WASHINGTON STATE UNIVERSITY EXTENSION

PEST MANAGEMENT GUIDE FOR APPLES IN WASHINGTON HOME ORCHARDS

Home Garden Series

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PEST MANAGEMENT GUIDE FOR APPLES IN WASHINGTON HOME ORCHARDS

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Abstract

This publication is designed to help the home gardener recognize the most important insects, diseases, and vertebrate pests that affect their apple trees. It offers cultural management techniques that one can use to reduce pest pressure, as well as a list of registered pesticides.

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Pest Management Guide for Apples in Washington Home Orchards

Apple is one of the most widely cultivated fruit trees in the temperate climates of the world, and can be successfully grown by home gardeners throughout the state of Washington. Home gardeners in eastern Washington generally have a temperate climate with dry spring weather and low rainfall. The region typically has warm sunny days and cool crisp evenings, perfect conditions for growing apples (Figure 1). Likewise, western Washington shares an ideal temperate climate, but generally experiences milder winter temperatures, and moderate rainfall during the spring months. Fortunately, there are thousands of apple varieties with different growth habits and eating qualities that are ideally suited for production in different temperate climates.

Figure 1. Braeburn apples. (Photo by Jackie King at WSU Mount Vernon)

There are numerous fungal and bacterial diseases, insects, mites, vertebrates, and weeds that can negatively impact the overall health and productivity of a backyard apple tree or reduce the quality and taste of the fruit. Some of these pest problems can be minimized by the proper selection of apple cultivars and placement of the apple tree in your home landscape. Other pest problems must be controlled through a combination of nonchemical and chemical strategies that manage these populations at tolerable levels.

Home gardeners can raise their own apple trees if they take care in selecting the best adapted cultivars to their growing region. They may utilize a deliberate and proactive pest management strategy as outlined in this publication. This strategy seeks to maintain the health of the apple tree(s), produce blemish-free apples, and ensure human safety from pesticide residues by minimizing adverse impacts of contaminants on home landscapes.

This publication addresses the most commonly found pests, diseases, and disorders that are found across Washington State. It has been organized by the stages of plant development to depict the insect/disease pests and the sign/symptoms that homeowners should scout for and manage as the seasons progress.

In eastern Washington, homeowners who plant apple trees are legally responsible for controlling the insect pests in host trees on their property in order to protect commercial orchards (Bush 2014). Knowing your fruit tree pest history and monitoring your tree's health and fruit quality are the best indicators of the need for management.

Choose non-chemical management as your first choice. Some pests may require pesticide sprays to provide supplemental control. Homeowners must refer to the pesticide label before they purchase and apply a pesticide to confirm that the product may be applied to backyard fruit trees.

In this publication, look for the letter **O,** designating that the pesticide may be acceptable in organic production.

Foliar Pesticide Applications:

Many newer pesticide labels have the following statement on them, "For trees taller than 10 feet, consider hiring a licensed professional." Consider the use of dwarf rootstocks or training/pruning methods to keep trees under 10 feet in height. (Foss 2015).

Organic by Design

It is possible to produce a pest-free fruit by adopting the following practices from across the state:

- Select a full sun site with good soil drainage
- Prune and train trees in the fall
- Purchase trees on full dwarfing rootstocks (M9, M27, Bud 9) or utilize the new dwarfing Geneva rootstocks if fireblight is a problem
- Use scab and mildew resistant cultivars (Figure 2)
- Apply organic kaolin clay to ward off key insect pests (Figure 25)
- Cover apple with fruit bags (Figure 24)

Refer to WSU Extension Publication *Organic Pest Management in Backyard Fruit Trees and Berry Patches* (Brun 2013).

Figure 2. Akane apple is both scab and mildew resistant. (Photo by Charles Brun)

Pest Management Decision Guide

Apple Trees during the Dormant Plant Stage (resting stage)

January through February

Moss and lichens: In areas west of the Cascades, moss, lichen, and algae (Figure 3) can build up on the limbs in wetter regions (>60" of rainfall); typically these branch and twig growths seldom warrant pesticide applications. Ensure that new trees are planted in open areas with full sun and air movement.

Anthracnose cankers: The fungus *Cryptosporiopsis curvispora* is responsible for causing cankers (Figure 4) on apple twigs and small branches. Cankers are often noted in the dormant season when the tree is pruned. This disease is most commonly found in the higher rainfall areas west of the Cascades (Dugan 1993).

Unsightly cankers enlarge to 1-10 in. in length by midsummer. Within the canker, the bark splits away around a sunken area. As the bark tissue dies, it leaves "fiddle strings" extending the length of the canker. All apple cultivars are susceptible; Spartan, Gala, Melrose, and Akane are highly susceptible. Search and prune out branches with cankers as they are found. Refer to university pruning publications that cover trees on dwarfing rootstocks (Parker 2009; Marini 2015).

Mites, scale insects, and aphids: During the dormant season, European red mite (*Panonychus ulmi*) eggs (Figure 5) may be found on the trunks. If red mite problems were experienced the previous season, apply horticultural/petroleum oils at the dormant to delayed dormant stage (February & March) to control overwintering mite eggs (Table 1; Godfrey 2011). Some of these products may be formulated as organic. These same products will provide control for over-wintering scale insects and aphids.

Burrknots: In areas of lower light levels, higher humidity, and cooler weather, burrknots can form (Figure 6). They are classified as differentiated root tissue that often appears above the soil line. They form on the rootstock of the tree, below the bud union, and on the trunks of dwarf trees. Large burrknots can girdle the tree.

Table 1. Mites and Scale insecticides*

Product name	Active ingredient
All Seasons Horticultural & Dormant Spray Oil Concentrate Organic Gardening (O)[1]	superior oil/petroleum distillate
Bayer Advanced Natria Neem Oil Concentrate (O)	clarified hydrophobic extract of neem oil
Lilly Miller Spray Oil	petroleum oil

*These products also help reduce over-wintering aphid populations that may arise during petal fall.
[1] Refer to WSU HortSense for current pesticide recommendations (Foss 2015)

Figure 3. Winter moss. (Photo by Charles Brun)

Figure 4. Anthracnose canker. (Photo by Charles Brun)

Figure 5. Red mite eggs. (Photo by Ken Grey photos, Oregon State University)

Mound the soil around the tree to cover the burrknots beneath the bud union. If the bud union is accidently covered, the scion (top part of the tree) could take root and offset the dwarfing effect of the rootstock.

The full dwarfing M.9 rootstock (30% of seedling) does suffer from burrknots (Crassweller 2015). The new Geneva 16 rootstock is a fully dwarfing alternative to M9, and offers burrknot resistance (Lyga 2015). Retail garden centers in WA now sell trees on M.27, and M.9 rootstocks for full dwarfing, and M.7 for semi-dwarfing. They are also available from mail order and on-line sites. The Geneva rootstock trees are available from mail order supply nurseries.

Figure 6. Burrknots. (Photo by Charles Brun)

Apple Trees during the Delayed Dormant Plant Stage (bud swell stage)

March

Vole damage: Voles (*Microtus spp.)* are small mammals that resemble field mice. Voles feed on grasses, roots, and bulbs, but will attack the apple tree in March when their traditional food sources are scarce (Pehling 2013). Feeding scars with visible teeth imprints are found at the base of the tree (Figure 7). Vole feeding damage can girdle the base of the tree, thus killing the tree.

Figure 7. Vole girdling. (Photo by Charles Brun)

To reduce the incidence of vole feeding, keep all grass and wood chips a foot away from the base of the tree. Also consider setting out conventional mouse traps, baited with peanut butter, near the tree in the winter. Hardware cloth and plastic spiral trunk protectors can be used to protect the base of the trunk. There are no registered rodenticides for home use.

Scale insects: Apples are susceptible to scale insects. These are tiny sucking insects covered by a waxy secretion. Scales can build up on the bark, thus reducing the tree's growth (Kabashima 2014). Scout for adult scales (*Quadraspidiotus perniciosus)* that often shelter eggs of the next generation of pests. If scale problems were experienced in the previous season, apply horticultural oils in the dormant season to control over-wintering scales (Table 1).

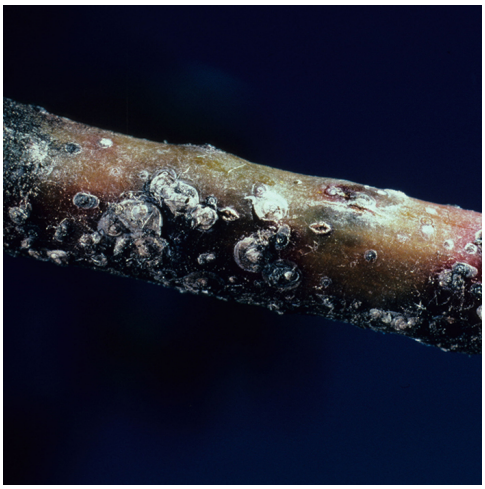

Figure 8. Scale insects. (Photo by Elizabeth Beers, WSU Wenatchee)

Oils kill exposed insects and mites by either suffocating them or by directly penetrating the outside cuticle and destroying internal cells. Apply dormant oil and appropriate insecticides for mites, scales (Figure 8), and aphids beginning at green tip (Figure 9) when temperatures are above 40°F, and no later than ½ in. green (Figure 10, Antonelli 2001). If oil is applied after ½ in. green tip, it will burn the developing tissue. In addition to mites and scale insects, these horticultural oil sprays reduce aphid and some caterpillar populations. Some of these products are formulated as organic.

Apple scab: The most common disease in western WA is apple scab (*Venturia inaequalis*). This disease can result in significant apple malformation at harvest (Figure 43). The wet spring weather in late April is largely responsible for the spread of fungal spores that over-wintered in the debris beneath the tree. The easiest way to avoid apple scab is to grow scab resistant cultivars (Table 2).

On the east side of the Cascades, the spring weather is generally considerably drier in the spring. This allows homeowners to raise cultivars found in the supermarkets such as Gala, Fuji, Honeycrisp, and Braeburn. All of these have excellent storage qualities and eating appeal (crunch, flavor, sweetness, etc.).

For scab-susceptible cultivars, manage the primary infection stage shortly after green tip (Figure 9) or during ½ in. green (Figure 10), when the first ascospores become mature. Refer to Table 3 for the suggested list of fungicides.

Table 2. Scab management is directly tied to cultivar selection

Scab susceptible cultivars: Fuji, Gala, Granny Smith, Jonathon, Red Delicious, Rome Beauty, Summerred, Winesap
Intermediate resistance: Jonagold, King, Melrose, Spartan
Scab resistant cultivars: Akane, Chehalis, Freedom, Honeycrisp, Jonafree, Liberty, Prima, Pristine

Table 3. Scab fungicides.

Product name	Active ingredient
Captan 50% WP Fruit & Ornamental	captan
Lilly Miller Polysul Summer and Dormant Spray Concentrate	calcium polysufide
Spectracide IMMUNOX Multi-Purpose Fungicide	myclobutanil

Powdery mildew: This is the most prevalent disease found on apples in eastern Washington, though it can occur all through the state. Apples are susceptible to the fungus *Podosphaera leucotricha*, that over-winters in the terminal buds (Gubler 2011). Losses are due to stunted canopy growth (Figure 16), crop yield reduction, and apple surface russeting (Figure 39) on highly susceptible cultivars. There is considerable variation in the susceptibility to powdery mildew. Select mildew resistant cultivars to reduce the need for fungicides (Table 4).

Table 4. Mildew management is directly tied to cultivar selection.

Mildew resistant cultivars:	**Mildew susceptible cultivars:**
Akane, Chehalis, Delicious, Enterprise, Fuji, Jonafree, Gala, Liberty, Pristine, Winesap	Braeburn, Cortland, Empire, Golden Delicious, Granny Smith, Jonathon, Liberty, Rome Beauty

Powdery mildew does best in moderate temperatures, high relative humidity, and shade. The spores are inhibited by extreme heat and direct sunlight. For susceptible cultivars, apply fungicides (Table 5) at green tip (Figure 9), in order to kill the mildew spores before they can germinate. Prune the canopy in the dormant season to ensure good air circulation.

Table 5. Mildew fungicides.

Product name	Active ingredient
Bi-Carb Old-Fashioned Fungicide (O)	potassium bicarbonate
Fertilome Dusting Sulfur	wettable sulfur
Lilly Miller Polysul Summer and Dormant Spray Concentrate	calcium polysufide
Monterey Horticultural Oil (O)	mineral oil/petroleum distillate
Safer Brand Garden Fungicide/Flowers, Fruit & Vegetables Concentrate	sulfur
Spectracide IMMUNOX Multi-Purpose Fungicide	myclobutanil

Figure 9. Green tip. (Photo by Charles Brun)

Figure 10. 1/2 inch green. (Photo by Charles Brun)

Apple Trees during the Blooming Plant Stage

April

Apple scab: For scab susceptible cultivars, apply fungicides (Table 3) as flower clusters show first pink (Figure 11), and then again at open cluster (Figure 12). If wet weather continues into full bloom, wait until 80% of the petals have fallen before applying the final fungicide application. Avoid all pesticides during bloom (Figure 13) as they can harm honey bees.

Aphids: If aphids were not addressed during the dormant season with oils (Table 1), leaf curling will occur in late April (Figure 14). There are non-oil alternatives that can be used during the growing season when the leaves are un-folding (Table 6). Timing is crucial, as once the leaves curl about the aphids, insecticide applications are ineffective.

Table 6. Aphid insecticides.

Product name	Active ingredient
Azamax Botanical Insecticide, Miticide, & Nematicide (O)	azadirachtin
Concern Insect Killing Soap Concentrate	potassium laurate
Safer Brand Insect Killing Soap with Seaweed Extract II (O)	potassium laurate

Codling Moth: *Cydia pomonella*, commonly known as the codling moth, is the key insect pest in backyard apples throughout Washington (Bush 2013). Codling moth is highly mobile and can establish itself on untreated backyard apples annually. During the flowering period, one can set out codling moth detection traps (Figure 15) to help determine the emergence of the first moths by mid-May. Wait until after petal fall before enacting any type of pest management strategy for controlling codling moth. Garden centers in Washington state may carry the codling moth detection traps.

POLLINATOR PROTECTION

Apples will fruit poorly without bees for pollination. In order to protect honey bees, avoid the use of any pesticides when apples are in bloom (Figure 13). While the diversity of potential pollinators is quite extensive, European honey bees are the primary pollinators in the home orchard. In addition, avoid spraying insecticides on any flower blooming in the home landscape, including weeds in the ground cover or flower in nearby bushes and shrubs. If you must use a pesticide on your fruit trees prior to or during bloom, use a product with low toxicity to bees and do not apply until late in the day, just before dark or early in the morning, when bees are not present. Look for the "Protection of Pollinators" section on product label for information on the toxicity of the product to bees. Always follow label recommendations when applying any product.

Figure 11. First pink. (Photo by Charles Brun)

Figure 12. Open cluster. (Photo by Charles Brun)

Figure 13. Full bloom. (Photo by Charles Brun)

Figure 14. Rosy apple aphid leaf curl. (Photo by Charles Brun)

Figure 15. Delta-wing codling moth detection trap. (Photo by Charles Brun)

Apple Trees after the Petal fall Plant Stage

May

Powdery mildew: The first sign of mildew shows up early in May. Young infected leaves or entire shoot tips develop a white or grayish powdery coating (Figure 16). Later in the season, affected leaves twist and curl, then turn brown in color as the leaf tissues die. On susceptible cultivars, pick off the infected terminals when the symptoms are first noted. This practice is practical on small trees, or when scab infection levels are low. There is no point in applying fungicides at this stage, as the damage to shoot growth has already occurred.

Apple scab lesions: The first signs of scab (Figure 17) are the presence of grey, smoky spots on the under-side of the leaves. On the upper leaf surface, a raised puckered area appears. By the end of May, the upper leaf shows olive-green to black lesions and leaf curling begins. Fungicide applications have no effect on the tree as this stage, as the damage is already done.

June drop: Two to three weeks after petal fall (Figure 18) developing pea-sized fruit may be shed, due to a lack of pollination. This so called “June drop” is normal.

Fire blight: The bacterium *Erwinia amylovora* is responsible for blossom blight in late May (Figure 19). Wet and warm weather during bloom helps fire blight spread and infect flower blossoms. Infected flowers exhibit a water-soaked appearance, followed by petal wilting and browning. Infected blossoms do not drop, but remain attached to the branches through the summer months. The bacterium continues to spread throughout the tree, causing leaves, twigs, and shoots to blight. Blighted shoots may form a “shepherd’s crook” (Beckerman 2007).

Management of fire blight begins with the use of blight resistant apple cultivars (Table 7), as well as blight resistant rootstocks. Homeowners should regularly scout their apple trees for fire blight shoot strikes and prune out all strikes as they appear. Make the cuts at least 6” below the blighted stem tissue to ensure that the tissue-invading bacteria are completely removed. Homeowners need to dip the pruning shears into household bleach to disinfect them between cuts. Nurseries sell the Geneva rootstocks (Table 8), which impart resistance to fire blight under orchard conditions (Norelli 2000). Fire blight is not a serious problem in western Washington.

Figure 16. Powdery mildew. (Photo by Charles Brun)

Figure 17. Apple scab on lower leaf surface. (Photo by Charles Brun)

Table 7. Fire blight cultivar susceptibility.

Susceptible cultivars: Fuji, Gala, Idared, Jonathon, Mutsu, Paulared, Rome Beauty
Resistant cultivars: Akane, Cox's Orange Pippin, Empire, Freedom, Haralson, Liberty, Prima

Table 8. Fire blight rootstock susceptibility.

Susceptible rootstocks		Resistant rootstocks[1]	
Fully dwarfing (staking required); trees grow to 6 ft in height	Semi-dwarfing (staking not required); trees can grow to 15 ft in height	Fully dwarfing (staking required); trees grow from 6-10 ft in height	Semi-dwarfing trees can grow to 15 ft in height
M 27, M 9	Mark, M 26, M 7	Bud 9, Geneva 11, 16, 41, 65	Geneva 30[2], Geneva 935

[1] Gardeners in eastern WA should consider fire blight resistant rootstocks
[2] This rootstock is brittle and the tree will require staking.

Figure 18. Petal fall. (Photo by Charles Brun)

Figure 19. Fire blight strike. (Photo by Clemson University, USDA Cooperative Extension Slide Series, Bugwood.org)

Figure 20. Rosy apple aphids on underside of an apple leaf. (Photo by Charles Brun)

Aphids: Several aphid species can become pests in apples, including the Green Apple Aphid (*Aphis pomi*) and the Rosy Apple Aphid (*Dysaphis plantaginea*). Aphid populations can build up throughout spring. Aphids are associated with the vigorous growth on young trees. Aphid feeding results in sticky honeydew, leaf curling (Figure 14), shoot malformation, and even tree stunting.

In late May, homeowners should examine the new leaves at the tip of shoots for aphid colonies on the undersides of leaves (Figure 20). Homeowners can prune out aphid-infested shoots and upright water sprouts. Aphids can be washed from the tree with a strong stream of water. If aphid populations are high, predators are low, and plant damage is apparent, there are a number of pesticide options available to homeowners (Table 5).

Tent caterpillars: In mid-May, tent caterpillars (*Malacosoma* spp.), with their characteristic webbing, or tents (Figure 21), may show up in the orchard. Tent caterpillars do minor and localized damage to the tree. On young trees, simply cut off the caterpillar nests as they are found. If pesticides are used (Table 9), apply them promptly at the first sign of caterpillar feeding. Do not apply pesticides to large, well-developed tents, as the caterpillars are mature and too sheltered in the tent to be affected.

Codling moth: During the final weeks of May, homeowners can plan a season-long strategy for codling moth prevention. It is hard to scout for the adults, as they fly during dawn and dusk hours, but detection traps can simplify this. Male codling moth adults (Figure 22) will appear in the detection traps (Figure 15) in late May. The key to codling moth management is to prevent the larvae from entering the fruit. There are three effective management strategies for codling moth control.

The first strategy is to apply an insecticide to coat the fruit before the larvae eats its way in. In eastern Washington, where codling moth pressure can be high, insecticidal cover sprays can be used to protect apples (Table 10). As there can be up to three generations of hatching larvae each summer, this approach requires multiple applications of insecticides. Note that some spinosad insecticide products are organically approved.

Table 9. Tent caterpillar insecticides.

Product name	Active ingredient
Bonide Thuricide BT Concentrate	*Bacillus thuringiensis* subsp. *Kurstaki*
Bull's-Eye Bioinsecticide	spinosad
Monterey Garden Insect Spray (O)	spinosad
Ferti-lome Borer, Bagworm, Tent Caterpillar & Leafminer Spray	(spinosyn A+D)
Concern Garden Defense Multi-Purpose Spray (O)	clarified hydrophobic extract of neem oil
Safer Brand Garden Defense Multi-Purpose Spray Concentrate (O)	clarified hydrophobic extract of neem oil

Table 10. Codling moth/apple maggot insecticides.

Product name	Active ingredient
Monterey Bug Buster II	esfenvalerate
Ortho Bug B Gon Max Lawn and Garden Insect Killer	esfenvalerate
Monterey Garden Insect Spray (O)	spinosad
Ortho Flower, Fruit and Vegetable Insect Killer RTU	acetamiprid
Spectracide Triazicide Insect Killer for Lawns & Landscapes Concentrate	gamma-cyhalothrin
Surround At Home Crop Protectant (O)	kaolin clay

The second approach to codling moth management involves applying the pesticide, kaolin clay. When mixed with water, the clay coating helps to repel the moths and to deter egg lying. In western Washington, where there are fewer commercial orchards, this approach is more feasible. The apple tree needs to be sprayed at least every 14 days from mid-June through the end of August. Note that kaolin clay is an organically approved insecticide.

Finally the most environmentally friendly approach involves bagging the young fruit to physically prevent the adult moths from landing on the surface of developing apples (Bush 2013). It is not practical to bag apples on a standard sized tree, but it is entirely feasible to bag all of the thinned fruit on apple trees under ten feet in height. In order to develop good fruit color, the bags can be removed a couple weeks prior to apple harvest.

Figure 21. Tent catepillar webbing. (Photo by Charles Brun)

Figure 22. Adult codling moth. (Photo by Scott Bauer, USDA Agricultural Research Service, Bugwood.org)

Apple Trees in the Early Summer

June

Fruit thinning: The first task in early June is to thin the number of fruit on the apple tree. Fruit trees tend to set too many fruit, which develop into numerous, but much smaller apples. In apple trees, fruit is often set in clusters of five (Figure 23). When the fruit are about 1 in. in diameter, thin or pinch off all but the center apple. Ideally, the goal is to retain one apple every six to seven inches along the branches. Thinning young fruit early in the summer results in larger fruit at harvest. It also makes pest management and pest scouting considerably easier during the summer months, as it facilitates fruit inspection (Parker 1999).

Figure 23. Thin fruit clusters to one apple. (Photo by Charles Brun)

Codling moth: Homeowners who prefer a non-chemical approach to codling moth management should consider protecting each apple on their tree(s) with a protective paper bag (Figure 24). If apples bags are not available at a garden center, there are online gardening supply houses that carry these bags. When combined with fruit thinning, the use of fruit bagging is a very effective, non-chemical approach to protecting fruit from insects all season long (Caprile 2011). Common paper lunch sacks, which measure 7.25 in. by 4 in., can also be used. Cut a 2 in. slit in the bottom fold of the sack and then slip it over the fruit, forming a seal around the stem of the apple. Finally, staple the open end of the sack shut.

Figure 24. Fruit protected within an apple bag. (Photo by Charles Brun)

For an organic pesticide, apply kaolin clay (Figure 25) to the entire tree in early June, or immediately after the first adult moths are trapped (Figure 15). This product is sprayed on as a liquid, which evaporates, leaving a protective and non-toxic powdery film on the surfaces of the fruits and leaves. Conventional pump sprayers can be used frequently, but thorough coverage is important, especially when the apples are rapidly sizing up. Hose-end sprayers are popular but perform poorly. Pump-up sprayers break up the droplets, ensuring much better coverage. Kaolin clay is effective for 7-14 days before it will need to be re-applied. The white coating on the fruit can be washed off with water and a soft brush at harvest.

Figure 25. Apples protected with Kaolin clay. (Photo by Charles Brun)

If one fails to properly control codling moth, fruit infestation will be found by mid-June, as the larvae bore into the fruit towards the core of the apple (Figure 26). Larvae may enter through the sides, stem end, or calyx end of the fruit. The most visible sign of an infested apple is a brown granular material found in and about the larval entry holes (Figure 27). During this period, homeowners should periodically scout for and remove/destroy all infested apples (Caprile 2011).

Fruit russeting: By mid/early June, the first signs of russeting appear on young apples. Russeting manifests as corky, roughened, or brownish areas (Figure 28) on the surface of the fruit. There are several causes of russeting. Cool, wet weather from pre-pink (before Figure 11) until three weeks after petal fall can lead to russeting, notably near the stem end of the fruit. Powdery mildew can also cause russeting. Cultivars with Jonathon or McIntosh in their lineage are more prone. Fungicides applied for scab or mildew may reduce the incidence of apple russeting.

Apple maggot: The western WA homeowner needs to develop a pest management strategy for dealing with apple maggot (*Rhagoletis pomonella*). This insect has recently expanded its distribution into parts of the Pacific Northwest (Bush 2005). West of the Cascades, apple maggot is a threat to developing fruit. Adult flies resemble house flies (Figure 29), but are not commonly encountered.

To determine their presence, set out apple maggot traps (Figure 30) coated with tangle foot adhesive by mid-June. These traps determine the presence of the adult flies that over-winter as pupae from the ground beneath the trees. Each of the three strategies described for codling moth management will also be effective for apple maggot. Apply insecticides as outlined in Table 10 or bag the fruit (Figure 24) to protect them from apple maggots.

Aphids: Aphids are preyed on by natural enemies, like lady beetles and lacewings. Conserve these natural enemies by avoiding insecticides as much as possible during the spring. Most aphids leave apple trees for summer plant hosts. Scout apple trees for those aphids that remain. At high population densities, aphids may cause severe shoot malformation, excessive honeydew, and tree stunting, and may feed directly on the fruit. The potassium laurate products in Table 6 can be used for summer aphid management.

Figure 26. Codling moth tunneling. (Photo by Charles Brun)

Figure 27. Codling moth exudate. (Photo by Charles Brun)

Figure 28. Fruit russeting. (Photo by Charles Brun)

Figure 29. Female adult apple maggot. (Photo by Charles Brun)

Figure 30. Apple maggot fly detection trap. (Photo by Charles Brun)

Apple Trees in the Mid Summer

July

Apple scab: By early July, scab becomes evident on the scab-susceptible cultivars. The leaves start to turn yellow (Figure 31) and drop. The fruit shows the corky brown lesions, often accompanied by fruit deformation. Within these lesions, spores are released that can further infect leaves and fruit. Fungicide applications have no effect on apple scab, as the tree and fruit damage is already done.

Kaolin barrier: Continue to apply the kaolin clay barrier (Figure 32) during the summer months to reduce apple maggot and codling moth infestations. Kaolin clay will also protect the fruit against sunburn damage. Sunburn damage (Figure 33) results in discoloration to the surface of the apple. Damage occurs when the surface exceeds 126°F, which can occur on hot summer days under clear skies and a lack of wind. The damage does not extend into the core of the fruit, and is only found on the side of the fruit that receives direct light late in the afternoon.

Codling moth: Un-managed orchards show codling moth infestation by early July. At this time, apples may be cut open (Figure 34) to reveal second generation larvae or empty larval tunnels that lead to the apple core. The orchard should be walked on a weekly basis to look for codling moth infested fruit. This fruit should be picked and destroyed or crushed, and put into a properly maintained compost pile. Do not simply leave the fruit on the ground under the host tree, as these so called "windfalls" will continue to serve as breeding sites for additional codling moths. If the orchard is treated with insecticides (Table 10), be sure to keep up spraying the fruit as the label directs because the residue coverage can be degraded by sun, washed off by rain or water, or disrupted as the fruit grows in size.

Apple maggot: Beginning in early July, apple maggot adults (Figure 29) emerge from the soil under the tree and fly into the apple tree canopy. Fly activity can be detected on the surface of the fruit or on the surface of monitoring traps (Figure 30). As with codling moth, keep the fruit covered with clay or protective barriers, or spray with insecticides with the first emergence of flies. In eastern Washington, gardeners may decide to remove their apple trees near commercial apple districts rather than protect them from pests. Home gardeners that plant apples near the major fruit growing districts are legally responsible for pests such as apple maggot and codling moth (Bush 2014).

Woolly apple aphids: During the summer months, homeowners may notice the cottony masses of white wax (Figure 35) secreted by the woolly apple aphid (*Eriosoma lanigerum*) on the trunk and branches of trees. Overwintering aphids survive as adults on the roots. While the above-ground populations of woolly apple aphids are unsightly and their feeding causes branch or trunk swellings, root-infesting populations are considered minor pests that cause root galls, and interfere with the overall health of the apple tree. If trees are found with this problem, consider using neem insecticide. Beneficial insects, including lacewings, lady beetles, and syrphid fly larvae, as well as parasitic wasps may provide adequate control of this pest. A steady stream of water from a garden hose directed at the above-ground populations helps considerably. Trees on the Geneva 11 or 41 rootstock are resistant to infestation by woolly apple aphid (Lyga 2015).

Figure 31. Apple scab. (Photo by Charles Brun)

Figure 32. Kaolin clay residues. (Photo by Charles Brun)

Figure 33. Sunburn damage. (Photo by Charles Brun)

Spider Mites: In most seasons, mites are controlled by natural enemies, such as predatory mites. Conserve natural enemies by using insecticides only when necessary to maintain the health of the tree. Avoid tree stress, especially improper irrigation. Mites can be washed off trees with applications of insecticide soaps. Summer horticultural oils reduce spider mite populations. Mite damage during the summer is rarely found in areas west of the Cascades, but is made worse by water stress (drought) in eastern Washington.

Figure 34. Signs of an apple infested with CM larva. (Photo by Charles Brun)

Figure 35. Woolly apple aphids. (Photo by Charles Brun)

Apple Trees in the Late Summer

August

Apple scab: As the summer progresses, the severity of scab increases to the extent that the entire fruit surface becomes covered with the corky tissue (Figure 36), especially on scab susceptible cultivars. Overall fruit size will be reduced by harvest.

Apple maggot: In August, the first sign of apple maggot infestation shows up as dimples (Figure 37) on the skin of the fruit. Each dimple represents a site where the female fly laid an egg. These dimples, or stings, may indicate the presence of the tissue-tunneling maggots. Often the windfalls are the first to show the puncture wounds. When the fruit is cut open, characteristic signs include small, brownish, irregular, and threadlike tunnels (Figure 38). Periodically walk through the orchard and pick up any windfalls with signs of apple maggot infestation. Ideally, this infested fruit needs to be removed or destroyed to kill the maggots within the fruit.

Powdery mildew: Towards the end of the summer, mildew is found on the surface of apples (Figure 39), particularly in the susceptible cultivars. Lightly scarred fruit are safe to eat. Peel as desired. Prune off branch tips with signs of powdery mildew.

FIgure 36. Scab infected fruit may become deformed. (Photo by Charles Brun)

Figure 37. Apple maggot stings. (Photo by Charles Brun)

Stink bug (including brown marmorated stink bug): The brown marmorated stink bug (BMSB, *Halyomorpha halys*) is an invasive pest accidentally introduced to the east coast of the United States from Asia in the 1998. It has now spread all across the country. It was first detected in Washington State in 2013. By late summer, adult stink bugs (Figure 40) leave summer hosts and nearby woods and move into nearby host plants, including apples.

Control of stink bugs is difficult due to the limited effectiveness of insecticides and a constant influx of stink bugs from outside areas (Murray 2012). Pyrethroid insecticides are most effective, so choose products that contain the active ingredient esfenvalerate (Table 10). Products containing spinosad (Table 10), may require frequent spraying (refer to label). Kaolin clay has only proven fair in reducing damage. Apple bags will provide protection from stink bug feeding.

Figure 38. Apple maggot internal injury. (Photo by Charles Brun)

Figure 39. Powdery mildew russet on apple. (Photo by N.S. Luepschen, Bugwood.org)

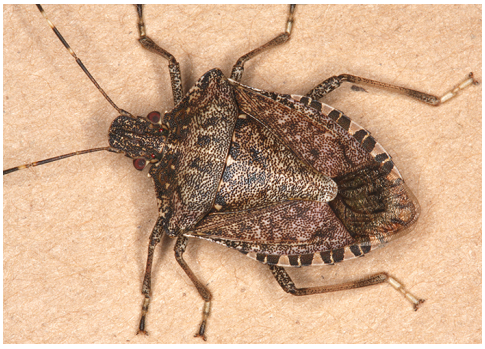

Figure 40. Brown marmorated stink bug adult. (Photo by Steve Jacobs, Penn State University)

Apple Tree Harvest

September through October

Apple maggot damage: Fruit with apple maggot damage becomes soft, rotten, inedible, and often drops from the tree (Figure 41). Pick up the spoiled fruit from the floor of the orchard. Either dispose of it in the trash or compost it in a black compost bin. Avoid placing fruit on flat exposed compost piles, as the apple maggot pupae will survive over the winter. Adult flies emerging the following summer can start new infestations. Exposed compost piles do not attain temperatures high enough to kill pupae.

Codling moth: The damage may show up as core rot (Figure 42) or as tunnels that lead to the core of the apple. Do not leave any codling moth infested fruit on the orchard floor. Pick up infested apples and place them in a black compost bin to destroy any larvae inside the apple.

Figure 41. Apple maggot damage. (Photo by Charles Brun)

Apple scab: By harvest, scab-infected fruit may appear unsightly (Figure 43), but the lesions do not extend into the flesh. With judicious peeling, they are still safe to consume.

Stink bug damage: Apple fruit are periodically prone to damage by stink bug feeding. The adults use their piercing-sucking mouthparts to inject its saliva into the flesh of apple. What starts out as a tiny pinprick from feeding, turns into a darkened, dimpled depression (Figure 44) on the surface of the fruit. When the apple skin is peeled back, one will find brown pithy areas (Figure 45). Infected fruit are generally considered un-palatable.

Leafrollers: Home gardeners occasionally find fruit at harvest with scars (Figure 46) on the surface of the fruit that do not extend into the core of the fruit. This damage may be caused by the larvae of one of several leafroller species in the Tortricidae moth family (Beers 1993). Typically leafroller caterpillars roll-up and tie young leaves together with silk, then hide in the rolled leaves while feeding on leaf tissues (Beers 1993). The larvae sometimes tie leaves to the surface of developing apples and feed on the surface of the fruit during the summer. The damage by leafrollers to apples can be peeled and eaten fresh, but damaged apples do not store well. If leafroller damage is widespread on apples at harvest, consider the use of the tent caterpillar insecticides spinosad and *Bacillus thuringiensis* next season, listed in Table 9.

Anthracnose cankers: Fungicides applied to the susceptible cultivars in the fall, prior to the onset of fall rains (Table 11), can protect limbs from further infection, but have no effect on established cankers. During the dormant season, prune out the cankers as they are found. All apple cultivars are susceptible, while Spartan, Gala, Melrose, and Akane are highly susceptible (Pscheidt, 2015).

Table 11. Anthracnose fungicides.

Product name	Active ingredient
Bonide Liquid Copper fungicide (O)	copper octanoate
Bonide Copper Fungicide Spray or Dust (RTU) (O)	basic copper sulfate
Lilly Miller Kop-R-Spray Concentrate	metallic copper

Figure 42. Codling moth injury damage. (Photo by Charles Brun)

Figure 43. Apple scab. (Photo by Charles Brun)

Figure 44. Stink bug injury. (Photo by Bryan Butler, University of Maryland)

Figure 45. Brown marmorated stink bug internal damage. (Photo by Peter Shearer, Oregon State University, Hood River)

Figure 46. Leaf-roller damage. (Photo by Charles Brun)

Apple Trees After Harvest

November

Bull's eye rot: The fungus *Neofabraea malicorticis* is responsible for a post-harvest storage rot known as Bull's-eye rot. The symptoms include circular, brown lesions with a target-like appearance on the fruit (Figure 47). Fungal spores spread from cankers (anthracnose, Figure 4, and perennial canker, Figure 54) on the tree to the fruit, especially during rainy weather near harvest. Fruit that is wet when it goes into storage is prone to this disease. If fungicides are used to protect tree limbs from anthracnose or perennial cankers (Table 11), there will be protection for the fruit in storage as well. Any fungicide program should be conducted in combination with canker removal.

Figure 47. Bull's Eye rot. (Photo by Chang-Lin Xiao, San Joaquin Ag Sciences Center, Parlier, California)

Windfalls: Many diseases and insects reproduce or spend the winter on dropped fruit known as windfalls (Figure 48). Both codling moths and apple maggots complete their life span after the fruit has fallen from the tree, thus it is best to pick up and properly destroy windfalls as they occur. Pestiferous voles will also be attracted to windfalls.

Figure 48. Windfall fruits. (Photo by Charles Brun)

Orchard sanitation: Reduce the incidence of apple scab and fruit-inhabiting insects by raking up all the leaves (Figure 49). Dispose of these leaves in a hot compost bin. Fallen leaves harbor the scab fungus, so ideally rake and destroy them before they become brittle and break into tiny fragments under the tree. Conversely, use a mulching lawnmower to chop the leaves to very fine pieces, thus encouraging their decomposition before spring. On scab-susceptible cultivars, orchard sanitation is considered marginal unless it is combined with the proper use of fungicides applied before pre-pink (Figure 11) and after the petal fall stage (Figure 18).

Collar rot: Apple trees can suffer from collar rot caused by a soil-borne fungus (*Phytophthora cactorum*). Symptoms include premature bronzing, purpling, or yellowing of the foliage on one or more limbs. The leaves are smaller and the branches are shorter. Near the soil line, the rootstock bark reddens. If one scrapes the soil away from the root crown, the underlining bark is red (Figure 50). This fungus is associated with wet soil conditions. If the tree is in poorly drained soil and receives an excessive amount of irrigation, it becomes susceptible to collar rot. By the time the tree starts to decline from collar rot, it is too late to save it. The dwarfing rootstock M9, recommended for the home orchard, is resistant to collar rot. There are no fungicides for the management of collar rot in the home orchard. All of the Geneva rootstocks impart resistance to color rot (Lyga 2015).

Figure 49. Scabby leaves. (Photo by Charles Brun)

Figure 50. Collar rot at the base of the tree. (Photo by Tim Smith, Washington State University)

Apple Trees during the Dormant Plant Stage

December

Nectria canker: This canker is caused by the fungus *Neonectria galligena*. This disease is commonly found in western Washington, in areas of high rainfall. Symptoms include sunken areas and pinkish or coral-colored fruiting bodies of fungus that appear on the smaller branches (Figure 51). Look for cankers at leaf scars, or where any branch or trunk injury has occurred. The fungus grows deep into the wood and forms wound callus tissue as it develops. Each year a successive layer of callus develops, resulting in the formation of a target-like canker.

To prevent Nectria canker, care should be taken to leave clean pruning cuts during the dormant season. As cankers are found, they need to be cut out when possible. If not removed, the branch or limb can be girdled and killed. After pruning activities, consider using fungicides to protect the surrounding limbs. The fungicides used for anthracnose cankers (Table 11) are effective on Nectria canker. These fungicides protect the limbs from further infections, but will have no effect on established cankers. The cultivars, Gravenstein, Red Delicious, Gala, Spartan and McIntosh, are very susceptible, while the cultivars, Jonagold, Rome Beauty, and Jonathon, are less susceptible to Nectria canker.

Fire blight canker: Branches and twigs infected with fire blight are darker in color (Figure 52), and the bark appears sunken and cracked. If shoot infections are promptly removed in the spring, there should be fewer branch cankers at the end of the season. During winter pruning, look for cankers and remove them with pruning saws or loppers when possible. There are rootstock differences in regards to fire blight. The popular M26 (semi-dwarfing) and M9 (full dwarfing) rootstocks are highly susceptible, while the semi-dwarfing M7 rootstock is considered tolerant. If the fire blight has moved into the main trunk, the tree will need to be completely removed, including the stump. Many of the scab resistant apples are also resistant to fire blight. Geneva rootstocks offer fire blight resistance (Lyga 2015).

Woolly apple aphid: During the dormant season, scout your apple trees for signs of woolly apple aphid feeding (Figure 36) that occurred in the summer. Infested trees will exhibit galls (Figure 53) on the stems and branches, along with white masses of aphid exudate. Prune to remove the infested limbs.

Perennial canker: Perennial canker is initially indistinguishable from anthracnose canker (Figure 4). Later in disease progression, perennial canker forms over-lapping concentric rings of woody tissue about the initial wound (Figure 54). This fungal disease is most commonly found east of the Cascades. Injury from wooly apple aphid feeding, winter injury, or wounds, serves to initiate perennial canker. Large cankers girdle the trunk and major limbs. Perennial cankers are best removed by pruning. There are no pesticides registered for perennial canker management.

Figure 51. Nectria canker (Coral spot). (Photo by Bruce Watt, University of Maine, Bugwood.org)

Figure 52. Fire Blight canker. (Photo by William Jacobi, Colorado State University, Bugwood.org)

Figure 53. Woolly apple aphid galls on limbs. (Photo by Charles Brun)

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Figure 54. Perennial canker. (Photo by H.J. Larsen, Bugwood.org)

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Use pesticides with care. Apply them only to plants, animals, or sites as listed on the label. When mixing and applying pesticides, follow all label precautions to protect yourself and others around you. It is a violation of the law to disregard label directions. If pesticides are spilled on skin or clothing, remove clothing and wash skin thoroughly. Store pesticides in their original containers and keep them out of the reach of children, pets, and livestock.

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