotoxicity to fruit and foliage when applied at this stage of development.
Captan has potential restrictions for baby food production (marketing issue).

"TO DO" list

Regulatory: Restrictions on Captan use for export to Canada.

Research: Timing for latent infections; predictive modeling; weather conditions for rot; methods for inoculum quantitation for rot fungi.

Education: None.

Fire blight	**CHEMICAL OPTIONS**			
	Prohexadione-Calcium (Apogee)	$ G-E	12	45

Notes: Describe management options for fire blight after bloom and resistance management concerns with Streptomycin (Agri-mycin 17).

"TO DO" list

Regulatory: Prohexadione-Calcium (Apogee) is the only effective choice for shoot blight management at this time; effectiveness of copper for shoot blight control is variable.

Research: Because of the potential for resistance to Streptomycin (Agri-mycin 17) and cost of Prohexadione-Calcium (Apogee), evaluation of new materials should continue; continue to improve predictive models for fire blight; at what age do susceptible rootstocks become resistant; local evaluation of rootstocks for blight resistance; determine insects associated with fire blight shoot blight epidemics.
Education: monitor infection periods and make information available to growers and consultants.

*E = excellent efficacy; G = good; F = fair; P = poor, V = variable
$ = significantly more expensive than other chemical options, but disease complex controlled needs to be considered.

(I) = See label
(II) = See label. Restricted-entry interval may be more restrictive than days-to-harvest limitations.
(III) = Maximum 24 oz. per acre/per season.

10-30 days postbloom

Insects and mites

Target Insect/Mite	MANAGEMENT OPTIONS	Efficacy*	REI (hrs)	PHI (days)
Codling moth (CM)	**CHEMICAL OPTIONS**			
	Organophosphates			
	Azinphos-methyl (Guthion)	E	(I)	14 (II)
	Phosmet (Imidan)	G	72	7
	Carbamates			
	Methomyl (Lannate)	G	72	14

	Carbaryl (Sevin)	G	12	3
	Pyrethroids			
	Cyhalothrin (Warrior)	E	24	21
	Esfenvalerate (Asana)	E	12	21
	Fenpropathrin (Danitol)	E	24	14
	Other Chemicals			
	Acetamiprid (Assail)	G$	12	7
	Azadirachtin (Aza-Direct)	F-G	4	0
	Indoxacarb (Avaunt)	G	12	28
	Kaolin (Surround)	P-F$	4	0
	Methoxyfenozide (Intrepid)	G	4	14
	Oil	F	12	0
	Pyriproxyfen (Esteem)	F-G	12	45
	Unregistered Chemicals			
	Fenoxycarb	?		
	Novaluron (Diamond)	G		
	Thiacloprid (Calypso)	F-G		

Notes: A major driver of OP use and the main target during this time period. Control is recommended at various degree day timings (depending upon product) if the pheromone trap capture exceeds 5 moths per trap per week. High rates of carbamates are needed to be effective which may lead to mite increases; short residual of methomyl. Pyrethroids are discouraged at this time because of toxicity to mite predators, resulting in mite increases. Control with kaolin has been inconsistent. Use of oil may result in incompatibility when tank mixed with certain fungicides. Resistance to azinphos-methyl has been reported in the Northwest. Resistance to fenoxycarb and methoxyfenozide, and cross resistance to the pyrethroids has been reported in Europe. High rates of Assail and Intrepid are needed to provide effective control. Surround and Aza-Direct are organic options.

"TO DO" list

Regulatory: Register new compounds. Legislation dealing with abandoned orchard removal. Address tolerance issue for internal worms.

Research: Screen new insecticides. Continue to study pheromone mating disruption to include feasibility in the East, application methods, economics, multiple-pest pheromone release systems. Identify cross resistance between new products and OPs. Determine contribution to commercial orchards from abandoned orchard and wild host populations. Evaluate efficacy of granulosis virus.

Education: Teach growers new methods, spray timing and techniques as they become available.

Plum curculio (PC)				

Notes: A second application may be needed at first cover to control this insect. See petal fall stage above for management options and needs.

Borers (DWB, APB, ABB)	**CHEMICAL OPTIONS**	Efficacy *	REI (hrs)	PHI (days)
	Organophosphates			
	Chlorpyrifos (Lorsban)	E	96	28 (III)
	Pyrethroids			
	Esfenvalerate (Asana)	G	12	21

	Other Chemicals			
	Endosulfan (Thionex)	G	24	21 or 30 (IV)
	Indoxacarb (Avaunt)	G	12	28
	Unregistered Chemicals			
	None identified			
	NON-CHEMICAL OPTIONS			
	Mound soil to cover burr knots	G		
	Weed control around trunks	G		
	White paint on trunks	F		
	Deeper planting of trees	E		
	Avoid spiral-wrap tree guards	F-G		

Notes: Chlorpyrifos has provided the most effective and consistent control with wide flexibility in application timing. This pest is likely to increase in importance with increased planting of dwarf trees which are more prone to burr knot formation.

"TO DO" list

Regulatory: Provide incentives to develop new products.

Research: Identify specific pheromone for monitoring. Evaluate pheromone mating disruption/attract and kill. Develop resistant rootstock/scion combinations. Evaluate various cultural practices such as orchard floor management, role of tree guards. Screen new products/application methods for efficacy. Conduct biological/life history studies.

Education: Instruct growers on use of new monitoring/management tools as they become available. Instruct growers on role of mouse guards in promoting burr knot/borer incidence. Train growers in identifying pest species and damage.

Potato leafhopper (PLH)	**CHEMICAL OPTIONS**	Efficacy *	REI (hrs)	PHI (days)
	Organophosphates			
	Azinphosmethyl (Guthion)	F	(I)	14 (II)
	Dimethoate (Cygon)	G	48	28
	Carbamates			
	Carbaryl (Sevin)	E	12	3
	Methomyl (Lannate)	G	72	14
	Oxamyl (Vydate)	G	48	14
	Pyrethroids			
	Cyhalothrin (Warrior)	G	24	21
	Esfenvalerate (Asana)	G	12	21
	Fenpropathrin (Danitol)	G	24	14
	Other Chemicals			
	Acetamiprid (Assail)	E	12	7
	Endosulfan (Thionex)	G	24	21 or 30 (IV)
	Imidacloprid (Provado)	E	12	7
	Kaolin (Surround)	F$	4	0
	Thiamethoxam (Actara)	E	12	14 or 35 (IV)
	Unregistered Chemicals			
	Thiacloprid (Calypso)	E		

Notes: This insect is primarily a problem on young trees.

“TO DO” list

Regulatory: None.

Research: Identify and determine role of natural enemies as control agents.

Education: None.

*E = excellent; G = good; F = fair; P = poor efficacy.
$ = significantly more expensive than other chemical options, but pest complex controlled needs to be considered.
(I) = See label. Restricted-entry interval may be more restrictive than days-to-harvest limitations.
(II) = 21 days if over 2 lbs/acre.
(III) = Postbloom handgun application to lower 4 ft of trunk for borer control.
(IV) = See label.

10-30 days postbloom

Diseases

TARGET DISEASE	MANAGEMENT OPTIONS	Efficacy*	REI (hrs)	PHI (days)
Scab	**CHEMICAL OPTIONS**			
	Dodine (Syllit)	Excellent (resistance may be present in some areas but in other areas may be useful for suppression of scab lesions)	48	7
	Captan	G	96	U
	Fenarimol (Rubigan) + Captan	E	12 / 96	30 / (II)
	Fenarimol (Rubigan) + Mancozeb	E	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Metiram (Polyram)	E	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Ziram	E	12 / 48	30 / 14
	Myclobutanil (Nova) + Captan	E	24 / 96	14 / (II)
	Myclobutanil (Nova) + Mancozeb	E	24 / 24	14 / (I)
	Myclobutanil (Nova) + Metiram (Polyram)	E	24 / 24	14 / (I)
	Myclobutanil (Nova) + Ziram	E	24 / 48	14 / 14
	Triflumizole (Procure) + Captan	E	12 / 96	14 / (II)
	Triflumizole (Procure) + Mancozeb	E	12 / 24	14 / (I)
	Triflumizole (Procure) + Metiram (Polyram)	E	12 / 24	14 / (I)
	Triflumizole (Procure) + Ziram	E	12 / 48	14 / 14
	Ziram	F-G	48	14
	Kresoxim-Methyl (Sovran)	E	12	30
	Trifloxystrobin (Flint)	E	12	14
	Sulfur	F	24	0
	Lime-sulfur	G	48 (I)	(I)
	Ziram + Mancozeb	G	48 / 24	14 / (I)
	Ziram + Metiram (Polyram)	G	48 / 24	14 / (I)
	Captan + Mancozeb	G	96 / 24	(II) / (I)
	Captan + Metiram (Polyram)	G	96 / 24	(II) / (I)

	EBDC (high rate option)	G	24	(I)

Notes: Rubigan, Nova, Procure; Trifloxystrobin (Flint) and Kresoxim-Methyl (Sovran); Vangard; and Dodine (Syllit) are different classes of fungicides and are all at risk for resistance development
Captan, sulfur are incompatible with oil;
Ratings are based on disease pressure, which takes into account disease history and prevailing weather patterns and specific weather parameters.
Combinations of SI's + EBDC's are used to combine the disease eradication activity of the SI with the disease protection activity of the EBDC.
Choice of fungicide at this early stage may be based on the occurrence of infection periods
Sulfur and lime-sulfur would be used primarily by organic growers
Lime-sulfur may cause phytotoxicity (yellowing of foliage, premature abscission)

"TO DO" list

Regulatory: None.

Research: Assessment of the sensitivity of the scab fungus to the various classes of fungicides should be conducted periodically; continue investigations on new materials for scab management; continue to examine new varieties for resistance to scab; validate degree-day models for the end of primary scab season.

Education: None.

Powdery mildew	**CHEMICAL OPTIONS**			
	Fenarimol (Rubigan) + Captan	E	12 / 96	30 / (II)
	Fenarimol (Rubigan) + Mancozeb	E	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Metiram (Polyram)	E	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Ziram	E	12 / 48	30 / 14
	Myclobutanil (Nova) + Captan	E	24 / 96	14 / (II)
	Myclobutanil (Nova) + Mancozeb	E	24 / 24	14 / (I)
	Myclobutanil (Nova) + Metiram (Polyram)	E	24 / 24	14 / (I)
	Myclobutanil (Nova) + Ziram	E	24 / 48	14 / 14
	Triflumizole (Procure) + Captan	G	12 / 96	14 / (II)
	Triflumizole (Procure) + Mancozeb	G	12 / 24	14 / (I)
	Triflumizole (Procure) + Metiram (Polyram)	G	12 / 24	14 / (I)
	Triflumizole (Procure) + Ziram	G	12 / 48	14 / 14
	Kresoxim-Methyl (Sovran)	G - E	12	30
	Trifloxystrobin (Flint)	G - E	12	14
	Sulfur	F-G	24	0
	Lime-sulfur	G	48 (I)	(I)
	Triadimefon (Bayleton)	E	12	45 (III)
	Armicarb (eradicant, mildew only)	$ F-G	(I)	(I)
	JMS stylet oil	F-G	(I)	(I)
	BIOLOGICAL OPTIONS			
	AQ10 (mildew only)	F-G	(I)	(I)
	CULTURAL OPTIONS			
	Remove infected terminals May be used in organic systems More effective if used at tight cluster stage	F		

Notes: Mildew control is achieved mostly with the SI portion of the combination

"TO DO" list

Regulatory: None.

Research: Continue investigations on new materials for mildew management; continue to examine new varieties for resistance to mildew

Education: Make available new information on the disease susceptibility of new varieties

Rusts	**CHEMICAL OPTIONS**			
	Fenarimol (Rubigan) + Mancozeb	E	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Metiram (Polyram)	E	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Ziram	E	12 / 48	30 / 14
	Myclobutanil (Nova) + Mancozeb	E	24 / 24	14 / (I)
	Myclobutanil (Nova) + Metiram (Polyram)	E	24 / 24	14 / (I)
	Myclobutanil (Nova) + Ziram	E	24 / 48	14 / 14
	Triflumizole (Procure) + Mancozeb	E	12 / 24	14 / (I)
	Triflumizole (Procure) + Metiram (Polyram)	E	12 / 24	14 / (I)
	Triflumizole (Procure) + Ziram	E	12 / 48	14 / 14
	Ziram	G	48	14
	Triadimefon (Bayleton)	E	12	45 (III)
	Kresoxim-Methyl (Sovran)	F-G	12	30
	Trifloxystrobin (Flint)	F-G	12	14
	CULTURAL OPTIONS			
	Remove infected cedars	V		

Notes: Kresoxim-Methyl (Sovran) and Trifloxystrobin (Flint) applications are limited to a maximum of 4 per year, no more than 3 consecutive applications, with at least 2 applications of different chemistry materials in between (see recommendation in spray guide and place this note on each page where these products are listed); combination of SI's with dithiocarbamate protectants are used for scab control

"TO DO" list

Regulatory: None.

Research: None.

Education: Make available new information on the disease susceptibility of new varieties

Rots and frogeye leaf spots	**CHEMICAL OPTIONS**			
	Captan	G	96	U
	Fenarimol (Rubigan) + Captan	F	12 / 96	30 / (II)
	Fenarimol (Rubigan) + Mancozeb	F	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Metiram (Polyram)	F	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Ziram	F	12 / 48	30 / 14
	Myclobutanil (Nova) + Captan	F	24 / 96	14 / (II)
	Myclobutanil (Nova) + Mancozeb	F	24 / 24	14 / (I)
	Myclobutanil (Nova) + Metiram (Polyram)	F	24 / 24	14 / (I)
	Myclobutanil (Nova) + Ziram	F	24 / 48	14 / 14
	Ziram	G	48	14
	Kresoxim-Methyl (Sovran)	G	12	30
	Trifloxystrobin (Flint)	G	12	14
	Sulfur	P	24	0
	Lime-sulfur	P	48 (I)	(I)
	Copper	G	(I)	(I)
	Thiram	F	24	0
	Ziram + EBDC	G	48 /	14 /

	Captan + EBDC	G	96 /	(II) /
	Trifloxystrobin (Flint) + Captan	G	12 / 96	14 / (II)
	CULTURAL OPTIONS			
	Remove inoculum sources			

Notes: When oil is used for thinning or mite control, use of captan is incompatible.
Copper may cause phytotoxicity to fruit and foliage when applied at this stage of development.
Captan has potential restrictions for baby food production (marketing issue).
Approaching 2nd cover growers need to be aware of the 77-day preharvest interval for EBDC's.

"TO DO" list

Regulatory: None.

Research: Timing for latent infections; predictive modeling; weather conditions for rot; methods for inoculum quantitation for rot fungi;

Education: None.

*E = excellent efficacy; G = good; F = fair; P = poor, V = variable
$ = significantly more expensive than other chemical options, but disease complex controlled needs to be considered.
(I) = See label
(II) = See label. Restricted-entry interval may be more restrictive than days-to-harvest limitations.
(III) = Maximum 24 oz. per acre/per season

30-60 days postbloom

Insects and mites

Target Insect/Mite	MANAGEMENT OPTIONS	Efficacy*	REI (hrs)	PHI (days)
Codling moth (CM)				

Notes: A second insecticide application may be needed during this time period. See the previous time period for management options and needs.

San Jose scale (SJS)	**CHEMICAL OPTIONS**			
	Other Chemicals			
	Avermectin (Agri-Mek)	G$	12	28
	Imidacloprid (Provado)	G	12	7
	Methomyl (Lannate)	F	72	14
	Pyriproxyfen (Esteem)	E$	12	45
	Unregistered Chemicals			
	None identified			

Notes: Sprays are targeted against the crawler stage and may be timed by degree days or the use of black electrician's tape.

"TO DO" list

Regulatory: Provide incentives for development of new products.

Research: Develop and evaluate new compounds. Validate degree day model in the East. Evaluate potential of parasites to provide biological control and integrate with pesticide timing. Determine efficacy of newer neonicotinoids.

Education: Train growers in the use of new tools as they become available.

Leafrollers **Tufted apple bud moth (TABM)** **Variegated leafroller (VLR)** **Oblique-banded leafroller (OBLR)** **Redbanded leafroller (RBLR)**	**CHEMICAL OPTIONS**	Efficacy *	REI (hrs)	PHI (days)
	Organophosphates			
	Azinphos-methyl (Guthion)	F	(I)	14 (II)
	Carbamates			
	Methomyl (Lannate)	G-E	72	14
	Pyrethroids			
	Cyhalothrin (Warrior)	E	24	21
	Esfenvalerate (Asana)	E	12	21
	Fenpropathrin (Danitol)	E	24	14
	Other Chemicals			
	BT	G	4	0
	Indoxacarb (Avaunt)	F-G	12	28
	Methoxyfenozide (Intrepid)	E	4	14
	Spinosad (SpinTor, Entrust)	E	4	7
	Unregistered Chemicals			
	Emamectin benzoate (Proclaim)	E		
	NON-CHEMICAL OPTIONS			
	None identified			

Notes: Various levels of leafroller resistance to azinphos-methyl and methomyl exist in most orchards. Pyrethroid and methomyl use is likely to lead to mite increases because of toxicity to predators. Avaunt is poor for OBLR control.

"TO DO" list

Regulatory: None.

Research: Evaluate pheromone mating disruption (multiple species, delivery systems, economics). Determine potential of biological control. Conduct resistance and cross resistance studies. Evaluate feasibility and desirability for genetic engineering (BT gene in apple tree). Develop good economic thresholds based on pheromone trap capture. Develop degree day model for VLR.

Education: Train growers in use of new tools/management options as these become available.

Green aphids (SA/AA)	**CHEMICAL OPTIONS**	Efficacy *	REI (hrs)	PHI (days)
	Organophosphates			
	Dimethoate (Cygon)	F-G	48	28
	Carbamates			
	Methomyl (Lannate)	F-G	72	14
	Oxamyl (Vydate)	F-G	48	14

	Other Chemicals			
	Acetamiprid (Assail)	E	12	7
	Endosulfan (Thionex)	F-G	24	21 or 30 (III)
	Imidacloprid (Provado)	E	12	7
	Thiamethoxam (Actara)	E	12	14 or 35 (III)
	Unregistered Chemicals			
	Thiacloprid (Calypso)	E		
	NON-CHEMICAL OPTIONS			
	Various predators	G-E		

Notes: Low to moderate populations can be tolerated without detrimental effects. Control is recommended if more than 4 infested leaves per shoot are found and less than 20% of the aphid colonies have predators.

"TO DO" list

Regulatory: None.

Research: Determine suitability of SA as a host for predators. Evaluate existing thresholds to determine population levels causing economic impact.

Education: Train growers in the identification of various aphid predators and their importance.

Spotted tentiform leafminer (STLM)	**CHEMICAL OPTIONS**	Efficacy *	REI (hrs)	PHI (days)
	Carbamates			
	Methomyl (Lannate)	G	72-96	14
	Oxamyl (Vydate)	G	48	14
	Other Chemicals			
	Acetamiprid (Assail)	G-E	12	7
	Imidacloprid (Provado)	E	12	7
	Spinosad (SpinTor, Entrust)	E	4	7
	Thiamethoxam (Actara)	G-E	12	14 or 35 (III)
	Unregistered Chemicals			
	Thiacloprid (Calypso)	E		
	NON-CHEMICAL OPTIONS			
	Various predators and parasites	G-E		

Notes: This insect is not a problem in most commercial orchards because of high levels of predation/parasitism. Low to moderate populations can be tolerated without economic impacts.

"TO DO" list

Regulatory: None.

Research: None.

Education: None.

Woolly apple aphid (WAA)	**CHEMICAL OPTIONS**	Efficacy *	REI (hrs)	PHI (days)
	Organophosphates			
	Diazinon	G-E	24	21
	Dimethoate (Cygon)	F-G	48	28

	Other Chemicals			
	Acetamiprid (Assail)	?	12	7
	Endosulfan (Thionex)	G	24	21 or 30 (III)
	Imidacloprid (Provado)	G	12	7
	Thiamethoxam (Actara)	G	12	14 or 35 (III)
	Unregistered Chemicals			
	Thiacloprid (Calypso)	?		
	NON-CHEMICAL OPTIONS			
	Predators and parasites	G-E		
	Rootstock resistance	G-E		

Notes: This insect typically becomes problematic where excessive methomyl or pyrethroid use has eliminated predators/parasites. Few chemicals are considered excellent against this insect. This insect may also be problematic in nurseries.

"TO DO" list

Regulatory: Provide incentives to develop new compounds and maintain Diazinon label for this pest. Register an effective neonicotinoid compound for soil application.

Research: Determine economic threshold and develop monitoring techniques. Identify various predators/parasites and determine their impact. Screen new rootstocks for susceptibility. Evaluate new compounds for efficacy. Conduct research on role of abiotic factors on population development and role of predators/parasites.

Education: Train growers in the use of new monitoring and management tools as they become available.

Oriental fruit moth (OFM)	**CHEMICAL OPTIONS**			
	Other Chemicals			
	Pheromone mating disruption	E	4 (IV)	0

Notes: Initiate mating disruption just prior to beginning of second flight. Adjacent habitats may influence success of mating disruption.

"TO DO" list

Regulatory: None.

Research: None.

Education: Train growers in determining timing for initiation of mating disruption. Instruct growers on potential importance of adjacent habitats in influencing mating disruption success.

Potato leafhopper (PLH)	**CHEMICAL OPTIONS**	Efficacy *	REI (hrs)	PHI (days)
	Organophosphates			
	Azinphos-methyl (Guthion)	F	(I)	14 (II)
	Dimethoate (Cygon)	G	48	28
	Carbamates			
	Carbaryl (Sevin)	E	12	3
	Methomyl (Lannate)	G	72	14
	Oxamyl (Vydate)	G	48	14
	Pyrethroids			
	Cyhalothrin (Warrior)	G	24	21

	Esfenvalerate (Asana)	G	12	21
	Fenpropathrin (Danitol)	G	24	14
	Other Chemicals			
	Acetamiprid (Assail)	E	12	7
	Endosulfan (Thionex)	G	24	21 or 30 (III)
	Imidacloprid (Provado)	E	12	7
	Kaolin (Surround)	F$	4	0
	Thiamethoxam (Actara)	E	12	14 or 35 (III)
	Unregistered Chemicals			
	Thiacloprid (Calypso)	E		

Notes: This insect is primarily a problem on young trees.

"TO DO" list

Regulatory: None.

Research: Identify and determine role of natural enemies as control agents.

Education: None.

*E = excellent; G = good; F = fair; P = poor efficacy.
$ = significantly more expensive than other chemical options, but pest complex controlled needs to be considered.

(I) = See label. Restricted-entry interval may be more restrictive than days-to-harvest limitations.
(II) = 21 days if over 2 lbs/acre.
(III) = See label.
(IV) = For sprayable formulation.

30-60 days postbloom

Diseases

TARGET DISEASE	MANAGEMENT OPTIONS	Efficacy*	REI (hrs)	PHI (days)
Scab	**CHEMICAL OPTIONS**			
	Dodine (Syllit)	Excellent (resistance may be present in some areas but in other areas may be useful for suppression of scab lesions)	48	7
	Captan	G	96	U
	Fenarimol (Rubigan) + Captan	E	12 / 96	30 / (II)
	Fenarimol (Rubigan) + Mancozeb	E	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Metiram (Polyram)	E	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Ziram	E	12 / 48	30 / 14
	Myclobutanil (Nova) + Captan	E	24 / 96	14 / (II)
	Myclobutanil (Nova) + Mancozeb	E	24 / 24	14 / (I)
	Myclobutanil (Nova) + Metiram (Polyram)	E	24 / 24	14 / (I)

	Myclobutanil (Nova) + Ziram	E	24 / 48	14 / 14
	Triflumizole (Procure) + Captan	E	12 / 96	14 / (II)
	Triflumizole (Procure) + Mancozeb	E	12 / 24	14 / (I)
	Triflumizole (Procure) + Metiram (Polyram)	E	12 / 24	14 / (I)
	Triflumizole (Procure) + Ziram	E	12 / 48	14 / 14
	Ziram	F-G	48	14
	Kresoxim-Methyl (Sovran)	E	12	30
	Trifloxystrobin (Flint)	E	12	14
	Sulfur	F	24	0
	Lime-sulfur	G	48(I)	(I)
	Ziram + Mancozeb	G	48 / 24	14 / (I)
	Ziram + Metiram (Polyram)	G	48 / 24	14 / (I)
	Captan + Mancozeb	G	96 / 24	(II) / (I)
	Captan + Metiram (Polyram)	G	96 / 24	(II) / (I)
	Trifloxystrobin (Flint) + Captan	G	12 / 96	14 / (II)

Notes: Rubigan, Nova, Procure; Trifloxystrobin (Flint) and Kresoxim-Methyl (Sovran); Vangard; and Dodine (Syllit) are different classes of fungicides and are all at risk for resistance development
Captan, sulfur are incompatible with oil;
Ratings are based on disease pressure, which takes into account disease history and prevailing weather patterns and specific weather parameters.
Combinations of SI's + EBDC's are used to combine the disease eradication activity of the SI with the disease protection activity of the EBDC.
Sulfur and lime-sulfur would be used primarily by organic growers
Lime-sulfur may cause phytotoxicity (yellowing of foliage, premature abscission)
Growers need to be aware of the 77-day preharvest interval for EBDC's; Romes, Fuji, York, Granny Smith, and later cultivars can still be sprayed with EBDC's at this time; growers need to be aware of total pounds of these products so as not to exceed the label limits (21 lbs/acre/yr)

"TO DO" list

Regulatory: None.

Research: Assessment of the sensitivity of the scab fungus to the various classes of fungicides should be conducted periodically; continue investigations on new materials for scab management; continue to examine new varieties for resistance to scab

Education: None.

Powdery mildew	**CHEMICAL OPTIONS**			
	Fenarimol (Rubigan) + Captan	E	12 / 96	30 / (II)
	Fenarimol (Rubigan) + Mancozeb	E	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Metiram (Polyram)	E	12 / 24	30 / (I)
	Fenarimol (Rubigan) + Ziram	E	12 / 48	30 / 14
	Myclobutanil (Nova) + Captan	E	24 / 96	14 / (II)
	Myclobutanil (Nova) + Mancozeb	E	24 / 24	14 / (I)
	Myclobutanil (Nova) + Metiram (Polyram)	E	24 / 24	14 / (I)
	Myclobutanil (Nova) + Ziram	E	24 / 48	14 / 14
	Triflumizole (Procure) + Captan	G	12 / 96	14 / (II)
	Triflumizole (Procure) + Mancozeb	G	12 / 24	14 / (I)
	Triflumizole (Procure) + Metiram (Polyram)	G	12 / 24	14 / (I)
	Triflumizole (Procure) + Ziram	G	12 / 48	14 / 14
	Kresoxim-Methyl (Sovran)	G - E	12	30
	Trifloxystrobin (Flint)	G - E	12	14
	Sulfur	F-G	24	0

	Lime-sulfur	G	48 (I)	(I)
	Triadimefon (Bayleton)	E	12	45 (III)
	Trifloxystrobin (Flint) + Captan	G	12 / 96	14 / (II)
	Armicarb (eradicant, mildew only)	$ F-G	(I)	(I)
	JMS stylet oil	F-G	(I)	(I)
	BIOLOGICAL OPTIONS			
	AQ10 (mildew only)	F-G	(I)	(I)

Notes: Mildew control is achieved mostly with the SI portion of the combination

"TO DO" list

Regulatory: None.

Research: Continue investigations on new materials for mildew management; continue to examine new varieties for resistance to mildew

Education: make available new information on the disease susceptibility of new varieties

Brooks spot	**CHEMICAL OPTIONS**			
	Kresoxim-Methyl (Sovran)	E	12	30
	Trifloxystrobin (Flint)	E	12	14
	Thiophanate-Methyl (Topsin-M) + Captan	E	12 / 96	0 / (II)
	Thiophanate-Methyl (Topsin-M) + Ziram	E	12 / 48	0 / 14
	Captan	G	96	(II)
	Captan + Ziram + Thiophanate-Methyl (Topsin M)	G	96 / 48 / 12	(II) /14 / 0
	Ziram	G	48	14
	Trifloxystrobin (Flint) + Captan	E	12 / 96	14 / (II)

Notes: Can be a problem locally and usually indicates a gap in spray coverage during the 2nd-3rd cover period.

"TO DO" list

Regulatory: None.

Research: None.

Education: None.

Sooty blotch and flyspeck	**CHEMICAL OPTIONS**			
	Kresoxim-Methyl (Sovran)	E	12	30
	Trifloxystrobin (Flint)	E	12	14
	Thiophanate-Methyl (Topsin M) + Captan	E	12 / 96	0 / (II)
	Thiophanate-Methyl (Topsin M) + Ziram	E	12 / 48	0 / 14
	Captan	G	96	(II)
	Captan + Ziram + Thiophanate-Methyl (Topsin M)	G	96 / 48 / 12	(II) /14 / 0
	Ziram	G	48	14
	Trifloxystrobin (Flint) + Captan	E	12 / 96	14 / (II)

Notes: Accumulated wetting hours reflect disease development.

"TO DO" list

Regulatory: None.

Research: Refine predictive models for pathogen development and timing of fungicides; what is the ability of some fungicides to eradicate SB and FS; what is the relationship of these diseases with the rot pathogens;how to determine which blocks are likely to be most prone to SB and FS;

Education: Accumulated wetting hours need to be monitored and discussed in the educational setting;

Black rot and white rot	**CHEMICAL OPTIONS**			
	Kresoxim-Methyl (Sovran)	G	12	30
	Trifloxystrobin (Flint)	G	12	14
	Thiophanate-Methyl (Topsin M) + Captan	G	12 / 96	0 / (II)
	Thiophanate-Methyl (Topsin M) + Ziram	G	12 / 48	0 / 14
	Captan	G	96	(II)
	Captan + Ziram + Thiophanate-Methyl (Topsin M)	G	96 / 48 / 12	(II) /14 / 0
	Ziram	F	48	14
	Trifloxystrobin (Flint) + Captan	G	12 / 96	14 / (II)
	Ziram + EBDC	G	48 /	14 /
	Captan + EBDC	G	96 /	(II) /

Notes: White rot levels may be related to levels of insect damage (leafrollers); Pristine, famoxate are new materials with broad spectrum activity;
Cuprofix is good for rots and labeled for summer use but has some phytotoxicity considerations.
Also, basic copper 53 (include coppers in list).
Indar, an SI, has good summer disease activity and is good against mildew; fluazinam has good broad spectrum activity but is no longer being developed on apples (Syngenta, labeled on peanuts);

"TO DO" list

Regulatory: Look at fluazinam for summer diseases (put in request to IR-4)

Research: Development of model for disease development; develop new products or combinations to improve the level of control; continue to study effectiveness of existing materials in new usage patterns; understand role of "weathering" of residues and when additional applications are needed; storability of fruit as related to fungicide and insecticide programs (economics);role of latent infections;

Education: None.

Bitter rot	**CHEMICAL OPTIONS**			
	Kresoxim-Methyl (Sovran)	G	12	30
	Trifloxystrobin (Flint)	G	12	14
	Thiophanate-Methyl (Topsin M) + Captan	F	12 / 96	0 / (II)
	Thiophanate-Methyl (Topsin M) + Ziram	F	12 / 48	0 / 14
	Captan	G	96	U
	Captan + Ziram + Thiophanate-Methyl (Topsin M)	G	96 / 48 / 12	(II) / 14 / 0
	Ziram	G	48	14
	Trifloxystrobin (Flint) + Captan	G	12 / 96	14 / (II)
	Ziram + EBDC	G	48 /	14 /
	Captan + EBDC	E	96 /	(II) /
	Trifloxystrobin (Flint) + EBDC	E	12 /	14 /
	Kresoxim-Methyl (Sovran) + EBDC	E	12 /	30 /

Notes: Higher fungicide rates are needed to manage bitter rot, 8 lbs captan per acre; keep seasonal limits of pounds per acre in mind;

"TO DO" list

Regulatory: None.

Research: Role of sexual stage of C. acutatum; need additional test data for different fungicide combinations; development of model for disease development; develop new products or combinations to improve the level of control; continue to study effectiveness

Education: None.

*E = excellent efficacy; G = good; F = fair; P = poor, V = variable
$ = significantly more expensive than other chemical options, but disease complex controlled needs to be considered.

(I) = See label
(II) = See label. Restricted-entry interval may be more restrictive than days-to-harvest limitations.
(III) = Maximum 24 oz. per acre/per season

60-90 days postbloom

Insects and mites

Target Insect/Mite	MANAGEMENT OPTIONS	Efficacy*	REI (hrs)	PHI (days)
Apple maggot (AM)	**CHEMICAL OPTIONS**			
	Organophosphates			
	Azinphos-methyl (Guthion)	E	(I)	14 (II)
	Phosmet (Imidan)	E	72	7
	Carbamates			
	Carbaryl (Sevin)	G	12	3
	Methomyl (Lannate)	F-G	72	14
	Pyrethroids			
	Cyhalothrin (Warrior)	G-E	24	21
	Esfenvalerate (Asana)	G-E	12	21
	Fenpropathrin (Danitol)	G-E	24	14
	Other Chemicals			
	Indoxacarb (Avaunt)	F-G	12	28
	Kaolin (Surround)	F-G$	4	0
	Spinosad (SpinTor, Entrust)	F-G	4	7
	Unregistered Chemicals			
	None identified			
	NON-CHEMICAL OPTIONS			
	Mass trapping (red spheres)	F-G$		
	Attract and kill (red spheres)	?		

Notes: Important period for OP use as other chemicals are not as effective. Pyrethroid use is likely to lead to mite increases because of toxicity to predators. This insect is not normally a threat in most commercial orchards, but usually only those adjacent to abandoned orchards and wild hosts.

"TO DO" list

Regulatory: Legislation to remove abandoned orchards. Examine export protocols for appropriate insecticides.

Research: Develop and screen new compounds. Develop resistant varieties. Evaluate attract and kill technology and economics of non-chemical strategies. Determine role of environmental conditions in population levels and occurrence.

Education: Train growers in use of new techniques as they become available.

Codling moth (CM)				

Notes: Second generation control is justified where pheromone trap capture exceeds 5 moths per trap per week, with spray application based on degree day timing. See 10-30 day postbloom period for management options.

European red mite (ERM) **Twospotted spider mite (TSSM)**	**CHEMICAL OPTIONS**	Efficacy*	REI (hrs)	PHI (days)
	Carbamates			
	Oxamyl (Vydate)	F	48	14
	Other Chemicals			
	Bifenazate (Acramite)	G-E	12	7
	Clofentezine (Apollo)	E	12	45
	Dicofol (Kelthane)	F-G	48	7
	Fenbutatin oxide (Vendex)	F-G	48	14
	Hexythiazox (Savey)	E	12	28
	Pyridaben (Pyramite)	E	12	25
	Oil	G	12	0
	Unregistered Chemicals			
	Spirodiclofen (Envidor)	G-E		
	Etoxazole (Zeal)	E		
	NON-CHEMICAL OPTIONS			
	Predators	G-E		

Notes: Use of oil may result in compatibility problems when tank mixed with certain fungicides. Biological control is likely to occur if pesticides toxic to predators are avoided. Some fungicides and herbicides can be disruptive to biological control. Higher rate of Pyramite is needed for TSSM. TSSM is more susceptible than ERM to Acramite. Acramite is sensitive to water hardness. Clofentezine and Hexythiazox are likely to be more effective at petal fall and should be tank mixed with another acaricide if motile stages are especially abundant. A variety of predators are important for mite management which differ in pesticide susceptibility.

"TO DO" list

Regulatory: Register unregistered compounds so effective materials are available for rotation to avoid resistance development.

Research: Evaluate new compounds. Develop resistance management strategies. Investigate population dynamics and suitability of alternative predators not common to mid-Atlantic area. Investigate relationship of other pests and stresses on mite thresholds.

Education: Provide training in identification and importance of various mite predators.

Japanese beetle (JB)	CHEMICAL OPTIONS	Efficacy *	REI (hrs)	PHI (days)
	Organophosphates			
	Azinphos-methyl (Guthion)	F-G	(I)	14 (II)
	Phosmet (Imidan)	F-G	72	7
	Carbamates			
	Carbaryl (Sevin)	E	12	3
	Methomyl (Lannate)	G	72	14
	Pyrethroids			
	Cyhalothrin (Warrior)	E	24	21
	Esfenvalerate (Asana)	E	12	21
	Fenpropathrin (Danitol)	E	24	14
	Other Chemicals			
	Imidacloprid (Provado)	F-G	12	7
	Kaolin (Surround)	G-E$	4	0
	Unregistered Chemicals			
	None identified			
	NON-CHEMICAL OPTIONS			
	None identified			

Notes: OPs are only effective against low to moderate populations. Use of carbaryl, methomyl or pyrethroids may cause mite increases due to toxicity to predators.

"TO DO" list

Regulatory: None.

Research: Develop and evaluate new compounds, including repellents and feeding attractants. Investigate role of predators in population control.

Education: Train growers in use of new management options as they become available.

Oriental fruit moth (OFM)	CHEMICAL OPTIONS	Efficacy *	REI (hrs)	PHI (days)
	Organophosphates			
	Azinphos-methyl (Guthion)	G-E	(I)	14 (II)
	Phosmet (Imidan)	G-E	72	7
	Carbamates			
	Carbaryl (Sevin)	G	12	3
	Methomyl (Lannate)	G	72	14
	Pyrethroids			
	Cyhalothrin (Warrior)	E	24	21
	Esfenvalerate (Asana)	E	12	21
	Fenpropathrin (Danitol)	E	24	14
	Other Chemicals			
	Acetamiprid (Assail)	G	12	7
	Indoxacarb (Avaunt)	G	12	28
	Methoxyfenozide (Intrepid)	G	4	14
	Unregistered Chemicals			
	Thiacloprid (Calypso)	G		
	NON-CHEMICAL OPTIONS			
	Pheromone mating disruption	E	4 (IV)	0

Notes: Control second generation where the pheromone trap capture exceeds 10 moths per trap per week by applying above insecticides at 1150-1200 degree days after biofix (methoxyfenozide) or at 1450-1500 degree days after biofix (all other materials). Use of carbaryl, methomyl or pyrethroids may cause mite increases due to toxicity to predators.

"TO DO" list

Regulatory: None.

Research: Determine levels of resistance and cross resistance to registered and unregistered compounds. Evaluate pheromone mating disruption combined with CM. Determine impact of environmental conditions on performance of mating disruption technologies.

Education: Provide training on parameters and procedures for use of pheromone mating disruption. Provide demonstration trials on pheromone mating disruption.

Rose leafhopper (RLH)	**CHEMICAL OPTIONS**	Efficacy*	REI (hrs)	PHI (days)
	Carbamates			
	Carbaryl (Sevin)	G-E	12	3
	Methomyl (Lannate)	G	72	14
	Oxamyl (Vydate)	F-G	48	14
	Pyrethroids			
	Cyhalothrin (Warrior)	G	24	21
	Esfenvalerate (Asana)	G	12	21
	Fenpropathrin (Danitol)	G	24	14
	Other Chemicals			
	Acetamiprid (Assail)	E	12	7
	Endosulfan (Thionex)	G	24	21 or 30 (III)
	Imidacloprid (Provado)	E	12	7
	Indoxacarb (Avaunt)	F-G$	12	28
	Kaolin (Surround)	F-G$	4	0
	Thiamethoxam (Actara)	E	12	14 or 35 (III)
	Unregistered Chemicals			
	Thiacloprid (Calypso)	E		
	NON-CHEMICAL OPTIONS			
	Predators and parasites	F-G		

Notes: This insect is more problematic in those orchards adjacent to wild brambles and multiflora rose, which serve as overwintering hosts.

"TO DO" list

Regulatory: None.

Research: Determine cumulative effect of RLH and WALH over full season. Determine role of overwintering hosts on commercial orchard populations. Determine effectiveness of perimeter sprays on preventing migration of first generation adults into commercial orchards.

Education: Train growers on how to differentiate RLH from WALH.

*E = excellent; G = good; F = fair; P = poor efficacy.

$ = significantly more expensive than other chemical options, but pest complex controlled needs to be considered.
(I) = See label. Restricted-entry interval may be more restrictive than days-to-harvest limitations.
(II) = 21 days if over 2 lbs/acre.
(III) = See label.
(IV) = For sprayable formulation.

60-90 days postbloom

Diseases

TARGET DISEASE	MANAGEMENT OPTIONS	Efficacy*	REI (hrs)	PHI (days)
Scab	**CHEMICAL OPTIONS**			
	Dodine	Excellent (resistance may be present in some areas but in other areas may be useful for suppression of scab lesions)	48	7
	Captan	G	96	U
	Fenarimol (Rubigan) + Captan	E	12 / 96	30 / (II)
	Fenarimol (Rubigan) + Ziram	E	12 / 48	30 / 14
	Myclobutanil (Nova) + Captan	E	24 / 96	14 / (II)
	Myclobutanil (Nova) + Ziram	E	24 / 48	14 / 14
	Triflumizole (Procure) + Captan	E	12 / 96	14 / (II)
	Triflumizole (Procure) + Ziram	E	12 / 48	14 / 14
	Ziram	F-G	48	14
	Kresoxim-Methyl (Sovran)	E	12	30
	Trifloxystrobin (Flint)	E	12	14
	Sulfur	F	24	0
	Lime-sulfur	G	48 (I)	(I)
	Trifloxystrobin (Flint) + Captan	G	12 / 96	14 / (II)

Notes: Rubigan, Nova, Procure; Flint and Sovran; Vangard; and Dodine are different classes of fungicides and are all at risk for resistance development.
Captan and sulfur are incompatible with oil.
Ratings are based on disease pressure, which takes into account disease history and prevailing weather patterns and specific weather parameters.
Sulfur and lime-sulfur would be used primarily by organic growers
Lime-sulfur may cause phytotoxicity (yellowing of foliage, premature abscission).
Growers need to be aware of the 77-day preharvest interval for EBDC's; Romes, Fuji, York, Granny Smith, and later cultivars can still be sprayed with EBDC's at this time; growers need to be aware of total pounds of these products so as not to exceed the limit of 21 lbs. per acre per year.

“TO DO” list

Regulatory: None.

Research: Assessment of the sensitivity of the scab fungus to the various classes of fungicides should be conducted periodically; continue investigations on new materials for scab management; continue to examine new varieties for resistance to scab

Education: None.

Powdery mildew	Fenarimol (Rubigan) + Captan	E	12 / 96	30 / (II)
	Fenarimol (Rubigan) + Ziram	E	12 / 24	30 / (I)
	Myclobutanil (Nova) + Captan	E	24 / 96	14 / (II)
	Myclobutanil (Nova) + Ziram	E	24 / 24	14 / (I)
	Triflumizole (Procure) + Captan	G	12 / 96	14 / (II)
	Triflumizole (Procure) + Ziram	G	12 / 24	14 / (I)
	Kresoxim-Methyl (Sovran)	G - E	12	30
	Trifloxystrobin (Flint)	G - E	12	14
	Sulfur	F-G	24	0
	Lime-sulfur	G	48 (I)	(I)
	Triadimefon (Bayleton)	E	12	45 (III)
	Trifloxystrobin (Flint) + Captan	G	12 / 96	14 / (II)
	JMS stylet oil	F-G	(I)	(I)
	Armicarb (eradicant, mildew only)	$ F-G	(I)	(I)
	BIOLOGICAL			
	AQ10 (mildew only)	F-G	(I)	(I)

Notes: Mildew control is achieved mostly with the SI portion of the combination

"TO DO" list

Regulatory: None.

Research: Continue investigations on new materials for mildew management; continue to examine new varieties for resistance to mildew.

Education: Make available new information on the disease susceptibility of new varieties

Brooks spot	**CHEMICAL OPTIONS**			
	Kresoxim-Methyl (Sovran)	E	12	30
	Trifloxystrobin (Flint)	E	12	14
	Thiophanate-Methyl (Topsin-M) + Captan	E	12 / 96	0 / (II)
	Thiophanate-Methyl (Topsin-M) + Ziram	E	12 / 48	0 / 14
	Captan	G	96	(II)
	Captan + Ziram + Thiophanate-Methyl (Topsin-M)	G	96 / 48 / 12	(II) / 14 / 0
	Ziram	G	48	14
	Trifloxystrobin (Flint) + Captan	E	12 / 96	14 / (II)

Notes: Can be a problem locally and usually indicates a gap in spray coverage during the 2nd-3rd cover period.

"TO DO" list

Regulatory: None.

Research: None.

Education: None.

Sooty blotch and flyspeck	**CHEMICAL OPTIONS**			
	Kresoxim-Methyl (Sovran)	E	12	30
	Trifloxystrobin (Flint)	E	12	14
	Thiophanate-Methyl (Topsin-M) + Captan	E	12 / 96	0 / (II)
	Thiophanate-Methyl (Topsin-M) + Ziram	E	12 / 48	0 / 14
	Captan	G	96	(II)
	Captan + Ziram + Thiophanate-Methyl (Topsin-M)	G	96 / 48 / 12	(II) / 14 / 0
	Ziram	G	48	14
	Trifloxystrobin (Flint) + Captan	E	12 / 96	14 / (II)

Notes: Accumulated wetting hours reflect disease development.

"TO DO" list

Regulatory: None.

Research: Refine predictive models for pathogen development and timing of fungicides; what is the ability of some fungicides to eradicate sooty blotch and flyspeck; what is the relationship of these diseases with the rot pathogens; how to determine which blocks are likely to experience heavy disease incidence?

Education: Accumulated wetting hours need to be monitored and discussed in the educational setting;

Black rot and white rot	**CHEMICAL OPTIONS**			
	Kresoxim-Methyl (Sovran)	G	12	30
	Trifloxystrobin (Flint)	G	12	14
	Thiophanate-Methyl (Topsin-M) + Captan	G	12 / 96	0 / (II)
	Thiophanate-Methyl (Topsin-M) + Ziram	G	12 / 48	0 / 14
	Captan	G	96	(II)
	Captan + Ziram + Thiophanate-Methyl (Topsin-M)	G	96 / 48 / 12	(II) / 14 / 0
	Ziram	F	48	14
	Trifloxystrobin (Flint) + Captan	G	12 / 96	14 / (II)
	Ziram + EBDC	G	48 / 24	14 / 77
	Captan + EBDC	G	96 / 24	(II) / 77

Notes: White rot levels may be related to levels of insect damage (leafrollers); Pristine, famoxate are new materials with broad spectrum activity; Cuprofix is good for rots and labeled for summer use but has some phytotoxicity considerations. Also, Basic Copper 53 good for white and black rot suppression.

"TO DO" list

Regulatory: Look at fluazinam for summer diseases (put in request to IR-4)

Research: Development of model for disease development; develop new products or combinations to improve the level of control; continue to study effectiveness of existing materials in new usage patterns; understand role of "weathering" of residues and when; test other combinations of materials such as Ziram + sulfur, copper + ziram or captan.

Education: None.

Bitter rot	**CHEMICAL OPTIONS**			
	Kresoxim-Methyl (Sovran)	G	12	30
	Trifloxystrobin (Flint)	G	12	14
	Thiophanate-Methyl (Topsin-M) + Captan	F	12 / 96	0 / (II)

	Thiophanate-Methyl (Topsin-M) + Ziram	F	12 / 48	0 / 14
	Captan	G	96	(II)
	Captan + Ziram + Thiophanate-Methyl (Topsin-M)	G	96 / 48 / 12	(II) /14 / 0
	Ziram	G	48	14
	Flint + Captan	G	12 / 96	14 / (II)
	Ziram + EBDC	G	48	14 / 77
	Captan + EBDC	E	96	(II) / 77
	Trifloxystrobin (Flint) + EBDC	E	12 /	14 / 77
	Kresoxim-Methyl (Sovran) + EBDC	E	12 /	30 / 77

Notes: Higher fungicide rates are needed to manage bitter rot, 8 lbs captan per acre; keep seasonal limits of pounds per acre in mind.

"TO DO" list

Regulatory: None.

Research: Role of sexual stage of *C. acutatum*; need additional test data for different fungicide combinations; development of model for disease development; develop new products or combinations to improve the level of control; continue to study effectiveness of new and currently registered fungicides.

Education: None.

*E = excellent efficacy; G = good; F = fair; P = poor, V = variable
$ = significantly more expensive than other chemical options, but disease complex controlled needs to be considered.
(I) = See label
(II) = See label. Restricted-entry interval may be more restrictive than days-to-harvest limitations.
(III) = Maximum 24 oz. per acre/per season

90+ days postbloom

Insects and mites

Target Insect/Mite	MANAGEMENT OPTIONS	Efficacy*	REI (hrs)	PHI (days)
Apple maggot (AM) **Borers (DWB, ABB)** **Codling moth (CM)** **Oriental fruit moth (OFM)** **San Jose scale (SJS)** **Leafhoppers (WALH, RLH)** **Leafrollers (TABM, VLR, RBLR, OBLR)**				

Notes: Most of the above pests have multiple generations per year and will reappear during this time of the season. Effectiveness of management programs for these pests earlier in the season usually determines their severity at this time. See management options in earlier stages. Season maximum amounts and PHI of insecticides will need to be considered for management of each specific pest. Address internal worm tolerance issue.

Stink bugs **Brown stink bug (BSB)** **Dusky stink bug (DSB)** **Green stink bug (GSB)**				

Notes: These pests have been shown to cause late season fruit injury similar to and misdiagnosed as the physiological disorders known as cork spot and bitter pit. No management options have been identified for these pests on apple.

"TO DO" list

Regulatory: Register products identified as efficacious against this group of pests.

Research: Determine impact of these pests on fruit quality and storability. Develop and evaluate monitoring techniques and establish threshold levels for management decisions. Evaluate compounds for efficacy, considering effect of changing from OPs to more selective chemistries for other pests which do not control SBs; determine resistance levels. Identify proper timing of chemical application for management.

Education: Train growers to identify injury, and provide instruction in monitoring and management as new tools become available.

90+ days postbloom

Diseases

TARGET DISEASE	MANAGEMENT OPTIONS	Efficacy*	REI (hrs)	PHI (days)
Scab	**CHEMICAL OPTIONS**			
	Dodine (Syllit)	Excellent (resistance may be present in some areas but in other areas may be useful for suppression of scab lesions)	48	7
	Captan	G	96	(II)
	Fenarimol (Rubigan) + Captan	E	12 / 96	30 / (II)
	Fenarimol (Rubigan) + Ziram	E	12 / 48	30 / 14
	Myclobutanil (Nova) + Captan	E	24 / 96	14 / (II)
	Myclobutanil (Nova) + Ziram	E	24 / 48	14 / 14
	Triflumizole (Procure) + Captan	E	12 / 96	14 / (II)
	Triflumizole (Procure) + Ziram	E	12 / 48	14 / 14
	Ziram	F-G	48	14
	Kresoxim-Methyl (Sovran)	E	12	30

	Trifloxystrobin (Flint)	E	12	14
	Sulfur	F	24	0
	Lime-sulfur	G	48?	
	Trifloxystrobin (Flint) + Captan	G	12 / 96	14 / (II)

Notes: Rubigan, Nova, Procure; Trifloxystrobin (Flint) and Kresoxim-Methyl (Sovran); Vangard; and Dodine (Syllit) are different classes of fungicides and are all at risk for resistance development
Captan, sulfur are incompatible with oil;
Ratings are based on disease pressure (see spray guide for wording)
Combinations of SI's + EBDC's are used to combine the kick back activity of the SI with the protectant activity of the EBDC.
Sulfur and lime-sulfur would be used primarily by organic growers
Lime-sulfur may cause phytotoxicity (yellowing of foliage, premature abscission)
Growers need to be aware of the 77-day preharvest interval for EBDC's and total pounds of these products so as not to exceed the label limits of 21 lb./acre/year.

"TO DO" list

Regulatory: None.

Research: Assessment of the sensitivity of the scab fungus to the various classes of fungicides should be conducted periodically; continue investigations on new materials for scab management; continue to examine new varieties for resistance to scab

Education: None.

Powdery mildew	**CHEMICAL OPTIONS**			
	Fenarimol (Rubigan) + Captan	E	12 / 96	30 / (II)
	Fenarimol (Rubigan) + Ziram	E	12 / 48	30 / 14
	Myclobutanil (Nova) + Captan	E	24 / 96	14 / (II)
	Myclobotanil (Nova) + Ziram	E	24 / 48	14 / 14
	Triflumizole (Procure) + Captan	G	12 / 96	14 / (II)
	Triflumizole (Procure) + Ziram	G	12 / 48	14 / 14
	Kresoxim-Methyl (Sovran)	G - E	12	30
	Trifloxystrobin (Flint)	G - E	12	14
	Sulfur	F-G	24	0
	Lime-sulfur	G	48?	(I)
	Triadimefon (Bayleton)	E	12	45 (III)
	Trifloxystrobin (Flint) + Captan	G	12 / 96	14 / (II)
	JMS stylet oil	F-G	(I)	(I)
	Armicarb (eradicant, mildew only)	$ F-G	(I)	(I)
	BIOLOGICAL			
	AQ 10 (mildew only)	F-G	(I)	(I)

Notes: Mildew control is achieved mostly with the SI portion of the combination

"TO DO" list

Regulatory: None.

Research: Continue investigations on new materials for mildew management; continue to examine new varieties for resistance to mildew

Education: Make available new information on the disease susceptibility of new varieties

Brooks spot	**CHEMICAL OPTIONS**			
	Kresoxim-Methyl (Sovran)	E	12	30
	Trifloxystrobin (Flint)	E	12	14
	Thiophanate-Methyl (Topsin M) + Captan	E	12 / 96	0 / (II)
	Thiophanate-Methyl (Topsin M) + Ziram	E	12 / 48	0 / 14
	Captan	G	96	(II)
	Captan + Ziram + Thiophanate-Methyl (Topsin M)	G	96 / 48 / 12	(II) /14 / 0
	Ziram	G	48	14
	Trifloxystrobin (Flint) + Captan	E	12 / 96	14 / (II)

Notes: Can be a problem locally and usually indicates a gap in spray coverage during the 2nd-3rd cover period.

"TO DO" list

Regulatory: None.

Research: None.

Education: None.

Sooty blotch and flyspeck	**CHEMICAL OPTIONS**			
	Kresoxim-Methyl (Sovran)	E	12	30
	Trifloxystrobin (Flint)	E	12	14
	Thiophanate-Methyl (Topsin M) + Captan	E	12 / 96	0 / (II)
	Thiophanate-Methyl (Topsin M) + Ziram	E	12 / 48	0 / 14
	Captan	G	96	(II)
	Captan + Ziram + Thiophanate-Methyl (Topsin M)	G	96 / 48 / 12	(II) /14 / 0
	Ziram	G	48	14
	Trifloxystrobin (Flint) + Captan	E	12 / 96	14 / (II)

Notes: Accumulated wetting hours reflect disease development.

"TO DO" list

Regulatory: None.

Research: Refine predictive models for pathogen development and timing of fungicides; what is the ability of some fungicides to eradicate SB and FS; what is the relationship of these diseases with the rot pathogens; how to determine which blocks are likely to develop high disease incidence.

Education: Accumulated wetting hours need to be monitored and discussed in the educational setting.

Black rot and white rot	**CHEMICAL OPTIONS**			
	Kresoxim-Methyl (Sovran)	G	12	30
	Trifloxystrobin (Flint)	G	12	14
	Thiophanate-Methyl (Topsin M) + Captan	G	12 / 96	0 / (II)
	Thiophanate-Methyl (Topsin M) + Ziram	G	12 / 48	0 / 14
	Captan	G	96	(II)
	Captan + Ziram + Thiophanate-Methyl (Topsin M)	G	96 / 48 / 12	(II) /14 / 0
	Ziram	F	48	14
	Trifloxystrobin (Flint) + Captan	G	12 / 96	14 / (II)
	Ziram + EBDC	G	48 /	14 /

	Captan + EBDC	G	96 /	(II) /

Notes:
White rot levels may be related to levels of insect damage (leafrollers); Pristine, famoxate are new materials with broad spectrum activity; Cuprofix is good for rots and labeled for summer use but has some phytotoxicity considerations. Also, Basic Copper 53 is effective against these diseases.

"TO DO" list

Regulatory: look at fluazinam for summer diseases (put in request to IR-4).

Research: development of model for disease development; develop new products or combinations to improve the level of control; continue to study effectiveness of existing materials in new usage patterns; understand role of "weathering" of residues and when reapplication is needed; test other combinations of materials such as Ziram + sulfur, copper + ziram or captan.

Education: None.

	CHEMICAL OPTIONS			
Bitter rot	Kresoxim-Methyl (Sovran)	G	12	30
	Trifloxystrobin (Flint)	G	12	14
	Thiophanate-Methyl (Topsin M) + Captan	F	12 / 96	0 / (II)
	Thiophanate-Methyl (Topsin M) + Ziram	F	12 / 48	0 / 14
	Captan	G	96	(II)
	Captan + Ziram + Thiophanate-Methyl (Topsin M)	G	96 / 48 / 12	(II) /14 / 0
	Ziram	G	48	14
	Trifloxystrobin (Flint) + Captan	G	12 / 96	14 / (II)
	Ziram + EBDC	G	48 /	14 /
	Captan + EBDC	E	96 /	(II) /
	Trifloxystrobin (Flint) + EBDC	E	14 /	14 /
	Kresoxim-Methyl (Sovran) + EBDC	E	12 /	30 /

Notes: Higher fungicide rates are needed to manage bitter rot, 8 lbs captan per acre; keep seasonal limits of pounds per acre in mind; regular use of calcium chloride may improve bitter rot control and improve fruit quality.

"TO DO" list

Regulatory: None.

Research: Role of sexual stage of *C. acutatum*; need additional test data for different fungicide combinations; development of model for disease development; develop new products or combinations to improve the level of control; continue to study effectiveness of new and currently registered fungicides.

Education: None.

*E = excellent efficacy; G = good; F = fair; P = poor, V = variable
$ = significantly more expensive than other chemical options, but disease complex controlled needs to be considered.
(I) = See label
(II) = See label. Restricted-entry interval may be more restrictive than days-to-harvest limitations.
(III) = Maximum 24 oz. per acre/per season.

Postharvest

Insects and Diseases

TARGET INSECTS	
San Jose Scale	Investigate the efficacy of a postharvest application of (pyriproxyfen) Esteem for control of the third generation
TARGET DISEASE	
Blue mold Gray mold Alternaria rot Other rots	- fruit treatments for storage - fruit treatments for storage - fruit treatments for storage from the orchard and/or when fruit are dipped for scald
OTHER POSTHARVEST TREATMENTS	Urea for scab Ridomil for Phytophthora
DRENCH MATERIALS	Mertect research needed, additional products for postharvest use could improve spectrum of disease control, widespread resistance to Mertect in Penicillium populations Captan and export restrictions
BIOLOGICAL CONTROLS	Aspire - effectiveness = fair

Nematode

Lesion Nematode (*Pratylenchus penetrans*) is associated with replant disease. It is a root parasite, feeding in fine feeder roots. Older trees are believed to be more tolerant, but young trees established at orchard replant sites may be seriously affected. Root damage is difficult to diagnose, and generally appears as poor growth and stunting of trees, often without any obvious above-ground symptoms.

Dagger Nematodes (the most common species are *Xiphinema americanum* and *X. rivesi*) are root parasites, but are most important as vectors of the Tomato Ringspot Virus. In susceptible rootstock/scion combinations, the virus causes Apple Union Necrosis and Decline. Varietal differences are important, as tolerant cultivars do not exhibit the disease while susceptible combinations can exhibit significant tree loss, usually after growers have invested several years in orchard establishment. Symptoms occur when stem tissue at the graft union becomes necrotic, girdling the stem and shutting off transport of water and nutrients. The weakened stem may break at the graft union, killing the tree.

Both nematodes are widespread in Mid-Atlantic orchards, occurring in 50-70 % of sites, but only 10-20 % orchards have population densities sufficient to cause economic losses. For both nematodes, long term management over the life of the orchard is important and the best time to start managing is before the orchard is planted.

Pre-plant Options	Rating
Fumigants	
Telone	G
Vapam	G
Methyl bromide (to be phased out by 2005)	E
Methyl iodide (under development) don't know how to use it yet	F

Cultural Controls

Rotation crops can be used to reduce populations before orchard planting. Various Brassica species, especially certain canola cultivars, have considerable promise as green manures crops. When foliage is plowed down while still green, thio-cyanate compounds are released that are toxic to nematodes.

Sudan grass is used for lesion nematode management, but is actually a fairly good host for dagger nematodes. Again, cyanides are released on plow-down. Tall fescue (endophyte-infected) is somewhat suppressive of dagger and lesion nematodes. These crops have been used as ground covers for many years, and may also be useful as preplant rotation crops. Endophyte-free varieties of fescue, often preferred for livestock forage to avoid toxicity to livestock, should be avoided as orchard cover crops as they do not suppress nematodes.

Post-Plant Options

Chemical nematicides

Nemacur.

High rates are needed to get nematode suppression. Provides short-term suppression, but nematode populations may bounce back. After several years of use, an “Aggressive Soil” may develop with microflora that rapidly degrade this chemical so that effectiveness may be lost after a couple of years.

Vydate.

Labeled on non-bearing trees only. Soil-applied at planting or foliar application at full leaf. Labeled for lesion nematode management, limited efficacy data available for dagger nematode.

Cultural Controls

Cover crops

Fescue (endophyte-infected) Used for many years in established orchards, just beginning to understand how it works.

Biological Controls

Several products are approaching commercialization, however, little research and development emphasis is focussed toward apple nematodes. Biocontrol agents currently being studied include:

Pasteuria penetrans. Efficacy is well established in literature, but this bacterium cannot currently be grown in culture in commercially viably quantities

Myrothecium spp. Labeled as suppressive to both dagger and lesion nematodes. Efficacy data mainly in annual crops.

Regulatory:

Priority needs:

Reduced Risk alternatives, (include economic concerns - reduced risk & affordable)

Additional Needs:

Methyl bromide alternatives

Virus certification of nursery transplant stock
preventing introduction in new orchard is critical

Broadleaf weeds are reservoirs for nematodes -

Research:

Priority

Evaluation of new biological, cultural and chemical controls.

Additional Needs

Mode of action of cultural controls.

Yield loss assessment from suppressed tree growth, which leads to longer time till production, multiple measures for loss assessment are needed.

Nematode population dynamics (role of suppressive soils and biocontrol agents).

Role of other related nematode species (*Pratylenchus crenatus*, *P. neglectus*, *Hoplolaimus* spp., etc.).

Cultivar resistance/tolerance.

Solarization.

Sampling/threshold issues.

Education:

Priority Need

Nematode monitoring by growers, long-term records are most useful, but routine sampling by growers is rare.

Additional Needs:

Disease identification, recognition of nematode problems when they occur.

Emphasize prevention and long-term management.

Need for control of broadleaf weeds, which are reservoirs for viruses vectored by dagger nematodes. 2,4-D would address broadleaf weed issues where grasses (including fescues, sudangrass) are used as cover.

Weeds

In apple orchards, weeds are considered important pests. They compete with the crop for nutrients, water, light, and space. Weed competition in orchards less than four years of age is capable of causing permanent yield reductions. Other undesirable attributes of weeds include interference with harvest, pollination, harboring of insect disease and rodent pests. Based on a national survey (Derr, J.F. 2001, Biological Assessment of Herbicide Use in Apple Production Part I and II, HortTechnology, 11:11-25.) it was inferred that the most viable method of managing weeds effectively in commercial orchards in through the use of herbicides.

The survey results also indicated that common weeds of orchards include annual grasses such as crabgrass, foxtails, fall panicum, and barnyardgrass and perennials like johnsongrass, quackgrass, purpletop, tall fescue, and orchardgrass. Annual broadleaves include pigweed, common lambsquarters, mustards, shepherdspurse, fleabane aster, horseweed, and hairy galinsoga. Perennial broadleaves include morningglory species, brambles, field bindweed, Canada thistle, dandelion, Virginia creeper, horsenettle, poison ivy, sumac, and white clover. Other troublesome perennials like tree-of-heaven, wild grape, multiflora rose, and bur cucumber have also been reported more recently. Among different types of weeds creeping perennial broadleaves pose the biggest problem in orchards due to their growth habits. These weeds include brambles, poison ivy, morningglory, Virginia creeper, and field bindweed. They (perennial weds) are difficult to manage using currently available selective broadleaf herbicides with 2,4-D being the only choice.

Weed management in most orchards is carried out using the strip system where row middles are kept weed free using herbicides and mowed sod is grown between the rows. One-third of the orchard is treated on a per acre basis in this method. Practices including use of mulches, keeping an orchard floor cover may serve as hiding grounds for vertebrate pests or compete with the crop for nutrients. Total vegetation management is not practical in the Northeastern states due to soil erosion concerns.

Herbicides used in orchards are dictated by the age of the trees and spectrum of weeds present. Most annuals and certain herbaceous perennials are managed by applying a tank-mixture of preemergence (PRE) and postemergence (POST) herbicides in spring. Subsequent applications are sometimes carried out in mid-summer and fall. Commonly used PRE herbicides for annual grasses and small-seeded broadleaves include oryzalin, napropamide, pendimethalin, and norflurazon. Other PRE herbicides effective mostly for broadleaves include, simazine, oxyfluorfen ($$), diuron, and terbacil. Perennial grassed are managed using pronamide, sethoxydim, and fluazifop. Non-selective herbicides including glyphosate, glufosinate, and paraquat are used to control perennial weeds. Glufosinate is not registered for use in first year of planting but could be a better option to manage certain weeds. Fall application may have some advantages, e.g., spread out labor, less effect on foraging insects in spring, and better control of perennials. Impact of application timing on management of mites and predatory insects need to be better understood. Testing and registration of potential herbicides like clopyralid, fluroxypyr, and sulfentrazone may help better manage perennial broadleaf weeds.

There are limited alternatives for herbicides to manage weeds in apple production. Herbicides available currently are used well to manage weeds in orchards. It is difficult to estimate the impact of herbicides in fruit production. Although alternatives exist within the toolbox to replace individual herbicides such losses would have indirect effects on resistance management (triazine resistant weeds have already been documented; more recently glyphosate resistant horseweed, a common weed in apple orchards, has been documented in Delaware and Maryland in soybean). More herbicide options will also allow growers to better manage shifts in weed population. More choices would also provide more options in today's competitive market. The safety of the alternatives and the potential to cause tree injury are also not known. Herbicides not registered yet but considered to be effective for weed management in apple include clopyralid, triclopyr, fluroxypyr, thiazopyr, halosulfuron, sulfentrazone, and flumioxazin.

The following efficacy tables were developed based on the ratings in the 2003 Virginia, West Virginia, Maryland Spray Bulletin for Commercial Tree Fruit Growers and the 2003 New Jersey Commercial Tree Fruit Production Guide.

Relative Effectiveness of Preemergence Herbicides in Tree Fruits

(E=excellent: G=good: F=fair: P=poor: N=none)

Please note: The ratings that are highlighted indicate the range to accommodate ratings from the two separate guides.

	Dichobenil (Casoron)	Diuron (Karmex)	Napropamide (Devrinol)	Norflurazon (Solicam)	Oryzalin (Surflan)	Oxyfluorfen (Goal)	Pendimethalin (Prowl)	Pronamide (Kerb)
ANNUAL GRASSES								
Barnyardgrass	F-G	G	G	G-E	G	F	G	F
Cheat	G	G	G	G	G	-	G	G
Crabgrass	F-G	F-G	G-E	G-E	G-E	F	G	G
Fall Panicum	G	F-G	G	G-E	G	F	G	F
Foxtails	F-G	G	G-E	G-E	G-E	F	G	G
Goosegrass	F-G	F-G	G-E	G	G-E	F	F-G	G
Johnsongrass (seedling)	F-G	N-G	P-G	G	F-G	P	F-G	-
ANNUAL BROADLEAF WEEDS								
Annual fleabane	E	G	G	F	G	-	-	F
Annual morningglory	G	G	N	F	N-F	F	N-G	F
Black nightshade	G	G	N	F-G	P-F	G	N	F
Carpetweed	G	G-E	G	P-G	F-G	G	G	G
Common chickweed	G	E	G	G	G	G	G	G
Common lambsquarters	G	G-E	F-G	F-E	F-G	G	F-G	F
Common ragweed	G	G-E	P-F	F-G	N-P	F-G	N	P
	Dichobenil (Casoron)	Diuron (Karmex)	Napropamide (Devrinol)	Norflurazon (Solicam)	Oryzalin (Surflan)	Oxyfluorfen (Goal)	Pendimethalin (Prowl)	Pronamide (Kerb)
Hairy galinsoga	P	G-E	F-G	-	N-G	G	N	-
Henbit	G	E	F	-	P	G	G	G
Horseweed	G	G	P	G	F	F	P	P
Knotweed	G	G	G	F	G	G	-	E
Mustards	G	G	P	F	P-F	G	-	G
Pennsylvania smartweed	G	F-G	P	-	P-F	G	P	-
Pigweeds	G	G-E	G	F	F-G	G	F-G	N
Prickly lettuce	G	G	G	-	F	G	-	-
Prickly sida	G	G	N	P	P-F	E	N	N
Purslanes	G	G-E	F-G	G	F-G	G	F-G	-
Shepherd's-	G	G	F	G	N-G	G	G	G

purse								
Speedwells	G	-	-	-	-	G	-	P
Velvetleaf	P	F-G	N	F	P-F	G	F-G	P
Virginia pepperweed	G	G	F	G	G	-	-	P

PERRENNIAL GRASSES AND SEDGES								
	Dichobenil (Casoron)	Diuron (Karmex)	Napropamide (Devrinol)	Norflurazon (Solicam)	Oryzalin (Surflan)	Oxyfluorfen (Goal)	Pendimethalin (Prowl)	Pronamide (Kerb)
Fescues	G	F	N	F	N	N	N	G
Johnsongrass (rhizome)	-	P	N	P	N	N	N	P
Nimblewill	-	P	N	F	N	N	N	P
Orchardgrass								
Quackgrass								
Yellow nutsedge	-	N	N-P	F	N	P	N	
Purpletop, Redtop								
Dallisgrass								
Bermudagrass								

PERENNIAL PERENNIAL BROADLEAF WEEDS								
	Dichobenil (Casoron)	Diuron (Karmex)	Napropamide (Devrinol)	Norflurazon (Solicam)	Oryzalin (Surflan)	Oxyfluorfen (Goal)	Pendimethalin (Prowl)	Pronamide (Kerb)
Broadleaf plantain	G	P-F	N	P	N	N	N	F
Buckhorn plantain	G	P-F	N	P	N	N	N	F
Canada thistle	F	N	N	N	N	N	N	-
Chicory	G	G	N	N	N	N	N	-
Common mallow	G	F	N	N	N	N	N	-
Common milkweed	-	N	N	N	N	N	N	-
Common yarrow	-	N	N	N	N	N	N	-
Dandelion	G	P-F	N	N	N	N	N	P
Docks (broadleaf, curly)	G	F	N	N	N	N	N	F
Goldenrod	F-G	-	N	N	N	N	N	-
Ground ivy	E	N	N	N	N	N	N	-
Hemp dogbane	N	N	N	N	N	N	N	-
Horsenettle	N	P-F	N	N	N	N	N	-
Mugwort	G	P	N	N	N	N	N	-
Red sorrel	G	N	N	N	-	N	N	F-G
Thistles (bull, musk, plumeless)		N	N	N	N	-	N	P
White flowered aster	F	N	N	N	N	N	N	-
Wild carrot	G	P	N	F	N	-	N	-
Wild strawberry	G	G	N	P	N	-	N	-
	Dichobenil (Casoron)	Diuron (Karmex)	Napropamide (Devrinol)	Norflurazon (Solicam)	Oryzalin (Surflan)	Oxyfluorfen (Goal)	Pendimethalin (Prowl)	Pronamide (Kerb)
Yellow rocket	G	P	N	F	N	-	N	P-F

Yellow woodsorrel	G	F	N	F	N	G	N	-
SPECIAL PERENNIAL WEED PROBLEMS								
Bigroot morningglory	-	N-G	N	N	N	N	N	N
Brambles (Rubus spp.)	N	N	N	N	N	N	N	N
Common greenbrier	N	N	N	N	N	N	N	N
Japanese honeysuckle	N	N	N	N	N	N	N	N
Poison-ivy	N	N	N	N	N	N	N	N
Virginia creeper	N	N	N	N	N	N	N	N
Wild garlic	N	N	N	N	N	N	N	N

Relative Effectiveness of Postemergence Herbicides in Tree Fruits
(E=excellent; G=good; F=fair; P=poor; N=none)

	Fluazifop (Fusilade DX)	Glufosinate (Rely)	Glyphosate (Various)	Paraquat (Gramoxone Extra)	Sethoxydim (Poast)	2,4-D	Clethodim (Select)
ANNUAL GRASSES							
Barnyardgrass	G-E	G	G-E	F-E	G-E	N	G-E
Cheat	G	-	E	G-E	-	N	G
Crabgrass	F-E	G	G-E	F-E	G-E	N	G-E
Fall Panicum	G-E	G	G-E	F-E	G-E	N	G-E
Foxtails	G-E	G	G-E	G-E	G-E	N	G-E
Goosegrass	G-E	G	G-E	F-E	G-E	N	G-E
Johnsongrass (seedling)	G-E	-	G-E	G-E	G-E	N	G-E
ANNUAL BROADLEAF WEEDS							
Annual fleabane	N	-	E	E	N	G	N
Annual Morningglory	N	G	F-G	F-G	N	G-E	N
Black nightshade	N	G	G-E	G	N	F-G	N
Carpetweed	N	-	G-E	E	N	G-E	N
Common chickweed	N	G	E	E	N	P	N
Common lambsquarters	N	G	G-E	F-E	N	F-G	N
Common ragweed	N	G	F-E	G-E	N	G	N
Hairy galinsoga	N	-	G-E	G-E	N	F-G	N
Henbit	N	G	E	E	N	P	N
Horseweed	N	G	E	G	N	P	N
	Fluazifop (Fusilade DX)	Glufosinate (Rely)	Glyphosate (Various)	Paraquat (Gramoxone Extra)	Sethoxydim (Poast)	2,4-D	Clethodim (Select)
Knotweed	N	-	E	F-G	N	F	N
Mustards	N	G	E	P-F	N	G	N
Pennsylvania smartweed	N	G	G-E	G	N	F-P	N
Pigweeds	N	G	G-E	G	N	G	N
Prickly lettuce	N	G	E	G	N	P	N
Prickly sida	N	G	E	E	N	G	N
Purslanes	N	G	G-E	F-G	N	G	N
Shepherd's-purse	N	G	G-E	F-G	N	G	N
Speedwells	N	-	E	P	N	P	N
Velvetleaf	N	G	G-E	E	N	G	N
Virginia pepperweed	N	-	E	G	N	G	N
PERENNIAL GRASSES AND SEDGES							
Fescues	P-F	F	E	F	F	N	F
Johnsongrass (rhizome)	G	-	E	P	G	N	G
Nimblewill	F-G	-	G-E	P	-	N	-
Orchardgrass	F	-	E	F	F	N	-

Quackgrass	G	P	G	P	G	N	G
Yellow nutsedge	N	G	F-G	P-G	N	N-P	N
Purpletop, Redtop	G	-	E	P	-	N	-
Dallisgrass	G	-	E	P	G	N	-
Bermudagrass	F-G	F	G	P	F-G	N	F-G

	Fluazifop (Fusilade DX)	Glufosinate (Rely)	Glyphosate (Various)	Paraquat (Gramoxone Extra)	Sethoxydim (Poast)	2,4-D	Clethodim (Select)
PERENNIAL BROADLEAF WEEDS							
Broadleaf plantain	N	-	E	P	N	G	N
Buckhorn plantain	N	F	E	P	N	G	N
Canada thistle	N	-	F-G	P	N	F-G	N
Chicory	N	-	E	P	N	G	N
Common mallow	N	-	E	P	N	-	N
Common milkweed	N	-	G	P	N	P-F	N
Common yarrow	N	-	G	P	N	F	N
Dandelion	N	G	E	P	N	G	N
Docks (broadleaf, curly)	N	-	G	P	N	G	N
Goldenrod	N	-	E	P-F	N	P-F	N
Ground ivy	N	G	E	P-F	N	P-F	N
Hemp dogbane	N	P	G	P	N	P-F	N
Horsenettle	N	G	F	P	N	P	N
Mugwort	N	-	F-G	P	N	P	N
Red sorrel	N	G	F	P	N	P	N
Thistles (bull, musk, plumeless)	N	-	G	P	N	F-G	N
White flowered aster	N	-	G	P-F	N	N	N
Wild carrot	N	-	E	P	N	G	N
Wild strawberry	N	-	E	P-F	N	P-F	N
Yellow rocket	N	-	E	F	N	P-F	N
Yellow woodsorrel	N	G	E	P	N	F	N
	Fluazifop (Fusilade DX)	Glufosinate (Rely)	Glyphosate (Various)	Paraquat (Gramoxone Extra)	Sethoxydim (Poast)	2,4-D	Clethodim (Select)
SPECIAL PERENNIAL WEED PROBLEMS							
Bigroot morningglory	N	-	F-G	P-F	N	F-G	N
Brambles	N	G	G	P	N	P	N
Common greenbriar	N	-	P	P	N	N	N
Japanese honeysuckle	N	-	F-G	P	N	P-F	N
Poison-ivy	N	-	G	P	N	P-F	N
Virginia creeper	N	-	F-G	P	N	P-F	N
Wild garlic	N	G	F	P	N	F	N

Vertebrate Pests

White-tailed deer:

Deer are 2-toed ungulates of the Cervid family. Deer are creatures of the forest edge rather than the dense, old-growth forest. They thrive in agricultural areas interspersed with woodlots and streamside habitats. They favor early success stages of brush and young saplings that keep browse (leaves and twigs) within reach. Dense cover for winter shelter and protection is preferred. Deer will eat browse (leaves, twigs, and buds) throughout the year. Spring and summer foods often consist of forbs (herbs) and fruits, nuts, and acorns are very important foods in autumn and early winter. Grasses, sedges, and ferns are not important food items. Deer will readily eat fruit trees, vegetables, legumes, small grains, soybeans, and corn when it is available.

Deer are most active at dawn and dusk. Damage is relatively easy to identify because white-tailed deer do not have upper incisor teeth. Thus, they yank the leaves and twigs off in away that leaves a jagged or torn surface of plants up to 5 or 6 feet height. The 2-toed footprint is very distinctive as are the feces pellets.

Breeding occurs from October to January with the peak rut occurring in November. Gestation is about 202 days and fawns are mostly born in May or June. Most adult does bear twin fawn that are rusty is color except for white spots. This permits very rapid repopulation after successful hunting seasons or significant population is other years. Bucks grow antlers during April through August that are covered with “velvet” that is rubbed off during the late autumn rut season. This act of rubbing off the velvet frequently takes a toll on fruit trees, Christmas trees and ornamentals.

Management: Deer population management is best accomplished through utilizing the legal hunting seasons or deer damage permits. When shooting is unfeasible or undesirable, exclusion utilizing fences has proven to be the best option. Fencing should be built by integrating modifications that will also control access of other animals, such as, rabbits and woodchucks.

Exclusion:

Fences: Permanent high-tensile electrified fences and 8-foot woven wire fences can provide year-round protection from deer and are the best option for high-value specialty and orchard crops. Such fences should be useful for a 25-30 year period. High-tensile fences that are 3-dimensional are more effective in excluding deer but are more expensive to build and maintain. Vertical fences that have 7 wires and are 8-feet high are usually used where deer damage is moderate to high. These type fences are considered to be the most cost effective, are easy to maintain, and can have 2 additional wires on vertical extenders added to prevent deer from jumping over top. Numerous other fence designs that are shorter or utilize polytape and other material are used where deer damage is light to moderate. Check with your county extension agent or local fence contractor for costs and designs.

Tree protector tube of plastic, or woven wire cylinders that are 4-5 feet tall can be used on individual trees to protect them from deer, rabbits and voles.

Cultural methods and habitat modification: Changes is the composition of timber species to reduce preferred food supplies (browse and acorns) and reducing the density of brush or shrubs used as shelter and resting areas can reduce deer populations.

Some people have planted food plots to lure deer away from orchards and had limited success.

Repellents: High costs, limitations on use, duration of chemical's effectiveness, and varying success cause repellents to be rated lower than fences in controlling deer damage in orchards. Repellents work through two methods. First, "contact" repellents are applied directly to plants and trees and repel deer by taste. They are most effective when applied to trees and shrubs during the dormant period. Contact repellents should not be used on fruits destined for human consumption, with the exception of Hinder. "Area" repellents are applied near trees being protected and by having offensive odors to deer.

"Deer Away Big Game Repellent" (37 % putrescent whole egg solids) is an effective contact repellent that is registered for use on fruit trees prior to flowering. When applied it to all susceptible new growth and leaders it is persistent and effective for 2-6 months. Rainfall is the major factor in how long it works.

Hinder (7-42 % tetramethylthiuram disulfide) is a contact repellent sold under trade names such as Bonide Rabbit-Deer Repellent, Nott's Chew-Not, and Gustafson 42-S, and others. It is most often used on dormant trees and shrubs but does not weather well without adding adhesives.

Miller's Hot Sauce Animal Repellent (2.5 % capsaicin) is a contact repellent for fruit trees that is applied by aerial sprayers to all new growth that can be reached by deer prior to fruit set.

Ro-pel (benzyldiethyl ammonium saccharide) is a contact repellent with a very bitter taste but cannot be sprayed on edible crops.

Other repellents that have been tried with variable success are animal tankage (putrified meat scraps), human hair, and perfumed soap bars. Noise created from gas exploders, shell cracker, fireworks, and gunfire has been used as a quick and temporary repellent.

Hunting: Effective use of all legal deer season options is probably the best way to control deer populations. Public access for hunting, fee hunting permits, hunting leases, and deer damage permits are all options orchardists need to consider.

Voles: Voles are also called meadow or field mice.: Voles are compact rodents with stocky bodies, short legs, and short hairy tails. Their eyes are small and their ears are partially hidden. Their undercoat is generally dense and covered with thicker, longer guard hairs. They are usually brown or gray, though many color variations exist. Voles that cause damage to fruit trees in our region are the Meadow Vole and the Pine or Woodland Vole. Voles prefer areas with heavy ground cover of grasses, grass-like plants, or litter. When the two species are found together, they usually occupy different habitats.

The meadow vole (Microtus pensylvanicus) is 5-7 inches long and the fur is normally gray to yellow-brown that is obscured by black-tipped hairs. Meadow voles prefer wet meadows and grassland habitats. They construct many tunnels and surface runways that are 1-2 inches wide with numerous burrow entrances.

The pine or woodland vole is 4-6 inches long and has brown fur that is soft and dense. The underparts are gray mixed with some yellow to cinnamon. The pine vole prefers heavy cover in orchards, abandoned fields, and pine or hardwood forests. Pine voles **do not build surface runways** but build an extensive system of underground tunnels.

Voles eat a wide variety of plants such as grasses and forbs. In late summer and autumn, they store seeds, tubers, bulbs, and roots. They frequently eat bark during autumn and winter.

Voles are active day and night throughout the year. A single burrow system may contain several adults and young. Voles breed throughout the year (spring and summer are preferred) and have 1-5 litters of 3-6 babies/litter. The gestation period is about 21 days.
Large population fluctuations are characteristic of voles. Populations peak every 2-5 years. Voles can cause extensive damage to orchards, ornamentals, and tree plantings due to their girdling of seedlings and mature trees. Girdling usually occurs during autumn and winter. Vole girdling can be differentiated from other animals by the irregular gnaw markings. They occur at various angles and in irregular patches. Gnaw marks are about 1/8 inch wide and 1/16 inch deep. Rabbit marks are larger and not distinct. Gnaw marks, feces, tracks should identify vole damage when combined with extensive surface runways and tunnels of the meadow vole and the underground tunnels of the pine vole.

Control methods: Voles populations are usually controlled by cultural modification to the habitat, toxicants, exclusion, trapping, or repellents. These can be tailored to the population density of voles, value of crops, and costs.

Cultural methods and habitat modification: Prime vole habitat can be reduced by eliminating dense weeds, ground cover, and litter around orchard trees, as well as, in nearby cultivated fields, abandoned fields and forests. Voles can live in high populations in ditch banks, rights-of-ways, and waterways that are unmanaged. Controlling such vegetation through mowing, grazing or spraying is very helpful.

Toxicants: Zinc phosphide is the most commonly used toxicant for vole control
It is a single-dose toxicant available in pelleted and grain bait formulations and as a concentrate. Zinc phosphide baits generally are broadcast at rates of 6-10 pounds per acre or are placed by hand in runways and burrow openings. Although pre-baiting (application of similar nontreated bait prior to applying toxic bait) is not usually needed to obtain good control, it may be needed if constant baiting causes voles to be wary of toxic baits. Zinc phosphide baits are potentially hazardous to ground-feeding birds, especially waterfowl. Placing baits into burrow openings may reduce this hazard.

Anticoagulant baits are also effective in controlling voles. Anticoagulants are slow-acting toxicants requiring 5-15 days to take effect and multiple feedings are needed to be effective. In many states it is necessary to be a registered applicator to use anticoagulants. Anticoagulants are also frequently placed in orchards in water repellent paper tubes and boxes that are commercially prepared and provide protection from moisture and reduces the potential impact on nontarget species.

Exclusion: Hardware cloth cylinders and plastic tree protector tubes can be used on seedlings and young trees. They need to be buried 6 inches deep to keep pine voles from burrowing underneath the cylinders and tubes.

Trapping: Small snap traps can be effective in controlling small populations of voles using a bait of peanut butter-oatmeal mixture, or apple slices. The snap trap should be place perpendicular to the runway with the trigger end in the runway. Trapping works best in autumn and winter.

Repellents: Thiram and capsaicin are two repellents that have been successfully used for short-term control of moles.

Cottontail Rabbits: The eastern cottontail rabbit is approximately 15-19 inches long and will weigh 2-4 pounds. Cottontails appear gray or brownish gray in the field. Closer examination revels a grizzled blend of white, gray, brown, and black guard hairs over a soft grayish or brownish underfur, with a rusty brown spot on the nape of the neck. They have large ears, hind feet that are much larger than the forefeet, and a white "cottontail" on the tail underside. Cottontails prefer brush fencerows or field margins, dense vegetation of brier patches, shrubs or gullies, and brushpiles. They use natural burrows and cavities dug by woodchucks or other animals for wet or cold weather and to escape predators. During the warm seasons rabbits will use grass and weed shelters where they can form a nestlike cavity in the dense vegetation. Rabbits only live an average of 12-15 months but can raise up to 6 litters a year. Gestation periods are 28-29 days before the 5-6 young are born. Under good conditions, a typical pair of rabbits can produce 18 young in a breeding season.
Rabbits usually eat forbs, flowers, and vegetables during the growing season but will readily eat bark and twigs in autumn and winter. They can seriously damage woody plants by gnawing bark or clipping off branches and seedlings. Deep winter snows allow rabbits to eat and gnaw higher up on stems and branches. In general, rabbits seem to prefer plants in the rose family that includes many orchard trees such as apples, cherry, plum, peach, and brambles. Rabbit damage can be identified by characteristic gnawing on older stems and clean-cut, angled clipping of young stems and branches. Distinctive round brownish droppings in small piles are another good identification sign.

Management: Cottontails are classified as game animals and are protected by laws throughout our region. Legal hunting, exclusion, habitat modification, trapping and repellents are options to manage rabbit populations.

Hunting: Rabbit hunting is fairly popular and long seasons and high bag limits offer an effective and cheap way to control rabbit numbers.

Exclusion: A 2-foot high wire fence of chicken wire with the bottom buried 2 inches in the ground will prevent access to rabbits. This will work for small areas, but cylinders and tubes work better for orchard trees.
Cylinders of ¼ inch mesh of hardware cloth or other materials that reach above the deepest expected winter snows or 5-6 feet height to prevent deer rubbing is effective. The wire cylinders should be staked to keep them at least 2 inches away from the tree bark.

Habitat modification: Vegetation control by mowing, grazing, or spraying along ditches, fencerows, and other areas will reduce cottontail numbers. Removing brush piles, dense weed and brier patches, piles of lumber, stone, and debris will rid the orchard of critical spots where rabbits live, rest, and hide. Old trees that are removed from the orchard and all annual pruning materials should be burned, chipped, or dumped where they do not become dens for rabbits and other animals.

Trapping: Rabbits are easily trapped in live traps of wire or in box traps of wood. Trapping works well around gardens, landscapes plants, etc. but is too time consuming for orchards. Baits can be apples, carrots, cabbage, fresh vegetables, or corn.

Repellents: Contact (taste) repellents are more effective with rabbits than "area" (odor) repellents. Success has been quite variable depending on food supplies and number of rabbits. Thiram based repellents have proven to be better than most other repellents and can be sprayed or brushed on the plants.

Woodchuck: The woodchuck (also called ground hog and whistle pig) is a member of the squirrel family. The hair is a grizzly brownish gray color and the short tail (4-6 inches long) is dark brown and furry. Woodchucks are compact and chunky with short strong legs and long claws for digging holes. A mature woodchuck will be about 16-20 inches long and will weigh 5-10 pounds. They have white or yellowish-white chisel-like incisor teeth. Their eyes, ears, and nose are located near the top of the head which allows them to remain in their burrows while checking for danger. Woodchucks can easily climb trees to escape danger or will scurry back to their dens when necessary.

Woodchucks prefer open farmland with adjacent areas of woods or brush. Burrows are commonly located in fields and pastures, along fencerows, stonewall, roadsides or near building foundations and bases of trees. Burrows are almost always in or near open, grassy meadows or fields. A large mound of earth marks the main entrance that will be up to a foot in diameter. Burrow systems will have 2 or more entrances that do not have mounds of earth and will be difficult to find.

Woodchucks prefer to eat in the early morning and evening hours. They are herbivores and eat a variety of grasses, legumes, and vegetables. Damage can occur on fruit trees where woodchucks gnaw or claw on the bark.

Woodchucks usually breed in March or April, have a gestation period of about 32 days, and a single litter annually of 2-6 young. They live about 3-6 years old and frequently use a burrow system for several seasons. Woodchucks are true hibernators for a 4 to 5 month period depending on the latitude.

Management: Woodchucks seldom build up is large numbers and do not cause major damage created by high populations of other animals. Hunting, fumigants, trapping, and exclusion are the most common control methods with woodchucks.

> **Hunting:** Woodchucks are considered game animals in most states, but there is seldom a bag limit and an open season is common.
>
> **Fumigants:** The most common method of woodchuck control is the use of commercial gas cartridges that suffocate the animals in their burrows. The cartridges are specially designed cardboard cylinders filled with slow-burning chemicals that produce poisonous carbon monoxide gas. Specific directions need to be followed in closing burrow entrances and using the gas cartridges. Cartridges should not be used under buildings or near fence posts because of potential fire hazard. Other woodchucks will often take up residence in treated burrows and it then becomes necessary to treat the den a second time.
>
> Burrows can also be treated with aluminum phosphide tablets. Aluminum phosphide is a restricted use pesticide and must be applied by a certified pesticide applicator. Tablets (2-4) are placed in the burrows and all entrances are covered. Aluminum phosphide in contact with soil moisture produces hydrogen phosphide (phosphine) gas that is poisonous and kills the woodchucks inside the den.
>
> **Trapping:** Trapping offers an alternative where shooting is unsafe or where gas cartridges are a fire hazard. No. 2 steel leghold and Conibear traps (110s, 160s and

220s are best) are effective ways to control woodchucks. Be sure to check with state game officials on trapping regulations that may apply.

Exclusion: Fencing that is 3 feet high made of heavy poultry wire with a maximum 2-inch mesh have helped control woodchucks. The fence must also be buried 10-12 inches in the ground or a foot-wide section bent at an L-shaped angle and buried about 2 inches deep.
An electrified wire at a height of 4-5 inches is an attractive option if combined with a vertical high tensile electric deer fence. This will also control access by rabbits and other small animals.

Beaver: The beaver (Castor canadensis) is North America's largest rodent and can weigh from 35-50 pounds. The beaver is a stocky rodent that has nose and ears that are valvular, and lips that close behind the teeth that allow it to remain underwater for long periods of time. The underfur is gray while the guard hairs range from yellowish brown to black, with reddish brown being the most common coloration. The large tail is flattened dorsally, scaly and almost hairless. Beavers have large front, bright orange incisors that are beveled so they continuously sharpen as the animal gnaws and chews. Beaver habitat can be in any constant standing water, such as streams, ditches, farm ponds, waste disposal ponds, or natural wetlands. Beaver can build dams to create a suitable habitat or to enlarge habitats.
Beavers prefer certain trees, such as aspen, cottonwood, willows, black cherry, tulip poplar. However, they will eat the bark, leaves, and twigs of most woody plants located near water, as well as, numerous herbaceous and aquatic plants. Beavers do not like to travel much over 300 feet from the nearest water.
Beavers are active about 12 hours each night. They communicate to each other through vocalizations, tail slapping, and scent posts. The average life span is about 10 years and beavers protect themselves in a large den covered with sticks, rocks and mud called a lodge or in a bank den. A pair of beavers will mate in late winter or early spring and after a gestation period of about 128 days, 3-4 kittens will be born.
Most beaver damage to orchards is from girdling or cutting fruit trees or flooding. Beaver damage can include the distinctive stick and mud dams or culverts and drainage pipes blocked with the same material. Bank dens are harder to locate but normally have sticks, limbs, and cuttings near the underwater entrance. The large teeth marks from gnawing and chewing are another sure sign of beavers. There will also be long and relatively straight drag-ways or water sluices where pieces of wood and food items are dragged to the standing water.

Management: Exclusion, cultural methods, and trapping are the best means to control beaver populations. These methods work well as part of an integrated system for controlling access by several other animals, such as rabbits and woodchucks that can be excluded by similar fences and techniques.

Exclusion: Fruit trees near farm pond, streams and other permanent water can be protected with hardware cloth cylinders, encircling with woven wire, tree protector tubes or similar material. Metal materials work better than plastic.

Cultural methods: Many attempts to destroy dams have only been partially successful. T-culvert guard and 3-log drains placed in dams have sometimes caused beavers to move to new locations.
A new device called the Clemson beaver pond leveler has proven quite successful. It allows continuous water flowing previously blocked culverts/drains and facilitates the

manipulation of water levels in beaver ponds. The device consists of a perforated PVC pipe that is encased in heavy hog wire fencing. This part is placed upstream of the dam or blocked culvert, in the main run or deepest part of the stream. It is connected to nonperforated sections of PVC pipe that are run through the dam or culvert to a water control structure downstream. It is effective because the beavers cannot detect the sound of falling or flowing water as the pond or culvert drains. Therefore, they do not try to plug the pipe. Details can be obtained from local county extension agents or state wildlife extension specialists.

Trapping: Trapping can be the most effective way to control beavers if the habits of beavers are understood. The trapper's knowledge of food preferences, and natural history will help the trapper to read the signs left by beaver, and where to place a trap. Use of leghold traps, conibear traps, or snares must be done within state regulations. The beaver is considered a legal furbearer and state laws dealing with seasons, bag limits, and trapping methods must be met.

Black bear: The black bear (Ursus americanus) is a large and strong, black hairy mammal weighing from 100-400 pounds. Adult males weigh an average of 250 pounds and adult females weigh an average of 150 pounds. The black bear is characterized by a tapering nose, short (3-6 inch long) tail, and small, rounded erect ears. The feet have 5 nonretractable inch-long claws that permit black bears to easily climb trees. Black bears walk with a shuffling gait but can run up to 30-35 miles per hour if necessary.

The natural range of black bears in the mid-Atlantic region is the forested Appalachian mountains of West Virginia and Virginia northeastward across western Maryland and central Pennsylvania to northeastern Pennsylvania. Numerous bears wander outside this area from time to time in search of food and new home territories.

Black bears are omnivorous and eat various foods based on seasonal availability. Their diet may consist of grasses, roots, berries, nuts/acorns, insects, and small mammals. They will readily eat carrion (dead animals) and garbage. Black bears do not hesitate to feed in orchards, cornfields and other agricultural areas, especially, when forest foods are scarce. They typically follow the same trail to and from orchards when feeding on apples, cherries, or peaches.

The black bear moves around a 6-19 square mile territory at night as it searches for food, shelter, and other needs. Bears mate during summer and semihibernate in hollow logs, windfalls, caves, holes, brushpiles and under buildings from December through April or May depending depending on the coldness of winter temperatures and the latitude. Two to three cubs that weigh 7-12 ounces at birth are born in late December. The mother and cubs leave the den when the weather warms up in spring.

Breaking down limbs laden with fruit is the most serious damage to orchards. This practice allows bears to leisurely eat fruits from the limb. Black bears will also claw off bark of fruit trees to mark territories. Black bears frequently raid bee hives that are placed in orchard to increase pollination of the flowers.

Management: Exclusion is the most often method used to control nuisance and damaging black bears. Cultural methods, frightening, trapping, and shooting are other useful control methods to consider.

Exclusion: If black bear pressure is high, a 5-foot tall, heavy gauge woven wire fence is best. Attach 2 outside strands of electrified high-tensile wires on the wooden posts at 6 and 56 inches above the ground.

A 4-strand high-tensile electrified fence with the wires spaced at 6, 16, 26, and

36 inches above the ground is another good way to exclude black bears. Electrified wires can be baited with salmon cans or bacon rinds to attract bears. A curious bear will sniff the bait material and get shocked on their tender noses. This should train them to stay away from bee hives and apple orchards.

Cultural: Any thing that makes the habitat less suitable for bear will discourage black bear from staying in an area. You can remove remove or change brushy areas, hollow logs, rocky areas, or other potential den sites. Keep all bee hives at least 50 yards away from wooded areas and protective bear cover. Clean up all fruit that falls to the ground and begins to rot.

Shooting: Hunting during regular seasons to keep bear populations within limits that can be tolerated is an excellent tool. Damage permits that permit shooting bear out of season is another tool when black bear populations are high. Bears shot in the hind quarters with 12-gauge plastic slugs or 38-mm rubber bullets will usually leave an area.

Trapping: Black bear are relatively easy to trap in a culvert or barrel trap that is baited with food. Trapped bears can then be transported to suitable habitat in a different location. Foot snares have also been quite successful.
Trapping must involve state wildlife personnel.

Frightening: Black bears can be scared by use of various devices, but these will only be temporarily successful. Strobe and night lights, loud music, pyrotechnics, exploder cannons, and scarecrows have worked when they are moved from one location to another regularly. Over time bears and other animals realize the scare tactics are not real and begin to ignore them.

Regulatory:

Priority needs:

Restructure state game commission advisory groups to include 2 agriculture and 2 forestry representatives.

Set various hunting seasons on on areas less than the size of a county (could include orchard areas and a buffer zone.

Research:

Priority needs:

Determine the number of deer per square mile that is acceptable to orchardists.

Test innovative fencing designs for controlling animal access.

Education:

Priority needs:

Provide an annual seminar/workshop for orchardists that updates animal damage & control.

Construct a website that is updated annually.

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