Nut Crops

Chestnut Pests

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Latest revision—March 2024

INCLUDES MANAGEMENT OPTIONS FOR COMMERCIAL AND HOME USE

In all cases, follow the instructions on the pesticide label. The *PNW Insect Management Handbook* has no legal status, whereas the pesticide label is a legal document. Read the product label before making *any* pesticide applications.

Note: Products are listed in alphabetical order and *not* in order of preference or superiority of pest control.

Chestnut—Filbertworm

Cydia latiferreana

Pest description and crop damage Adult moths have a wingspread of about 0.5 inch. Moths are gray to reddish with golden bands across each forewing. When mature, larvae are whitish with a translucent, amber-color head, 0.5 inch long. The larvae feed within the nut and destroy the kernel.

Biology and life history Filbertworm overwinter as larvae in silken cocoons, which may be found under leaves and leaf litter on the ground, or in cracks and crevices in bark. Some larvae also overwinter 1 to 2 inches beneath the soil surface. The larvae pupate, then the adults emerge beginning in mid-June. Moth emergence continues through October. After emergence, the adults find mates and lay eggs singly near developing nuts. Eggs mature in 8 to 10 days, and the larvae then move about in search of a nut to feed on. They burrow into the nut, feed on the kernel for 2 to 4 weeks, and bore their way back out. Most form cocoons to overwinter, although there may be a partial second generation.

Scouting and thresholds Pheromone traps are used to time sprays for this pest. A degree-day model is available on uspest.org.

Management—chemical control: HOME USE

- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- carbaryl—Do not apply to blooming trees or weeds or cover crops in bloom. Deadly to bees. Apply early July and again 3 weeks later.
- gamma cyhalothrin
- kaolin clay—Strong suppression effect. OMRI approved for organic use. 4-hour reentry. Apply prior to egg laying (815 DD), maintain coverage throughout flight period. Good agitation in spray tank is essential.
- lambda-cyhalothrin (often as mix with other chemicals)
- pyrethrins—Some formulations are OMRI-listed for organic use.
- spinosad—Some formulations are OMRI-listed for organic use. Apply at or just prior to egg hatch to target emergent larvae
- zeta-cypermethrin

Management—chemical control: COMMERCIAL

Pheromone trapping is encouraged for accurate spray timing.

- acetamiprid (Assail 70WP) at 2.3 to 4.1 oz/A (0.10 to 0.18 lb ai/A). PHI 14 days. No more than 4 applications per season.
- alpha-cypermethrin (Fastac CS) at 3.2 to 3.8 fl oz/A (0.021 to 0.025 lb ai/A). PHI 7 days. REI 12 hr. Do not exceed 11.4 fl oz/A per season. Highly toxic to bees, extremely toxic to fish and aquatic invertebrates. Do not apply within 25 feet of aquatic habitats, or with 150 ft if aerial application. Apply as indicated by scouting.
- beta-cyfluthrin (Baythroid XL) at 2.0 to 2.4 fl oz/A or 0.016 to 0.19 lb ai/A. Maximum per 14 day and per season: 0.022 lb ai/A. PHI 14 days.

- beta-cyfluthrin + imidacloprid (Leverage 360) at 2.8 fl oz/A (0.022 lb ai/A). Maximum 2.8 fl oz/A per year. PHI 14 days.
- bifenthrin—
    - Brigade WSB at 0.05 to 0.2 lb ai/A. PHI 7 days. REI 12 hr. Do not graze livestock on treated cover crops. Highly toxic to bees and toxic to fish and aquatic invertebrates.
    - Fanfare EC at 3.2 to 12.8 fl oz/A (0.05 to 0.20 lb ai/A). PHI 7 days. Do not graze livestock on treated cover crops. Highly toxic to bees and toxic to fish and aquatic invertebrates. WA only.
- carbaryl (Sevin XLR Plus or its equivalent in another formulation) at 0.5 to 1.25 quarts/100 gal water (2 to 5 quarts/A). PHI 14 days. REI 12 hr. May cause rapid increase of aphid populations 3 to 4 weeks after application. Extremely toxic to aquatic invertebrates.
- chlorantraniliprole (Altacor) at 3 to 4.5 oz/A. PHI 10 days. REI 4 hr.
- *Chromobacterium subtsugae* strain PRAA4 (Grandevo) at 1 to 3 lb/A. OMRI-listed for organic production.
- diflubenzuron (Dimilin 2L) at 16 fl oz/A. Most effective if applied before egg-laying. Extremely toxic to aquatic invertebrates. Do not apply within 25 ft of bodies of water. Do not make more than 4 applications per season. PHI 28 days. REI 12 hr.
- emamectin benzoate (Proclaim) at 3.2 to 4.8 oz/A. PHI 14 days.
- esfenvalerate (Asana XL) at 8 to 10 fl oz/100 gal water (9.6 to 19.2 fl oz/A or 0.05 to 0.1 lb ai/A). PHI 21 days. REI 12 hr. Do not apply more than 0.2 lb ai/A per season. Extremely toxic to fish and aquatic habitat.
- lambda-cyhalothrin (Warrior II) at 2.56 to 5.12 fl oz/A. PHI 14 days. REI 24 hr. Do not exceed 0.16 lb ai/A per season or 0.12 lb ai post bloom.
- methoxyfenozide (Intrepid 2F) at 8 to 16 fl oz/A. PHI 14 days. REI 4 hr. Apply when egg hatch begins. Reapply at 14- to 21-day intervals under high pressure or sustained moth flight. Do not exceed 24 fl oz/A per application or 64 fl oz/A (1 lb ai/A) per season. Do not apply within 25 ft of an aquatic habitat, 150 ft if applied by air.
- methoxyfenozide + spinetoram (Intrepid Edge) at 6 to 12 oz/A. Apply at initiation of egg hatch, if necessary, reapply after 14 –21 days, but not before 14 days. PHI 7 days. REI 4 hr. No more than 12 fl oz/A/season.
- permethrin—
    - Ambush 25W at 12.8 to 25.6 oz/A. PHI 14 days. Do not graze treated orchards. Extremely toxic to fish and aquatic habitat.
    - Ambush at 0.2 to 0.4 lb ai/A. PHI 14 days. REI 12 hr. Do not graze treated orchards. Extremely toxic to fish and aquatic habitat.
    - Pounce 3.2 EC at 8 to 16 oz/A. PHI 14 days. REI 12 hr. Do not graze treated orchards. Extremely toxic to fish and aquatic habitat.
- pyriproxyfen (Esteem 35 WP) at 4 to 5 oz/A. Do not apply more than twice per season. PHI 21 days. REI 12 hr.
- spinetoram (Delegate WG) at 1.5 to 1.75 oz/100 gal water (4.5 to 7 oz/A). PHI 14 days. Apply no less than one week apart, with a maximum 4 applications per season.
- spinosad (Entrust SC, Success Naturalyte) at 4 to 10 oz/A (0.06 to 0.16 lb ai/A). PHI 1 days. REI 4 hr. Entrust SC OMRI-listed for organic use. REI 4 hr. Do not exceed 29 oz/A (0.45 lb spinosad) per season.

Chestnut—Shothole borer

Scolytus rugulosus

Pest description and crop damage Shothole borers are small beetles that were introduced to North America and have been found in the PNW since the early 1900s. They are pests of forest trees, ornamental shade trees, and shrubs as well as nut trees. Borers are primarily a problem on injured or stressed plants, but healthy trees growing adjacent to blocks of neglected trees also may be attacked. Chestnut trees growing adjacent to woodlands are also at risk. The adult shothole borer is a brownish-black beetle about 0.08 inch long. The larvae are white, legless, and about 0.17 inch long. Larvae and adults bore into the cambial and vascular tissues of trees, weakening them and causing wilting and dieback of individual stems and branches. Trunks and branches can be completely riddled with galleries.

Biology and life history Shothole borers overwinter as a larva in burrows beneath the bark of infested trees. They pupate there, then adults emerge in spring or early summer, mate, and fly to susceptible trees to feed at the base of leaves or small twigs. They then tunnel into the tree, excavating galleries parallel to the wood grain. They lay eggs along the gallery. The eggs hatch and the larvae feed by tunneling at right angles to the main burrow, causing a characteristic pattern of damage. The burrows are filled with frass and increase in diameter as the larvae mature. After 6 to 8 weeks, the larvae pupate at the ends of the galleries, then emerge as adults starting in August. This activity creates many small, round exit holes that produce a "shothole" effect. There are two generations per year.

Scouting and thresholds Examine branches in late spring for holes 0.08 inch in diameter, oozing sap and sawdust. Beetles are especially attracted to unhealthy trees.

Management—cultural control

Select planting sites with well-drained, slightly acidic soils. The best management tool is keeping trees healthy through proper pruning, adequate watering, and fertilizing. Healthy trees repel the beetles by plugging bore holes with sap and resins. Remove and destroy infested wood on the tree or nearby piles of infested green wood, especially cherry wood. Once the bark on cut wood dries and sloughs off, it is no longer a host for the beetles. Whitewash trunks of young trees to prevent sunburn and reduce potential hazard of attack from shothole borer. Tanglefoot or other sticky substances applied to the trunk may be effective. Yellow sticky traps are effective for trapping these beetles. Lindgren funnel traps can also be effective. Ethanol baits can enhance trap captures.

Management—chemical control: HOME USE

Pesticides must be timed to manage adults and are often not very effective. The best control is preventative. Choose good planting sites, and maintain healthy trees through adequate, but not excessive irrigation, fertilization, and pruning practices, as well as proper sanitation (remove and destroy weak or diseased wood and infested limbs).

Management—chemical control: COMMERCIAL USE

No commercial products are specifically labeled for this pest, but products registered for chestnut with long residuals may be somewhat effective treatments for trunks and branches during flight periods to deter some borers from entering trees.

Hazelnut Pests

Nik Wiman and Erica Chernoh

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Protect pollinators: See How to Reduce Bee Poisoning from Pesticides.

Hazelnuts are wind pollinated but it is still important to be aware of pollinator activity in and around the orchard. Honey bees opportunistically forage on hazelnut pollen during winter and they can be present in the orchard throughout the growing season foraging on flowering weeds and hedgerows. Infestations of sucking insect pests such as aphids and scale produce honeydew, which can be highly attractive to honey bees and other sensitive pollinators. Take extra care to protect pollinators when flowering cover crops are present in orchards. Pay attention to bee warnings on pesticide labels and time applications to avoid bee kills.

The following suggests the amount of each spray material per acre when applied to mature trees. The size of trees, amount of foliage, type of equipment used, and other factors are important in determining the amount of spray to use per acre. Read the entire label of each material that is to be used carefully. Under present federal regulations, it is unlawful to apply any pesticide in a manner, rate, or dilution that is not so prescribed on the label. Check with the county agent or Research and Extension center in your area if there are any discrepancies between the recommendations in this handbook and a pesticide label. Practice integrated pest management (IPM) principles and avoid unnecessary or prophylactic insecticide use. Use scouting and monitoring to determine whether pest problems justify management.

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Hazelnut—Aphid

Filbert aphid (*Myzocallis coryli*)
Hazelnut aphid (*Corylobium avellanae*)

Pest description and crop damage Medium to small aphids that feed on leaves and husks and produce honeydew. Filbert aphid is typically light green or pale yellow and lacks well-developed cornicles, which are tube-like projections that emerge from the abdomen. Hazelnut aphid by contrast has well-developed cornicles, longer legs, and is a darker green color and may also have reddish coloration. Experimental evidence indicates that heavy infestations of filbert aphid should be controlled to prevent reduced kernel fill and smaller nut size. Less is known about the impact of hazelnut aphid or the potential synergistic impact of the two species occurring together. Damage caused by aphids is cumulative; benefits of control might not be seen during the first season, but they become evident after two years or more of aphid control. Honeydew produced by aphids is colonized by sooty mold fungus. Sooty mold fungus can impede photosynthesis and severely devitalize plants and retard growth. Honeydew is sweet and it attracts pollinators, so use caution when managing severe aphid infestations with insecticides. These aphid species are specific to hazelnut, they are not found on other plants outside the orchard other than wild hazelnut plants.

Biology and life history Both aphid species overwinter as eggs in crevices in bark and on twigs, and around buds and leaf scales. Eggs turn from a greenish color when they are first laid, to black as they mature. Around the time of bud swell, aphid eggs of both species begin to hatch, and the tiny nymphs move to the green buds and commence feeding. As leaves begin to develop and shoots elongate, both species are found on the underside of leaves and along the shoots, with hazelnut aphid tending to be more dominate on shoots and along leaf midribs. Filbert aphid tends to remain on undersides of leaves where it feeds on phloem along marginal leaf veins throughout the season, while hazelnut aphid tends to transition to nut husks and peduncles as they develop. The winged ‘stem mothers’, or fundatrices that develop from these first nymphs are capable of dispersing by flight, and they give live birth to nymphs that also give live birth when mature (viviparae). The population can increase rapidly, and there are 8 to 10 asexual generations per year. In the fall, winged sexual males and wingless females (oviparae) are formed. These mate and the oviparae females lay overwintering eggs.

Pest monitoring The sampling period is April 1–Sept 30. Check three terminal branches per tree and three leaves per terminal. Count the number of aphids per leaf and treat when the following thresholds for filbert aphid are reached: April: 20 per leaf, May: 30/leaf, June: 40/ leaf, and July: 40/ leaf with an increasing population. Because hazelnut aphid is a relative newcomer, action thresholds based on their density have not been developed. If there are signs of the parasitoid, *Trioxys pallidus*, hold off on treatment and check back on population levels in a week. Mummified aphids indicate that the parasitoid is active. Aphid mummies appear swollen, rounded, and darker and may have an exit hole chewed by the wasp. Note that

populations of aphids typically peak by June and will decrease substantially by July regardless of management action. Black mummies may be apparent on husks, indicating hazelnut aphids are under attack by other parasitoid species. An increase in aphid populations tends to occur in the late growing season when conditions are cooler and the period of egg laying approaches.

Management—biological control

An introduced parasitoid wasp (*Trioxys pallidus*) that attacks both aphid species is well established in the Willamette Valley. This wasp makes aphid sprays unnecessary in many hazelnut orchards. Learn to recognize mummies and the wasps and avoid treating when biological control is active. The aphid has a lower temperature threshold for development than the wasp, which typically emerges about two weeks after the aphids. As a result, there is lag time between population increase of aphids and the response of the wasp. Pest management practices that are detrimental to the wasp population can aggravate aphid problems. Note also that broad-spectrum insecticide applications made against aphids or other orchard pests that harm natural enemies can free the aphid populations from biological control, causing populations to surge. Products labeled for aphid control that contain pyrethroid may ultimately aggravate aphid problems. There are a number of important predators of aphids that occur in hazelnut orchards including: ladybird beetles (both larvae and adult beetles are predaceous), syrphid fly larvae*, Geocoris* (big-eyed bugs, Geocoridae family)*, Deraeocoris* (plant bugs, Miridae), *Orius* (minute pirate bugs, Anthocoridae) and lacewing larvae. Yellow jackets and paper wasps also prey on aphids.

Management—cultural control

Aphid populations tend to be higher in plants that are fertilized liberally with nitrogen. Avoid excess nitrogen applications, which produces flushes of succulent growth that are the ideal habitat for aphids. Home orchardists: Wash aphids from plants with a strong stream of water or by hand-wiping. Control ants, which “farm” the aphids for their honeydew and protect them from predators.

Management—chemical control: HOME USE

- acetamiprid—Do not make more than four applications per season. PHI 14 days.
- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- bifenthrin (as a mix with other ingredients)
- esfenvalerate—PHI 21 days
- imidacloprid—PHI 7 days.
- insecticidal soap—Some formulations OMRI-listed for organic use.
- kaolin—Some formulations are OMRI-listed for organic use.
- mineral or vegetable oils—Dormant or delayed dormant applications can kill aphid eggs. Use caution not to interfere with active pollination.
- plant-derived essential oils—Some formulations are OMRI-listed for organic use and have shown efficacy against aphids. Active ingredients include cinnamon oil, garlic oil, neem oil, clove oil, peppermint oil.
- potassium laurate—Good coverage is important with potassium salts of fatty acids. Some formulations are OMRI-listed for organic use. PHI 0 days. REI 12 hr.
- pyrethrins (often as a mix with other ingredients)—Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin—PHI 7 days

Management—chemical control: COMMERCIAL USE

- acetamiprid (Assail 70WP) at 0.57 to 1.0 oz/100 gal water (2.3 to 4.1 oz/A) (0.10 to 0.18 lb ai/A). PHI 14 days. REI 12 hr. No more than 4 applications per season.
- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- *Beauveria bassiana* (BioCeres WP and others)—Biological, entomopathogenic fungi. 1 to 3 lb/A. PHI 0 days. REI 4 hr. OMRI-listed for organic use.
- *Burkolderia* spp. (Venerate CG Bioinsecticide) Biological. 2 to 4 quarts per acre. Repeat applications on 3- to 10-day rotation. REI 4 hr. OMRI-listed for organic use.
- clothianidin (Belay) at 3 to 6 oz/100 gal water. Use the low rate for smaller infestations or smaller trees. Apply no more than 0.2 lb ai/Acre per year.
- diazinon (Diazinon AG 500) at 1 pint/250 to 400 gal water/A. No more than one application per season. PHI 45 days. REI 18 days. Washington and Oregon only.
- flupyradifurone (Sivanto) at 7.0 to 10.5 fl oz/A. PHI 7 days. REI 4 hr. Use no more than 28 fl oz/Acre/year.
- flonicamid (Beleaf 50 SG) at 2.0 to 2.8 oz/A. Use low rate for building population, high rate for damaging population. PHI 40 days. REI 12 hr.
- imidacloprid (Admire Pro, generics) at 3.4 to 7 fl oz/A. PHI 7 days. REI 12 hr. Can be ground-applied or chemigated. See label details.
- imidacloprid+beta-cyfluthrin (Leverage 360) at 2.8 oz/A (0.22 lb ai/A). PHI 14 days. REI 12 hr.
- imidacloprid+cyfluthrin (Leverage 2.7) at 3.8 to 5.1 oz/A (0.03 to 0.04 lb ai/A). PHI 14 days. REI 12 hr.
- *Isaria* (*Cordyceps*) *fumosoroseae* (PFR-97 20% WDG Microbial Insecticide) at 1 to 2 lb/A (0.2 to 0.4 lb ai/A). Pre-agitate for 30 min. Reapply on 3- to 10-day intervals. OMRI-listed for organic use. REI 4 hr.
- kaolin—Particle film. Some formulations are OMRI-listed for organic use.
- oils—Various vegetable (non-mineral) oils are registered and may be useful as delayed dormant or postharvest and sprays as smothering agents for eggs. Botanical oil sprays can also be useful in-season. Many of these are OMRI-listed for organic use. Active ingredients include cinnamon oil, garlic oil, neem oil, clove oil, peppermint oil, rosemary oil.
- Potassium laurate (Incl. DES-X, M-PEDE, others) at 2 to 4% v/v. Good coverage is important with and of the potassium salts of fatty acids. OMRI-listed for organic use. PHI 0 days. REI 12 hr.
- spirotetramat (Movento) at 6 to 9 fl oz/A (0.09 to 0.14 lb ai/A). PHI 7 days. REI 1 day.

- sulfoxaflor (Closer) at 1.5 to 2.75 oz/A. PHI 7 days.

Hazelnut—Brown Marmorated Stink Bug

Halyomorpha halys

Pest description and crop damage An invasive pest that has been increasingly attacking hazelnuts in the Willamette Valley. There are five immature stages, and all but the first feed on the plant. Early season feeding and reproduction in the orchard can lead to damaging populations that can damage kernels later in the growing season. Nymphs initially feed on vegetative structures such as leaves and husks, but later stages feed directly on nuts. Shell thickness or hardness does not protect kernels from feeding damage as the mouthparts of the insect can penetrate the shell allowing it to feed on the kernel within. Depending on when the insect feeds on the nuts, they can cause blanks, shrivel or corking damage on the kernels. See OSU EM 9102: How to Recognize Brown Marmorated Stink Bug Damage in Commercial Hazelnuts. Much of the damage to hazelnut kernels occurs in the latter part of the season according to research.

Biology and life history

See:

Brown Marmorated Stink Bug: An Emerging Threat to Pacific Northwest Agriculture

Pest monitoring Pheromone traps, visual samples, or beating trays are good methods for detection. Pheromone traps cause aggregations of adults and nymphs on surrounding vegetation. Place traps on orchard borders, rather than in orchards, and monitor orchard border vegetation. Management thresholds based on trap captures or other sampling methods are not yet established, but any trap captures warrant scouting of the orchard to detect potentially damaging populations. The presence of nymphs in the crop can be an indicator of potential damage. Stink bugs are very cryptic and can be difficult to detect in the crop. Slow movement when scouting can be important to detect nymphs without triggering a hiding or flight response. Scan the underside of leaf surfaces for egg masses and early nymphs. Standardize the amount of time spent visually searching for stink bugs (e.g., ten minutes) to compare samples from different times of the season or locations. Note that the highest pressure from this pest will be late in the season (August to October), although damaging levels can build much sooner. The population level at the end of the previous season, winter survival, and weather during spring are all factors affecting current season population levels. As fall approaches, BMSB will move to buildings to overwinter in aggregations. Overwintering populations in barns or outbuildings may move directly into the orchard in spring if adjacent.

Management—biological control

The samurai wasp, *Trissolcus japonicus*, an adventive parasitoid wasp from Asia was detected in Vancouver, Washington in 2015 and in Portland, Oregon in 2016. This parasitoid is becoming widely established in the Willamette Valley and researchers are actively redistributing the wasp. This wasp attacks the stink bug egg masses, turning them from bright green or blue to black as the wasps develop in the egg mass and eventually chew their way out of the eggs. The wasp is known to be a highly effective parasitoid against brown marmorated stink bug in Asia. Native parasitoids and predators can also help limit stink bug populations. There are numerous predators (spiders, katydids, lacewing larvae) that attack the eggs and early nymphs. The mature nymphs and adults have fewer natural enemies, but sometimes birds and spiders will target them. Crabronid wasps (*Astata bicolor*) are specialized predators that sting the nymphs to paralyze them, then carry the paralyzed stink bugs to their nests in the ground where the stink bugs are used to provision the nest for their young. Note that most chemical treatments for BMSB are broad-spectrum, so treatments may negatively impact biological control and cause flare-ups of secondary pests such as scale and aphids.

Management—cultural control

Hand-collecting and killing of egg masses, nymphs, and adults can be an effective management strategy if there are very few trees, but this method is not practical on a commercial scale. Home orchardists may also find that exclusion netting is possible. Eliminating or excluding aggregations of adults in overwintering sites, including farmhouses and outbuildings, may be beneficial to reduce local populations for commercial growers and home orchardists.

Management—chemical control: HOME USE

- bifenthrin and zeta-cypermethrin (Ortho)—Highly toxic to bees and toxic to fish and aquatic invertebrates.
- clothiandin and pyriproxyfen (Sumari)—Highly toxic to bees and aquatic organisms.
- azadirachtin (neem oil) (Azera Gardening)—Some formulations are OMRI-listed for organic use.
- esfenvalerate—Toxic to fish, birds and other wildlife
- kaolin (Surround at Home)—Kaolin can act as a deterrent to BMSB, full coverage of foliage and repeated applications are needed to be effective. Use 0.25 to 0.5 lb per 1 gal water.
- lambda-cyhalothrin + thiamethoxam
- plant-derived essential oils—Some formulations are OMRI-listed for organic use and have shown efficacy against aphids. Active ingredients include cottonseed oil, clove oil.
- permethrin

Management—chemical control: COMMERCIAL USE

Note: Management of filbertworm with select insecticides that are labeled for both pests can help control BMSB.

- acetamiprid (Assail 70WP) at 0.57 to 1 oz/100 gal water (2.3 to 4.1 oz/A) (0.10 to 0.18 lb ai/A). PHI 14 days. No more than 4 applications per season.
- beta-cyfluthrin (Baythroid XL) at 2 to 2.4 oz/A (0.016 to 0.019 lb ai/A). PHI 14 days. REI 12 hr.
- bifenthrin—
  - Brigade WSB at 0.05 to 0.2 lb ai/A. PHI 7 days. REI 12 hr. Do not graze livestock on treated cover crops. Highly toxic to bees and toxic to fish and aquatic invertebrates.
  - Fanfare EC at 3.2 to 12.8 fl oz/A (0.05 to 0.20 lb ai/A). PHI 7 days. Do not graze livestock on treated cover crops. Highly toxic to bees

and toxic to fish and aquatic invertebrates. WA only.

- clothianidin (Belays) at 6 oz/A. PHI 21 days. REI 12 hr. Systemic activity. Avoid drift to flowering crops. Low rate for low infestation and/or smaller trees. No more than 0.2 lb ai per year.
- fenpropathrin (Danitol 2.4 EC) at 10.3 to 21.3 oz/A (0.2 to 0.4 lb ai/A). PHI 3 days. REI 24 hr. At least 50 gal water for ground applications. Note buffer requirements for use near aquatic zones.
- imidacloprid (Admire Pro and generics) at 3.4 to 7 fl oz/A. PHI 7 days. REI 12 hr.
- kaolin—Some formulations are OMRI-listed for organic use. Kaolin can act as a deterrent to BMSB.
- lambda-cyhalothrin—
  - Drexel L-C at 2.56 to 5.12 fl oz/A. PHI 14 days. REI 24 hr. Do not exceed 0.16 lb ai/A per season or 0.12 lb ai post bloom.
  - Grizzly Too at 1.28 to 2.56 fl oz/A. PHI 14 days. REI 24 hr. Do not exceed 0.16 lb ai/A per season or 0.12 lb ai post bloom.
  - LambdaStar at 2.56 to 5.12 fl oz/A. PHI 14 days. REI 24 hr. Do not exceed 0.16 lb ai/A per season or 0.12 lb ai post bloom.
  - Warrior II at 1.28 to 2.56 fl oz/A (0.02 to 0.04 lb ai/A). PHI 14 days. REI 24 hr. Do not exceed 0.16 lb ai/A per season or 0.12 lb ai post bloom.
- permethrin—
  - Ambush 25W 12.8 to 25.6 oz/A. PHI 14 days. REI 12 hr. Do not graze treated orchards. Extremely toxic to fish and aquatic habitat.
  - PermaStar AG at 8 to 16 oz/A. PHI 14 days. REI 12 hr. Highly toxic to bees, toxic to fish and aquatic invertebrates.
  - Pounce 3.2 EC at 0.5 to 1 pint/A. PHI 14 days. REI 12 hr. Do not graze treated orchards. Extremely toxic to fish and aquatic habitat.
- sulfoxaflor (Transform WG) at 2 to 2.25 oz/A. PHI 7 days. REI 24 hr. Suppression only. No more than 8.5 oz per year. Avoid drift to blooming crops and weeds to protect pollinators.
- zeta-cypermethrin (Mustang Maxx) at 3.2 to 4 oz/A. PHI 7 days. REI 12 hr.

Hazelnut—California Prionus Beetle

Prionus californicus

Pest description and crop damage A very large (up to 3.5 inch body), brown native long-horned beetle with elongate serrated antennae and large mandibles (jaws). Three lateral spines are present on each side of the thorax. The adult beetles are capable of vocalizing when disturbed. The adults fly at night and are attracted to lights, making them familiar to residents of the Pacific Northwest. The larvae, or grubs, are also quite large, and range from 0.75 inch when young to more than 4 inches when mature. Adult beetles do not feed. The white legless larvae are the damaging stage as they destroy roots, typically starting as young larvae at the tips, and increasing in size as they mature and progress toward the root crown. This may cause symptoms of stress in the tree canopy that manifest as dieback, reduced growth/poor vigor or reduced nutrient status in plant tissues. *Prionus* can also damage subsurface drip irrigation lines and damage to anchorage roots can predispose trees to toppling in storms.

Biology and life history Eggs are laid just below the soil surface in summer. Larvae emerge from eggs and begin seeking out roots. As described above, the youngest larvae are found on more distal roots and the largest larvae are typically found within the crown. Larvae girdle roots and hollow them out with their tunnels. The larvae can develop for up to five years before pupating close to the soil surface and emerging as adults in mid-summer. Because they don't feed, the adults are not damaging to the orchard, and can live for close to a month producing up to 200 eggs per female.

Pest monitoring Pheromone traps are available to monitor adult beetle populations. The traps capture male beetles using a female-produced sex pheromone. Typically, a panel trap with large surface area is most appropriate for capturing beetles with the pheromone lure. Light traps can also capture adults. Larvae may be discovered by removing soil and examining roots for feeding damage. Trees with poor vigor or signs of canopy stress may help narrow down the search for larvae.

Management—biological control

Very little is known about potential biological controls. Soil-dwelling predators may cause some level of larval mortality. Entomopathogenic nematodes may attack grubs. Birds and small mammals may prey on adults.

Management—cultural control

Minimize drought stress and manage plant nutrition to prevent attack.

Management—behavioral control

There is potential for mass trapping adult males using the commercial pheromone lure. Enough male beetles can be caught to reduce mating success and lower the number of eggs laid into the soil, reducing the local population over time. Cross-vein panel traps are hung very low in the canopy and baited in the center. They should be deployed at the rate of 1 trap per 2 acres to maximize trap captures. Because the larvae are in the soil for so long and adults emerge each year, it is important to maintain the trapping program for several years to see any results. Mating disruption also shows promise but remains in the research phase of development. Light traps can be effective.

Management—chemical control: COMMERCIAL & HOME USE

No insecticides are labeled against *Prionus* in hazelnuts. Soil applied imidacloprid targeting aphids may kill some of the younger grubs.

Hazelnut—Eyespotted bud moth

Spilonota ocellana

Pest description and crop damage Adults are grayish moths about 0.4 inch long with a wide white band on each forewing. Larvae are chocolate-brown with black heads up to 1 inch long.

Larvae spend the winter in a cocoon on the bark in the crotches of small-diameter limbs. They become active around bud break and feed on leaves and buds, webbing together leaves and feeding within these nests. After feeding they pupate within the nest and adult moths emerge in early to mid-

summer. Eggs are laid on the lower surface of leaves. The larvae emerge and feed on the lower leaf surface until early August, at which time they construct their overwintering cocoons (hibernaculae). Feeding on buds in early spring can be particularly damaging for small trees. Eyespotted bud moth has not been consistently problematic in recent years.

Pest monitoring Look for larvae in nests of webbed-together leaves in the spring. Compare with similar pests such as leafroller and omnivorous leaftier. Note that adult moths have a pheromone component in common with filbertworm and may occasionally be caught in filbertworm traps. The two moths are about the same size and shape, but filbertworm can be distinguished by the gold scales on the wings, which are not present in eyespotted bud moth.

Management—chemical control: HOME USE

- carbaryl (Gardentech Sevin)—Highly toxic to bees. Do not apply when bees are actively foraging, wait until after the trees have flowered.

Management—chemical control: COMMERCIAL USE

- *Bacillus thuringiensis* var. *kurstaki*—See label for rates. PHI 0 days. Apply with spreader-sticker. Some formulations are OMRI-listed for organic use.
- diflubenzuron (Dimilin 2L) at 8 to 16 oz/A. Up to four applications per season. PHI 28 days. REI 12 hr.
- emamectin benzoate (Proclaim) at 3.2 to 4.8 oz/A. PHI 14 days. REI 12 hr.
- flubendiamide (Belt SC) at 3 to 4 oz/A. PHI 14 days. REI 12 hr. Do not exceed 12 oz/A per year or 4 oz per 7-day interval.
- methoxyfenozide (Intrepid 2F and generics) at 8 to 16 oz/A. PHI 14 days. REI 4 hr.
- methoxyfenozide + spinetoram (Intrepid Edge) at 6 to 12 oz/A. Apply at initiation of egg hatch, if necessary, reapply after 14–21 days, but not before 14 days. PHI 7 days. REI 4 hr. No more than 12 fl oz/A/season.
- tebufenozide (Confirm 2F) at up to 30 oz/A. PHI 14 days. REI 12 hr. Apply when egg hatch begins. Do not exceed 30 oz/A per application or 122 oz/A for the season.

Hazelnut—Filbert bud mite

Filbert bud mite (*Phytoptus avellanae)*
Cecidophyopsis vermiformis

Pest description and crop damage Microscopic mites damage hazelnut leaf and flower buds, and sometimes catkins. Filbert bud mite is the official recognized common name for *Phytoptus avellanae,* but *Cecidophyopsis vermiformis* also damages hazelnut buds, and the two species are often collectively and familiarly known as big bud mite, or simply, bud mite. Mite feeding forms galls in the buds, which swell to an abnormally large size. The blasted bud often dies, or if it survives, it will produce a shoot with abnormal growth. Definitive studies linking yield loss to bud mite infestation are lacking for different cultivars, but it has long been known that there is heritable genetic resistance and a spectrum of susceptibility among different hazelnut cultivars. The tightness of bud scales may be related to susceptibility. Up to 30% of infested buds have been observed in some orchards. Chronic bud mite infestation at this level can lead to trees with reduced fruiting wood in canopies. The OSU hazelnut breeding program selects against bud mites so blasted buds are not an issue in the most recent releases with genetic resistance to Eastern filbert blight. The exceptions are ‘Yamhill’ and ‘McDonald’. Other cultivars known to be highly susceptible to big bud mite include ‘Ennis’, ‘Lewis’, ‘Clark’, and ‘Casina’.

Biology and life history *Phytoptus avellanae* belongs to the Phytoptidae mite family and *C. vermiformis* belongs to family Eriophyidae. The two mite species have different life histories, but are similar in that they both spend months inside the buds. This limits pest management options because the swollen buds can protect the mites from miticides (acaricides). Bud mite infestations become most apparent in late winter and early spring as bud break approaches. At this time, both mite species are present in the buds and their populations are at a maximum, with some buds containing thousands of mites. As bud break and shoot elongation begins, the mite nymphs (immatures) migrate from blasted buds to the new axillary buds. During the growing season, *P. avellanae* remains relatively inactive in the buds, but buds infested by *C. vermiformis* swell and ultimately drop in the late growing season. The mites from these blasted buds migrate to the buds occupied by *P. avellanae,* and infested buds begin to swell during fall and winter. Mites spread via wind and phoresy (hitch-hiking on other animals), so re-infestation can easily occur.

Pest monitoring The best time to scout and evaluate bud infestation rates is in the spring near the onset of bud swell when blasted buds are most apparent. Most growers time sprays to intercept mites as they migrate from blasted buds to new buds in early spring. Sprays applied at the peak migration timing will be most successful. Recent research suggests the peak migration typically occurs from late March/early April to mid-May in the Willamette Valley. Monitoring is accomplished by placing double-sided sticky tape or tacky insect glue on branches below blasted buds and counting trapped mites under magnification at regular intervals. A microscope or 10x to 20x hand lens is useful for counting mites on tape traps that are clipped or removed from the tree. With magnification, mites can also be sampled by counting or estimating number of mites observed staging on the outside of blasted buds in anticipation of migration. The tree provides clues about the timing of the migration of mites. New axillary buds must be present for the mites to migrate to. The infested bud increasingly becomes inhospitable to the mites as bud break advances and the bud becomes increasingly blasted and necrotic. Warm spring days are also associated with migration activity, and depending on the weather conditions, migration can occur over a short time or a prolonged period lasting multiple weeks.

Management—biological control

Releases of predatory mites (*Galendromus* spp.) is often impractical in commercial settings, but may be effective for home use. Predatory mites, especially *Kampimodromus aberrans* cohabitate in blasted buds with bud mites during winter, eating eggs and nymphs of the pest species. Conserve predatory mite populations in the orchard. Mite flaring and high numbers of blasted buds may be linked to excess use of broad-spectrum insecticides impacting predatory mites in the orchard.

Management—cultural control

Sanitation is not practical in commercial orchards, but *home orchardists* could remove and destroy blasted buds ahead of the spring mite migration.

Management—chemical control: HOME USE

- kaolin (Surround at Home)—Deters mites from feeding, full coverage of foliage and repeated applications are needed to be effective. Use 0.25 to 0.5 lb per 1 gal water.
- mineral oil (Monterey Horticultural Oil RTU)
- plant-derived essential oils (Bonide Mite X)—Some formulations are OMRI-listed for organic use and have shown efficacy against aphids. Active ingredients include cottonseed oil, garlic oil, and clove oil.
- sulfur (Defend DF)

Management—chemical control: COMMERCIAL USE

Note: Most materials labeled for bud mite cannot be applied by air. Heat warnings on sulfur labels should be taken seriously, multiple sulfur applications or high rates can lead to long-lived residues that can burn leaves in hot weather weeks after application.

- abamectin (Agri-Mek, others) at 0.5 to 4.24 oz/A. PHI 21 days. REI 12 hr. Do not exceed two applications per season.
- calcium polysulfide (Sulforix) at 3 gal/A. REI 2 days.
- fenpyroximate (Fujimite XLO) at 2 to 4 pints/A in minimum of 100 gal water. No more than two applications per season.
- lime-sulfur (BSP) at 12 gal/A. REI 2 days.
- micronated sulfur (multiple SLN labels)—Use caution if hot weather is expected. Low rates are recommended.
  - Microthiol Disperss at 10 to 20 lb/A in 50 to 400 gal water. See 24(c) SLN label. Do not apply when air temperatures will exceed 90°F within 3 days of application. REI 24 hr.
  - Sulfur DF at 5 to 25 lb/A in 50 to 400 gal water. See 24(c) SLN label. Do not apply when air temperatures will exceed 90°F within 3 days of application. REI 24 hr.
  - Sulfur WG at 5 to 25 lb/A in 50 to 400 gal water. See 24(c) SLN label. Do not apply when air temperatures will exceed 90°F within 3 days of application. REI 24 hr.
- pyridaben (Nexter) at 2.67 oz/100 gal water (10.67 oz/A). PHI 7 days. Do not exceed two applications per season.
- spirodiclofen (Envidor 2SC) at 16 to 18 fl oz/A. PHI 7 days. REI 12 hr.
- tolfenpyrad (Bexar) at 27 oz/A. PHI 14 days. REI 12 hr. See 2(ee) label for hazelnut (OR/WA only).

Hazelnut—Filbert leafroller

Archips rosana

Pest description and crop damage Adult moths are 0.5 to 0.75 inch long, dark brown, with darker transverse lines on the forewings. The larvae are green with a light to dark brown head. Damage begins early in spring and includes rolling of leaves as well as feeding on foliage and buds. There is one generation each season.

Biology and life history This leafroller overwinters as eggs laid on the bark or limbs in irregular flat masses which appear grayish by spring. Eggs hatch in spring as buds are opening until petal fall. The larvae feed for 4 to 6 weeks, then pupate in the rolled leaves and emerge as moths in early summer. The overwintering eggs are laid on twigs and branches in July.

Pest monitoring Start checking for larvae around mid-March by inspecting three terminals per tree and three leaf clusters per terminal for tightly rolled leaves and feeding damage on new growth. Each terminal is a sampling unit. Treat for larvae when infestation level is 20 to 25%. Check for adults by using one pheromone trap for each 5 acres, place 6 ft high in the tree canopy starting in mid-May. Treat for adults when catch is 40 moths per week.

Management—biological control

Very low temperatures in winter significantly reduce overwintering populations of larvae. Spiders and parasitic wasps, as well as predators like the brown lacewing, greatly reduce leafroller populations throughout the year. Typically, biological control is sufficient to manage leafrollers and chemical control is rarely necessary. Similar to obliquebanded leafroller, there are numerous parasitoid wasps that target the later larval stages.

Management—cultural control

Home orchardists: Hand-pick and destroy rolled leaves containing larvae or pupae.

Management—chemical control: HOME USE

Spray in spring after overwintering eggs hatch, at about the time leaves are 0.75 to 1 inch long. Control is much more effective if sprays are applied when larvae are small. Avoid treating when larvae are mature; damage will already have occurred and natural enemies will be adversely affected.

- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- *Bacillus thuringiensis* var. *kurstaki*—Some formulations are OMRI-listed for organic use.
- carbaryl (Sevin)
- pyrethrins (often as a mix with other ingredients)—Some formulations are OMRI-listed for organic use.

Management—chemical control: COMMERCIAL USE

Make applications in spring after overwintering eggs hatch, about the time leaves are about 0.75 to 1 inch. Control is more effective if insecticides are applied when worms are small. Note that this pest has not been occurring at levels that would require management in recent years.

- *Bacillus thuringiensis* var. *kurstaki*—See label for rates. PHI 0 days. Apply with spreader-sticker. Some formulations are OMRI-listed for organic use.
- bifenthrin (Brigade WSB, other generics) at 0.05 to 0.2 lb ai/A. PHI 7 days. REI 12 hr.

- carbaryl (Sevin XLR Plus) at 0.5 to 1.25 quarts/100 gal water (2 to 5 quarts/A). PHI 14 days. REI 12 hr. May cause rapid increase of aphid populations 3–4 weeks after application. Extremely toxic to aquatic invertebrates.
- diazinon (Diazinon AG 500) at 1 pint/250 to 400 gal water per acre. One application per season. PHI 45 days. REI 18 days. WA and OR only.
- diflubenzuron (Dimilin 2L) at 12 to 16 fl oz/A. PHI 28 days. REI 12 hr. Extremely toxic to aquatic invertebrates. Do not apply within 25 ft of bodies of water.
- emamectin benzoate (Proclaim) at 3.2 to 4.8 oz/A. PHI 14 days. REI 12 hr.
- fenpropathrin + *Bacillus thuringiensis* var. *kurstaki*—(Danitol 2.4 EC + DiPel DF) at 10.3 to 21.3 oz/A (0.2 to 0.4 lb ai/A) + 0.5 to 2.0 lb/A. PHI 3 days. REI 24 hr. At least 50 gal water for ground applications. Note buffer requirements for use near aquatic zones.
- lambda-cyhalothrin—
  - Warrior II/ Grizzly Too at 1.28 to 2.56 fl oz/A (0.02 to 0.04 lb ai/A). PHI 14 days. REI 24 hr. Do not exceed 0.16 lb ai/A per season or 0.12 lb ai post bloom.
  - LambdaStar/ Drexel L-C at 2.56 to 5.12 fl oz/A. PHI 14 days. REI 24 hr. Do not exceed 0.16 lb ai/A per season or 0.12 lb ai post bloom.
- methoxyfenozide (Intrepid 2F and generics) at 8 to 16 fl oz/A. PHI 14 days. REI 4 hr. For control of foliar feeding leafroller larvae, apply when larvae are feeding. Most effective crop protection results from application made at the initiation of egg hatch. Do not apply more than 24 fl oz/A per application or 64 fl oz/A (1 lb ai) per season. Do not apply within 25 ft of an aquatic habitat, 150 ft if applied by air.
- methoxyfenozide + spinetoram (Intrepid Edge) at 6 to 12 oz/A. Apply at initiation of egg hatch, if necessary reapply after 14–21 days, but not before 14 days. PHI 7 days. REI 4 hr. No more than 12 fl oz/A/season.
- permethrin—
  - Ambush 25W at 12.8 to 25.6 oz/A. PHI 14 days. REI 12 hr. Do not graze treated orchards. Extremely toxic to fish and aquatic habitat.
  - Ambush 2E at 0.8 to 1.6 pints/A. PHI 14 days. REI 12 hr. Do not graze treated orchards. Extremely toxic to fish and aquatic habitat.
  - Pounce 3.2 EC at 0.5 to 1 pint/A. PHI 14 days. REI 12 hr. Do not graze treated orchards. Extremely toxic to fish and aquatic habitat.
- spinosyns—
  - spinetoram (Delegate WG) at 1.5 to 1.75 oz/100 gal water (4.5 to 7 oz/A). PHI 14 days. Apply no less than one week apart, with a maximum 4 applications per season.
  - spinosad (Entrust SC) at 4 to 10 oz/A (0.06 to 0.16 lb ai/A). PHI 1 days. REI 4 hr. OMRI-listed for organic use.
  - spinosad (Success Naturalyte) at 4 to 10 oz/A in 100 gal water (0.06 to 0.16 lb ai/A). PHI 1 day. REI 4 hr. Do not exceed 29 oz/A per season.

Hazelnut—Filbertworm

Cydia latiferreana

Pest description and crop damage Filbertworm is the key pest of hazelnuts in the Pacific Northwest and a close relative of codling moth, one of the most economically important insects worldwide. Adult moths are gray to reddish with golden bands across each forewing. Female moths lay the eggs on the upper surface of leaves. Recent research suggests that the larvae can subsist on leaves alone and they may damage early developing nut clusters before the nuts are big enough to physically infest. This can cause nuts or nut clusters to abort, which represents potential yield loss for the grower. However, the major concern is infestation of nuts, which is a major cause for dockage from nut processors. Larvae infest nuts and destroy the kernel, leaving only mold and frass. When fully developed, the larvae are whitish with a brown head capsule and are approximately 0.5 inch long. Research has shown that shell thickness at the basal scar/micropyle can affect susceptibility of different hazelnut cultivars to this pest. Trees are attacked by moths up to and beyond harvest, but nut susceptibility to attack by larvae can decline as shells fully harden.

Biology and life history The insect is found in several wild and cultivated nuts (see Chestnuts-Filbertworm) in North America but is particularly common in acorns and hazelnuts in the Pacific Northwest. The filbertworm overwinters as a larva in a silken cocoon (hibernaculum) under leaves and debris on the ground or in cracks and crevices on trees. Some larvae also overwinter 1–2 inches beneath the soil surface. The larvae pupate in spring and the adults begin to emerge and get caught in traps in early June through October. After mating, the female moths begin to lay single eggs on leaves. Eggs hatch in 8 to 10 days, and the tiny larvae search out nut clusters. They attack developing clusters and later burrow into the nuts, entering the shell through the micropyle, the pore in the center of the basal scar. Larvae feed on the kernel for 2 to 4 weeks. Mature larvae typically chew a larger exit hole through the side wall of the shell. After a period of wandering, larvae form cocoons (hibernaculae) to overwinter. Ideally, sprays are timed to target the eggs and the wandering larvae before they penetrate the nuts. Some materials will also kill adult moths and it is important to understand this when following trap captures. Only materials with adult activity (such as pyrethroids) will cause shutdown of pheromone trap captures. More selective sprays target the immature stages and will not shut down trap captures because they are less toxic to adult moths. However, the residue from such materials will continue to protect nuts from attack even as moths are caught in traps and are laying new eggs. Proper timing of spray applications is critical with selective materials and those with lower residual activity.

Pest monitoring Use of pheromone traps is recommended for timing management. Filbertworm flight has been starting earlier in the season compared to historic norms. Previous recommendations were to start hanging pheromone traps before the flight of filbertworm moths begins in mid-June, but now it is clear that traps should be placed by mid- to late May to capture the first moths in early June. Note that early moth captures can indicate potential for damage to developing nut clusters resulting in aborted nuts or clusters. Use 4 traps for the first 10 acres (or 1 trap per 2.5 acre) and one for each additional 4 acres. Lower densities of traps can be used successfully, but this may increase the likelihood of going over the threshold. Place the traps in the upper third of the canopy; moth captures will not be representative if traps are not placed high in the canopy (pheromone is heavier than air). Keep extra lures in the freezer (not in your vehicle), and replace lures and trap liners according to the recommendations of the manufacturer (dirty liners won't catch moths). The action threshold is an average of 2 to 3 moths per trap per week, or 5 moths in any one trap. Apply selective larvicidal insecticides 8 to 12 days after reaching the threshold in your orchard block to target larvae emerging from eggs and wandering on the tree. This delay reflects the time required for moths to mate and for females to mature fertilized eggs and for eggs to begin hatching. Products with long residuals can be applied soon after trap captures go above threshold. Products with ovicidal activity (kills eggs)

can be applied several days after going over the threshold because ovicides are most active when eggs are laid on top of residues. However, oils can be applied over the top of eggs to smother them and these should be applied prior to egg hatch 8 to 12 days after threshold is reached. A second cover spray may be necessary in 2–3 weeks, or later in the season if moths continue to be caught in traps at rates above the threshold and the residual activity of the first application is expired. Moths flying late in the season can cause unexpected crop damage, so it is important to keep monitoring traps and using trap capture action thresholds through nut drop. If the trap threshold is not reached, then sprays are not necessary.

Management—biological control

Predators and parasitic wasps likely assist in killing some eggs and larvae before they gain entry to the nuts. Some moths may also be killed by predators. Bats may capture moths on the wing during dawn and dusk flight periods. The activity of biological control will be affected by management tactics for other pests. For example, use of mating disruption against key pests has been shown to enhance biological control in orchards.

Management—cultural control

Hazelnut varieties are not equally susceptible to filbertworm. The thickness of the micropyle, which is the thinnest point of the shell on the basal scar of the nut determines susceptibility, as this is the point of entry for the newly hatched larvae into the nut. Hardness of the shell can also affect susceptibility later in the season. Of the hazelnut cultivars currently planted, Yamhill was found to have the thinnest average shell at the micropyle. McDonald, Wepster, Sacajawea, and PollyO had very similar shell thickness at the micropyle but thicker than Yamhill. Lewis, Jefferson, Dorris, and Barcelona had the thickest shell at the micropyle.

First nut drop typically contains a higher percentage of nuts infested by filbertworm. Flailing or otherwise destroying these first nuts prior to harvest may reduce infestation levels. Flailing acorns from oaks near the orchard may also help reduce filbertworm pressure.

Management—behavioral control

Isomate FBW Ring is a commercial mating disruption product. Apply a minimum 20 dispensers per acre (more point sources may enhance the effect). Hang pheromone dispensers high in the canopy on lateral branches before initial moth flight. Continue to monitor traps and prepare to apply border sprays or supplemental cover sprays if traps capture moths at rates above the threshold. Large, contiguous blocks are most conducive to mating disruption. The continual release of pheromone from dispensers in the orchard interferes with the male moth's ability to locate females for mating within the orchard. Mated females originating from outside the orchard can still come in and lay eggs resulting in damaged nuts. Mating disruption technology is best applied to low to moderate filbertworm populations, so consider getting any problematic moth populations under control before utilizing mating disruption. Do not apply to home orchards, orchards with steep slopes, or orchards with a high edge to core ratio.

Management—chemical control: HOME USE

- acetamiprid—PHI 14 days. No more than 4 applications per season.
- azadirachtin (as a mix with other ingredients)—Some formulations are OMRI-listed for organic use.
- bifenthrin (often as a mix with other ingredients)
- carbaryl
- esfenvalerate
- gamma cyhalothrin (as a mix with other ingredients).
- spinosad—Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin (often as a mix with other ingredients)

Management—chemical control: COMMERCIAL USE

Filbertworm emergence notices are sent to growers.

- acetamiprid (Assail 70WP) at 0.57 to 1 oz/100 gal water (2.3 to 4.1 oz/A) (0.10 to 0.18 lb ai/A). PHI 14 days. No more than 4 applications per season.
- alpha-cypermethrin (Fastac CS) at 3.2 to 3.8 fl oz/A (0.021 to 0.025 lb ia/A). PHI 7 days. REI 12 hr. Do not exceed 11.4 fl oz/A per season. Highly toxic to bees, extremely toxic to fish and aquatic invertebrates. Do not apply within 25 feet of aquatic habitats, or with 150 ft if aerial application. Apply as indicated by scouting.
- beta-cyfluthrin (Bathyroid) at 2 to 2.4 oz/A (0.016 to 0.019 lb ai/A). PHI 14 days. REI 12 hr.
- bifenthrin—
  - Brigade WSB at 0.05 to 0.2 lb ai/A. PHI 7 days. REI 12 hr. Do not graze livestock on treated cover crops. Highly toxic to bees and toxic to fish and aquatic invertebrates.
  - Fanfare EC at 3.2 to 12.8 fl oz/A (0.05 to 0.20 lb ai/A). PHI 7 days. Do not graze livestock on treated cover crops. Highly toxic to bees and toxic to fish and aquatic invertebrates. WA only.
- carbaryl (Sevin XLR Plus or its equivalent in another formulation)—See label for specific formulations as some concentrations vary. Seven XLR plus at 0.5 to 1.25 quarts/100 gal water (2 to 5 quarts/A). PHI 14 days. REI 12 hr. May cause rapid increase of aphid populations 3 to 4 weeks after application. Extremely toxic to aquatic invertebrates.
- chlorantraniliprole—
  - Altacor at 2.5 to 4.5 oz/A (0.055 to 0.99 lb ai/A). PHI 10 days. REI 4 hr. Make initial application just before or at filbertworm egg hatch. Depending on the length of the filbertworm moth flight, multiple applications may be required to protect the crop. Under heavy filbertworm pressure, apply ALTACOR on a 14-day retreatment interval. With low to moderate filbertworm pressure, apply ALTACOR no longer than 21-day interval.
  - Vantacor at 1.4 to 2.5 oz/A. Make no more than 4 applications per year and do not reapply within 7 days. PHI 10 days. REI 4 hr.
- cyfluthrin (Baythroid XL) at 2 to 2.4 oz/A (0.016 to 0.019 lb ai/A). PHI 14 days. REI 12 hr.
- diflubenzuron (Dimilin 2L) at 12 to 16 fl oz/A. PHI 28 days. REI 12 hr. Extremely toxic to aquatic invertebrates. Do not apply within 25 ft of

bodies of water.

- emamectin benzoate (Proclaim) at 3.2 to 4.8 oz/A. PHI 14 days.
- esfenvalerate (Asana XL) at 7.3 to 12.8 fl oz/100 gal water (9.6 to 19.2 fl oz/A or 0.05 to 0.1 lb ai/A). PHI 21 days. REI 12 hr. Do not apply more than 0.2 lb ai/A per season. Extremely toxic to fish and aquatic habitat.
- fenpropathrin (Danitol 2.4 EC) at 10.3 to 21.3 oz/A (0.2 to 0.4 lb ai/A). PHI 3 days. REI 24 hr. At least 50 gal water for ground applications. Note buffer requirements for use near aquatic zones.
- flubendiamide + buprofezin (Tourismo) 10 to 14 fl oz/A in a minimum of 100 gal water. Do not apply as alternate row middle (ARM) sprays; full cover sprays only. PHI 60 days. REI 12 hr.
- GS-omega/kappa-Hxtx-Hv1a (Spear-Lep) at 1 to 2 pints/A. Biological insecticide that should be tank mixed with equal parts of Bt. PHI 0 day. REI 4 hr.
- kaolin clay (Surround WP) at 50 to 75 lb/A. Suppression only, OMRI-listed for organic use. PHI 0 days. REI 4 hr.
- lambda-cyhalothrin—
  - Warrior II/ Grizzly Too at 1.28 to 2.56 fl oz/A (0.02 to 0.04 lb ai/A). PHI 14 days. REI 24 hr. Do not exceed 0.16 lb ai/A per season or 0.12 lb ai post bloom.
  - LambdaStar/ Drexel L-C at 2.56 to 5.12 fl oz/A. PHI 14 days. REI 24 hr. Do not exceed 0.16 lb ai/A per season or 0.12 lb ai post bloom.
- methoxyfenozide (Intrepid 2F, generics) at 8 to 16 fl oz/A. PHI 14 days. REI 4 hr. Apply when egg hatch begins. Reapply at 14- to 21-day intervals under high pressure or sustained moth flight. Do not exceed 24 fl oz/A per application or 64 fl oz/A (1 lb ai/A) per season. Do not apply within 25 ft of an aquatic habitat, 150 ft if applied by air.
- methoxyfenozide + spinetoram (Intrepid Edge) at 6 to 12 oz/A. Apply at initiation of egg hatch, if necessary, reapply after 14–21 days, but not before 14 days. PHI 7 days. REI 4 hr. No more than 12 fl oz/A/season.
- permethrin—
  - Ambush 25W at 12.8 to 25.6 oz/A. PHI 14 days. Do not graze treated orchards. Extremely toxic to fish and aquatic habitat.
  - Ambush 2E at 0.8 to 1.6 pints/A. PHI 14 days. REI 12 hr. Do not graze treated orchards. Extremely toxic to fish and aquatic habitat.
  - Pounce 3.2 EC at 0.5 to 1 pint/A. PHI 14 days. REI 12 hr. Do not graze treated orchards. Extremely toxic to fish and aquatic habitat.
  - PermaStar AG at 8 to 16 oz/A. PHI 14 days. REI 12 hr. Highly toxic to bees, toxic to fish and aquatic invertebrates.
- pyriproxyfen (Esteem 35 WP) at 3.2 to 4 oz/100 gal water (13 to 16 oz/A). Do not apply more than twice per season. PHI 21 day. REI 12 hr.
- spinosyns—
  - spinetoram (Delegate WG) at 1.5 to 1.75 oz/100 gal water (4.5 to 7 oz/A). PHI 14 days. Apply no less than one week apart, with a maximum 4 applications per season.
  - spinosad (Entrust SC) at 4 to 10 oz/A (0.06 to 0.16 lb ai/A). PHI 1 days. REI 4 hr. OMRI-listed for organic use.
  - spinosad (Success Naturalyte) at 4 to 10 oz/A in 100 gal water (0.06 to 0.16 lb ai/A). PHI 1 days. REI 4 hr. Do not exceed 29 oz/A per season. OMRI-listed for organic use.
- tebufenozide (Confirm 2F) at up to 30 oz/A. PHI 14 days. REI 12 hr. Apply when egg hatch begins. Do not exceed 30 oz/A per application or 122 oz/A for the season.

Hazelnut—Garden symphylan

Scutigerella immaculata

Pest description and crop damage Symphylans are not insects but represent a unique class of soil-dwelling arthropods similar in appearance to centipedes. They are white in color and are smaller than centipedes. Immatures have 6 legs, but as symphylans mature, they acquire up to 12 pairs of legs and the antennae elongate. There is just one pair of legs per segment which is similar to centipedes but different from millipedes (2 pair per segment). Garden symphylans can damage new orchard plantings if the orchard site has a history of pressure from this pest. Typically, this would occur when former grass seed or Christmas tree fields with a history of the pest are converted to hazelnut orchards. The symphylans move to the roots of newly planted hazelnut trees where they cause feeding damage. When a grass crop is sprayed out to plant a hazelnut orchard, the symphylans may aggregate at the roots of the newly planted hazelnut trees because there is no other food source. Tree damage may not be evident for some time after it has occurred, but trees that have been attacked may become symptomatic during periods of water stress when it becomes apparent that the damaged roots cannot support necessary water uptake. It is unlikely that the symphylans would actually be found during the hotter periods of the growing season as they utilize the soil profile to thermoregulate and typically go deeper when soil surfaces are too warm. The pest tends to aggregate in the upper soil profile in spring and fall when surface soil is moist and temperatures are moderate. Sampling efforts should be concentrated during these periods when the symphylans are in the upper soil strata. If there is a problem the white symphylans should be evident in the roots of establishing trees, so the problem cannot be diagnosed without digging up trees at a time when the symphylans are active. Older trees should be resistant to the pest. Symphylan “hot spots” or patches tend to recur year after year in the same areas of the field or orchard.

See:

Biology and Control of the Garden Symphylan

Pest monitoring Dig young trees when the soil is moist and temperatures are moderate in the spring or fall to inspect roots for symphylans. Soil samples can be used to collect symphylans and taking cores can help estimate activity at different depths. Baits can also be used to attract symphylans for detection and monitoring. Cut a carrot or potato in half and bury it in a shallow hole carefully dug so as to not disturb the below soil structure, then cover it. After 2-5 days recover the bait to examine for the presence of symphylans.

Management—cultural control

Sample for symphylans before planting the orchard, particularly if the orchard site was formerly producing grass seed or Christmas trees. Manipulation of soil structure is a management tactic. Tillage in particular can crush symphylans that are at the soil surface and may disrupt the soil

porosity that the symphylans rely upon to move through the soil profile. Symphylans cannot tunnel and they need naturally occurring pores to move through the soil. Slight soil compaction through rolling may also help reduce soil pore connectivity and symphylan presence in the upper soil profile.

Management—chemical control: HOME USE

This pest is unlikely to be an issue for home orchards.

Management—chemical control: COMMERCIAL USE

Pesticides or fumigants are more effective when applied prior to planting. Depending on the crop present prior to planting hazelnuts, more chemical pest management options may be available. While there are chemistries that are registered for hazelnut that can be somewhat effective, none are specifically labeled for garden symphylan.

Hazelnut—Nautical borer

Xylotrechus nauticus

Pest description and crop damage Coal-colored longhorn beetle (name refers to elongate antennae) with an elongated body and long legs. Grey or white 'W' or 'M' shaped bands are present on the elytra (wing covers). The larva is a large, roundheaded borer that attacks stressed, dying or dead hazelnut trees. It can be found in the scaffold branches or trunks of trees affected by eastern filbert blight but may also attack hazelnut trees that are stressed or dying for other reasons. The exit hole can be distinguished from that of Pacific flatheaded borer as it is much larger and oval, rather than "D" shaped.

Biology and life history Adults chew an opening into the bark for laying the eggs, often introducing disease organisms that cause the wood to break down. The larvae may feed for 1to 3 years, creating tunnels that wander beneath the bark and creating a white, splinter-like frass as they go. Adults emerge from oval emergence holes to mate.

Management—biological control

There are no known biological controls, but it is likely that certain parasitoid wasps would target larvae.

Management—cultural control

As this insect only attacks stressed or diseased trees its presence is a symptom of other problems with the orchard. Minimize tree stress through good orchard site selection, disease management, fertility practices and irrigation.

Hazelnut—Obliquebanded leafroller

Choristoneura rosaceana

Pest description and crop damage Bright green caterpillar with a black or brown head. Most feeding is on leaves and the larvae roll leaves together using silk to create protected feeding sites. The larvae can also inhabit the area between the husk and the shell of the nut, and when they do, damage to nuts can occur from feeding on green shells. Occasionally, the larvae may penetrate shells and feed on kernels. Leafroller damage to nuts is distinguished from filbertworm damage by additional scarring and deformation on the shell surface rather than a clean exit hole from the shell. Adult moths are bell-shaped, up to 1 inch long, tan to brown, with broad bands on the wings. Their appearance is very similar to filbert leafroller, although the filbert leafroller has a more pronounced bell shape to the wings when viewed from above.

Biology and life history There are two generations of obliquebanded leafroller each season, occurring from May through harvest. Early stage (minute) larvae overwinter under the bark on scaffold branches of a variety of host plants and may feed during warm periods in winter but become active in spring with the onset of new growth and they move into the buds. Larvae exhibit a characteristic rapid backwards wiggle from the feeding site when disturbed. They feed for several weeks in the leaves, typically forming a new feeding site prior to pupation. Adult moths emerge in late June to July. These moths lay eggs for the second generation. The second generation hatches in early July. Larvae feed on leaves but may occasionally damage nuts if their feeding site happens to be within a nut cluster or in direct contact with a nut cluster.

Pest monitoring Start checking for larvae around mid-March by inspecting three terminals per tree and three leaf clusters per terminal. Each terminal is a sampling unit. Check for adults by using one pheromone trap for each 5 acres, placed 6 ft high in the tree canopy starting in mid-May. Treat larvae when infestation level is 20 to 25%. Treat for adults when catch is 40 moths per week and larvae are feeding on nuts. The first flight usually is in June. Spray when pheromone traps catch five to eight moths over a 3-day period. The second flight usually is in September.

Management—biological control

Obliquebanded leafroller larvae are targeted by a wide variety of specialist and generalist parasitoids that normally keep populations under control after the spring generation. Sprays are rarely necessary, and if they are applied against mature larvae, they will likely harm natural enemy populations. Examine feeding sites of mature larvae to get an idea of natural enemy activity. Small cocoons or caterpillars being consumed by small larvae indicate active biocontrol. Conserve natural enemies through judicious insecticide use, but monitor leafroller numbers as population build-up can be rapid.

Management—chemical control: HOME USE

If necessary, spray in spring after overwintering larvae emerge, around the time leaves are 0.75 to 1 inch long. Control is much more effective if sprays are applied when larvae are small, but these young larvae are the most difficult to detect.

- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- *Bacillus thuringiensis* var. *kurstaki*—Some formulations are OMRI-listed for organic use.
- bifenthrin (often as a mix with other ingredients)
- esfenvalerate (Monterey bug buster)

- kaolin—Some formulations are OMRI-listed for organic use.
- lambda-cyhalothrin (as a mix with other ingredients)
- mineral oil
- permethrin
- pyrethrins (often as a mix with other ingredients)—Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin

Management—chemical control: COMMERCIAL USE

- alpha-cypermethrin (Fastac CS) at 3.2 to 3.8 fl oz/A (0.021 to 0.025 lb ia/A). PHI 7 days. REI 12 hr. Do not exceed 11.4 fl oz/A per season. Highly toxic to bees, extremely toxic to fish and aquatic invertebrates. Do not apply within 25 feet of aquatic habitats, or with 150 ft if aerial application. Apply as indicated by scouting.
- *Bacillus thuringiensis* var. *kurstaki*—See label for rates. PHI 0 days. Apply with spreader-sticker. Some formulations are OMRI-listed for organic use.
- bifenthrin—
  - Brigade WSB at 0.05 to 0.2 lb ai/A. PHI 7 days. REI 12 hr. Do not graze livestock on treated cover crops. Highly toxic to bees and toxic to fish and aquatic invertebrates.
  - Fanfare EC at 3.2 to 12.8 fl oz/A (0.05 to 0.20 lb ai/A). PHI 7 days. Do not graze livestock on treated cover crops. Highly toxic to bees and toxic to fish and aquatic invertebrates.
- carbaryl (Sevin XLR Plus) at 0.5 to 1.25 quarts/100 gal water (2 to 5 quarts/A). PHI 14 days. REI 12 hr. May cause rapid increase of aphid populations 3 to 4 weeks after application. Extremely toxic to aquatic invertebrates.
- chlorantraniliprole—
  - Altacor at 3 to 4.5 oz/A (0.066 to 0.099 lb ai/A). PHI 10 days. REI 4 hr.
  - Vantacor at 1.7 to 2.5 oz/A. Make no more than 4 applications per year and do not reapply within 7 days. PHI 10 days. REI 4 hr.
- cyfluthrin (Baythroid XL) at 2 to 2.4 oz/A (0.016 to 0.019 lb ai/A). PHI 14 days. REI 12 hr.
- diflubenzuron (Dimilin 2L) at 12 to 16 fl oz/A. PHI 28 days. REI 12 hr. Extremely toxic to aquatic invertebrates. Do not apply within 25 ft of bodies of water.
- diazinon (Diazinon AG 500) at 1 pint/250 to 400 gal water/A. No more than one application per season. PHI 45 days. REI 18 days. Washington and Oregon only.
- emamectin benzoate (Proclaim) at 3.2 to 4.8 oz/A. PHI 14 days.
- esfenvalerate (Asana XL) at 7.3 to 12.8 fl oz/100 gal water (9.6 to 19.2 fl oz/A or 0.05 to 0.1 lb ai/A). PHI 21 days. REI 12 hr. Do not exceed 0.2 lb ai/A per season. Extremely toxic to fish and aquatic habitat.
- fenpropathrin (Danitol 2.4 EC) at 10.3 to 21.3 oz/A (0.2 to 0.4 lb ai/A). PHI 3 days. REI 24 hr. At least 50 gal (100 gal better) water for ground applications. Note buffer requirements for use near aquatic zones.
- GS-omega/kappa-Hxtx-Hv1a (Spear-Lep) at 1 to 2 pints/A. Biological insecticide that should be tank mixed with equal parts of Bt. PHI 0 day. REI 4 hr.
- lambda-cyhalothrin—
  - Warrior II at 1.28 to 2.56 fl oz/A (0.02 to 0.04 lb ai/A). PHI 14 days. REI 24 hr. Do not exceed 0.16 lb ai/A per season or 0.12 lb ai post bloom.
  - LambdaStar at 2.56 to 5.12 fl oz/A. PHI 14 days. REI 24 hr. Do not exceed 0.16 lb ai/A per season or 0.12 lb ai post bloom.
  - Grizzly Too at 1.28 to 2.56 fl oz/A. PHI 14 days. REI 24 hr. Do not exceed 0.16 lb ai/A per season or 0.12 lb ai post bloom.
- methoxyfenozide (Intrepid 2F, generics) at 0.12 to 0.25 lb ai/A. PHI 14 days. REI 4 hr. Do not apply within 25 ft of an aquatic habitat, 150 ft if applied by air.
  - Spring (overwintering) generation—Apply once or twice, depending on infestation level.
  - Summer generation—Apply first during the period of peak egg lay to early egg hatch (200 to 400 DD, following biofix). Reapply 10 to 18 days later (usually 500 to 700 DD). Do not exceed 24 fl oz/A per application or 64 fl oz/A (1 lb ai/A) per season. Do not apply within 25 ft of an aquatic habitat, 150 ft if applied by air.
- methoxyfenozide + spinetoram (Intrepid Edge) at 6 to 12 oz/A. Apply at initiation of egg hatch, if necessary reapply after 14–21 days, but not before 14 days. PHI 7 days. REI 4 hr. No more than 12 fl oz/A/season.
- permethrin—
  - Ambush 25W 12.8 to 25.6 oz/A. PHI 14 days. REI 12 hr. Do not graze treated orchards. Extremely toxic to fish and aquatic habitat.
  - Pounce 3.2 EC at 0.5 to 1 pint/A. PHI 14 days. REI 12 hr. Do not graze treated orchards. Extremely toxic to fish and aquatic habitat.
  - PermaStar AG at 8 to 16 oz/A. PHI 14 days. REI 12 hr. Highly toxic to bees, toxic to fish and aquatic invertebrates.
- pyriproxyfen (Esteem 35 WP) at 3.2 to 4 oz/100 gal water (13 to 16 oz/A). Do not apply more than twice per season. PHI 21 day. REI 12 hr.
- spinosyns—
  - spinetoram (Delegate WG) at 1.5 to 1.75 oz/100 gal water (4.5 to 7 oz/A). PHI 14 days. Apply no less than one week apart, with a maximum 4 applications per season.
  - spinosad (Entrust SC) at 4 to 10 oz/A (0.06 to 0.16 lb ai/A). PHI 1 days. REI 4 hr. OMRI-listed for organic use.
  - spinosad (Success Naturalyte) at 4 to 10 oz/A in 100 gal water (0.06 to 0.16 lb ai/A). PHI 1 days. REI 4 hr. Do not exceed 29 oz/A per season.

Hazelnut—Omnivorous leaftier

Cnephasia longana

Pest description and crop damage European in origin, this pest has been present in Oregon since 1929. Adult female moths are grayish and mottled with brown spots. The male moth is grayish yellow. Larvae are a dirty yellow color. Larvae appear in early spring and roll and feed on leaves or inside buds. The larvae web leaves and flowers together and feed on developing buds, often resulting in destruction of the terminal growth. This pest can be a serious problem in young hazelnut orchards. Feeding on buds and early terminals can set back tree growth and can cause poor tree structure.

Pest monitoring Pry open buds at the time of bud break and look for larvae. Treat when you reach a 5% infestation level of buds checked. Compare with similar moth pests that may also be present as larvae in buds early in the season such as filbert leafroller, obliquebanded leafroller and eyespotted budmoth.

Management—chemical control: HOME USE

- *Bacillus thuringiensis* var. *kurstaki*—Some formulations are OMRI-listed for organic use.
- carbaryl
- permethrin

Management—chemical control: COMMERCIAL USE

- *Bacillus thuringiensis* var. *kurstaki*—See label for rates. PHI 0 days. Apply with spreader-sticker. Some formulations are OMRI-listed for organic use.
- carbaryl (Sevin XLR Plus) at 2 to 5 quarts/A. 4F and 80S formulations are also available. PHI 14 days. REI 12 hr. Extremely toxic to aquatic invertebrates and bees.
- diflubenzuron (Dimilin 2L) at 12 to 16 fl oz/A. PHI 28 days. REI 12 hr. Extremely toxic to aquatic invertebrates. Do not apply within 25 ft of bodies of water.
- fenpropathrin (Danitol 2.4 EC) at 10.3 to 21.3 oz/A (0.2 to 0.4 lb ai/A). PHI 3 days. REI 24 hr. At least 50 gal (100 gal better) water for ground applications. Note buffer requirements for use near aquatic zones.
- GS-omega/kappa-Hxtx-Hv1a (Spear-Lep) at 1 to 2 pints/A. Biological insecticide that should be tank mixed with equal parts of Bt. PHI 0 day. REI 4 hr.
- methoxyfenozide (Intrepid 2F, generics) at 0.12 to 0.25 lb ai/A. PHI 14 days. REI 4 hr. To control foliar feeding leafroller larvae, apply when larvae are feeding. Most effective crop protection results from application when egg hatch begins. Do not exceed 24 fl oz/A per application or 64 fl oz/A (1 lb ai/A) per season. Do not apply within 25 ft of an aquatic habitat, 150 ft if applied by air.
- methoxyfenozide + spinetoram (Intrepid Edge) at 6 to 12 oz/A. Apply at initiation of egg hatch, if necessary reapply after 14-21 days, but not before 14 days. PHI 7 days. REI 4 hr. No more than 12 fl oz/A/season

Hazelnut— Flatheaded borers

Chrysobothris mali
Chrysobothris femorata

Pest description and crop damage Flatheaded borers represent the metallic wood borer beetle family (Buprestidae), and there are two native species that affect hazelnuts. The Pacific flatheaded borer (*Chrysobothris mali*) is the more common species in the PNW, and the flatheaded apple tree borer (*C. femorata*) is also found attacking hazelnut. Both species are pests of many different trees and shrubs, including fruit trees and hazelnuts. In hazelnuts, flatheaded borers have been most destructive in new orchard plantings, where small trees are attacked and often killed at a high rate. Larger trees are also attacked on trunks and scaffold branchess, which is damaging but typically does not kill the tree. Adults are flat, metallic reddish bronze beetles with copper-color spots on wing covers, and about 0.25 to 0.5 inch long. The female is considerably larger than the male. The adult beetles are highly active and rarely observed. Adults may feed on leaf margins. The females lay their eggs on the trunk of young hazelnut trees, or imperfections on the wood of older trees. The larvae enter the wood, boring out the cambium as they feed and molt, creating a gallery that increases in size. Larvae are whitish to pale yellow and about 0.5 inch long when fully developed. The thorax of the larva is enlarged and flattened giving the "flat-headed" appearance. Larval feeding beneath the bark can cause partial or complete girdling, especially on young trees. The percentage of the trunk circumference that is girdled determines the outcome of the damage. A complete trunk girdle in newly planted trees causes certain tree death, and partial girdles can lead to a prolonged decline. In older trees, the feeding site obstructs the flow of water and nutrients from the roots to the leaves and branches. Damage symptoms can worsen drought stress on the tree during hot and dry weather because the tree cannot replenish canopy moisture effectively. A symptom of borer-infested trees is excessive wilting, yellowing and other signs of stress in individual trees during hot periods. The borers have already done most of their damage by the late season and the symptoms of girdling will be most apparent in the leaves and appearance of the tree at that time. Young trees that are exhibiting these symptoms should be examined for borer damage starting at the soil line and up the trunk to height of approximately 2.5 feet. The trunk may break easily at the damage site. In older trees, stress symptoms in the canopy can indicate flatheaded borer attack on scaffold branches or trunks. However, there are many different potential causes of such symptoms.

Biology and life history Adults begin to emerge from wood in late May or early June and continue emerging into August. They fly and mate and females seek out host trees to attack. The female lays eggs in imperfections on the bark, and the larvae hatch from the eggs and bore into the tree, mining mostly the cambium layer. The larvae have done most of the damage by the end of the growing season and they move to the heartwood to overwinter in the larval stage. In the spring, the larvae pupate, and the adult chews its way out of the host leaving a distinct "D" shaped emergence hole.

Pest monitoring Stunted leaves and wilting in the upper canopy of young trees while vigorous suckers or watersprouts are growing are a good indicator of girdling of the main trunk by Pacific flatheaded borer. Catkins may form but never distend. Sawdust frass may be apparent on the soil around the base of the tree, especially when trunk guards are removed. Watch for depressions in the bark or cracks through which frass may be seen.

The thin bark of hazelnuts will eventually peel back to reveal the feeding sites. The damage may resemble mechanical or rodent damage, but inspect for shallow galleries where the larvae were feeding and evidence of frass. Dead sticks can be flexed and the wood will typically break at the weak point where the larvae were feeding.

Management-biological control

Birds peck the larvae from under the bark with their beaks. Some wasp parasites attack the borer by drilling the ovipositor through the bark to lay the egg on the flatheaded borer larvae. Carpenter ants eat both larvae and pupae from the wood. Generalist predatory mites can enter galleries and feed on overwintering larvae and pupae.

Management-cultural control

Young, recently planted trees are most susceptible. Trees that are stressed because of drought or other causes are especially vulnerable. Irrigate new plantings. Minimize drought stress on young trees with irrigation. Avoid planting in very dry soils. Control weeds and avoid intercrop competition for moisture. These borers are attracted to weakened, sunburned, or injured parts of trunks and lay eggs in cracks on bark exposed to the sun. Plastic trunk guards and paint do not prevent attack on trunks of young hazelnut trees. However, these can help prevent sunburn and mechanical damage on trunks, which create weak imperfections that the adult beetles can exploit for egg laying. Sometimes trunk guards are too short to adequately protect trunks. Painting trunks and exposed wood with white latex paint will prevent sunburn. Manipulation of the tree canopy through pruning can expose wood that is normally shaded, resulting in sunburn. Straighten leaning trees to prevent burn. Remove infested trees from the orchard and destroy.

Management—chemical control: HOME USE

- azadirachtin (as a mix with other ingredients)—Some formulations are OMRI-listed for organic use.
- bifenthrin (often as a mix with other ingredients).
- emamectin benzoate
- imidacloprid (often as mix with other ingredients)
- pyrethrins (often as a mix with other ingredients)—Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin—Applied as trunk spray may have some efficacy.

Management—chemical control: COMMERCIAL USE

Approaches to management include treatment with systemic insecticides or applying residue barrier sprays to trunks.

- clothianidin (Belay) at 3 to 6 oz/100 gal water. Use the low rate for smaller infestations or smaller trees. Apply no more than 0.2 lb ai/A per year. PHI 21 day. REI 12 hr. 2(ee) recommendation for OR only.
- fenpropathrin (Danitol 2.4 EC) at 10.3 to 21.3 oz/A (0.2 to 0.4 lb ai/A). PHI 3 days. REI 24 hr. At least 50 gal water for ground applications. Note buffer requirements for use near aquatic zones.
- imidacloprid (Admire Pro) at 1.4 to 2.4 oz/A. Generic labels available. Can be applied as soil application through chemigation system, rates and restrictions differ for this application, see label. PHI 7 days. REI 12 hr. Not specifically labeled for Pacific flatheaded borer but applications for aphid control will help control this pest.

Hazelnut—Scale insect

Includes
Cottony scale (*Pulvinaria* spp.)
European fruit lecanium (*Parthenolecanium corni*)
Excrescent scale (*Eulecanium excrescens*)

Pest description and crop damage Lecanium scale is the most problematic species in hazelnuts, occasionally reaching high enough levels to require control. Mature scale are up to 0.2 inch across, reddish brown, and rounded, resembling small helmets or bumps on branches, stems, and the underside of leaves. Adult female cottony scale produce copious amounts of white cottony filaments containing eggs in summer, making them more apparent. The crawlers are flat, oval, and pinkish brown. Chemical management can target female scale or the crawler stage. Scale insects are closely related to aphids, mealybugs, and whiteflies. Like these insects, they also have piercing–sucking mouthparts. Severe infestations can kill twigs and may have reduced nut size and kernel fill similar to aphids. Large quantities of honeydew encourage growth of sooty mold fungus. Sooty mold fungus can impede photosynthesis, severely devitalizing plants and retarding growth.

Biology and life history Lecanium scale overwinters as an immature scale on twigs and branches. They resume feeding in the spring, and eggs are laid underneath the scales in May to June. The eggs remain under the scales until hatching in early summer. The emerging young scales, called "crawlers," migrate to the undersides of leaves to feed. The crawlers are most susceptible to insecticides. Young scales also can be dispersed by wind, rain, irrigation, or by the movement of people and machinery. After 4 to 6 weeks on the leaves, the young return to the stems and twigs to feed, mate, and overwinter. There is one generation per year.

Management-biological control

Parasitoids attack scale and scale outbreaks may be the result of broad-spectrum insecticide use causing the parasitoid population to decline. Monitor biological control by scouting for small emergence holes on the mature female scale where the parasitoid has chewed its way out of the scale host.

Management—cultural control

Home orchardists: Scale can be rubbed off plants by hand with a glove or toothbrush. Major infestations can be pruned off. Tanglefoot, "stickem," or a similar adhesive can be applied around infestations of adult scales to catch the crawler stage. As with aphids, avoid excessive nitrogen fertilizer or water applications, as this favors increases in the populations.

Management—chemical control: HOME USE

Applications are directed at crawlers that appear in June or early July. Take precautions when treating scale to avoid disrupting pollinators that may be actively foraging on honeydew.

- acetamiprid
- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- bifenthrin (as a mix with other ingredients).
- carbaryl
- emamectin benzoate
- esfenvalerate
- gamma cyhalothrin
- horticultural oil
- imidacloprid (often as a mix with other ingredients).
- insecticidal soap—Some formulations are OMRI-listed for organic use.
- lambda-cyhalothrin (as a mix with other ingredients).
- plant-derived essential oils (ex. cinnamon oil, garlic oil, peppermint oil, canola oil)—Some formulations are OMRI-listed and have shown efficacy against scale.
- potassium laurate (often as mix with other ingredients)
- pyrethrins (often as a mix with other ingredients)—Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin

Management—chemical control: COMMERCIAL USE

- acetamiprid (Assail 70WP) at 0.57 to 1.0 oz/100 gal water (2.3 to 4.1 oz/A) (0.10 to 0.18 lb ai/A). PHI 14 days. REI 12 hr. No more than 4 applications per season.
- buprofezin (Centaur WDG) at 34.5 to 46.0 oz/A. No more than one application per season. PHI 60 day. REI 12 hr.
- clothianidin (Belay) at 3 to 6 oz/100 gal water. Use the low rate for smaller infestations or smaller trees. Apply no more than 0.2 lb ai /year. PHI 21 day. REI 12 hr.
- imidacloprid (Admire Pro) at 1.4 to 2.4 oz/A. Generic labels available. PHI 7 days. REI 12 hr.
- pyriproxyfen (Esteem 35 WP) at 3.2 to 4 oz/100 gal water (13 to 16 oz/A). Do not apply more than twice per season. PHI 21 day. REI 12 hr.
- spirotetramat (Movento) at 6 to 9 oz/A (0.09 to 0.14 lb ai/A). Minimum reapplication interval is 14 days. PHI 7 day. REI 24 hr.

Hazelnut—Shothole and ambrosia borers

European shothole borer, pear-blight beetle (*Anisandrus dispar*)
Lesser shothole borer, fruit-tree pinhole borer (*Xyleborinus saxesenii*)
Shothole borer (*Scolytus rugulosus*)

Pest description and crop damage Any of this complex of small beetle species from the beetle subfamily Scolytinae are sometimes referred to as "shothole borer" because of the characteristic damage caused by entrance or emergence of adult beetles from the woody host, leaving many small holes resembling a shotgun pattern. Shothole borer (*Scolytus rugulosus*) feeds directly on the wood and each gallery contains many tunnels and emergence holes. The adult female beetle bores into the tree and excavates along the grain of the wood where roughly 50 eggs are deposited along gallery walls. Each larva mines its own tunnel out from the wall of the gallery, feeding perpendicular to the wood grain and replacing the empty space in the tunnel with sawdust excrement (frass). The many larval tunnels fan out from the egg gallery, each one expanding in diameter as the larvae inside mature. The larvae pupate at the ends of the mines leaving the adults to finish the tunnel by chewing their way to the outside.

The two other "shothole borer" species recovered from hazelnuts (*Anisandrus dispar* and *Xyleborinus saxesenii)* belong to an ecological guild known as ambrosia beetles. Ambrosia beetles have an obligate association with fungi, which they introduce to their tunnels and cultivate as their only food source. The larvae live together in the galleries feeding on the fungus rather than boring through the wood. The tunnels are maintained by the adult females and all debris generated by the residents is ejected through the entrance hole. The fungi introduced by ambrosia beetles can cause wilting and die-back of branches as the vascular tissue becomes restricted as the fungi colonize the tree. Opportunistic wood decay fungi may be introduced into the wood as a result of attack by any of the borers affecting hazelnuts. The adults can be difficult to identify, but the galleries are easily distinguished. The clean, uniform-size tunnels in the galleries of ambrosia beetles can be easily distinguished from the numerous expanding frass-filled tunnels radiating out from the central egg gallery in *S. rugulosus.*

These borers were introduced to North America and have been found in the PNW since the early 1900s. They are pests of forest trees, ornamental shade trees, and shrubs as well as nut trees. Borers are primarily a problem on injured or stressed plants, but healthy trees growing adjacent to blocks of neglected trees also may be attacked. Hazelnut orchards adjacent to woodlands are also at risk. The adult shothole borer is a brown or black beetle about 0.08 inch long. The larvae are white, legless, and about 0.17 inch long.

Biology and life history Shothole borer larvae overwinter beneath the bark of infested trees where they pupate. Adults emerge in spring or early summer, mate, and fly to susceptible trees to feed at the base of leaves or small twigs. They then tunnel into the tree, excavating galleries parallel to the wood grain where they lay their eggs. The eggs hatch and the larvae feed by tunneling at right angles to the main burrow, causing a characteristic pattern of damage. The burrows are filled with frass and increase in diameter as the larvae mature. After 6 to 8 weeks, the larvae pupate at the ends of the galleries, then emerge as adults starting in March. This activity creates many small, round exit holes that produce a "shothole" effect. There are multiple generations per year. The holes that these species leave in their hosts are always small and round in contrast with the flattened D-shaped exit holes left by Pacific flatheaded borer.

Scouting and thresholds Examine branches in late spring for holes 0.08 inch in diameter, oozing sap and sawdust. Beetles are especially attracted to unhealthy trees, particularly trees where roots may be suffering from lack of oxygen because soil is saturated with water ("wet feet"). Entrance holes often appear as wet stains on hazelnut trunks.

Management—cultural control

The best management tool is keeping trees healthy and vigorous. Healthy trees repel the beetles by plugging galleries with sap and resins. This group of borers are highly attracted to trees planted in heavy soils where there is excess water on roots. One way to prevent problems from this pest is to promote adequate drainage and to avoid over watering trees.

Sanitation is important. Remove and destroy infested wood on the tree or nearby piles of infested green wood, especially cherry. Once the bark on cut wood dries and sloughs off, it is no longer a host for the beetles. Yellow sticky cards are effective for monitoring flights of adult beetles (March-September). Commercial or homemade lures that release ethanol are very attractive to adult beetles. Intensive mass trapping of adult beetles in orchards could help reduce damage.

Management—chemical control: HOME USE

- azadirachtin (neem oil) (Azera Gardening)— OMRI-listed for organic use.

Management—chemical control: COMMERCIAL USE

- azadirachtin + pyrethrins (Azera) at 2 pints/A. OMRI-listed for organic use. PHI 1 day. REI 12 hr.
- pyrethrins 5% (PyGanic, Lynx) at 15 to 17 oz/A. No residual activity. PyGanic OMRI-listed for organic use. PHI 1 day. REI 12 hr.

Hazelnut—Spider mite

Tetranychus urticae.

Pest description and crop damage Tiny, eight-legged, non-insect pests that suck juices and devitalize trees. Webbing accompanies heavy infestations. Undersides of leaves become yellow and silver where the mite colonies form, and later the entire leaf may bronze. Spider mites are common late in the growing season, and they sometimes reach populations that are high enough to cause major defoliation of the orchard. This problem is likely to increase with climate change if growing seasons continue to get hotter.

Management—biological control

Rain and cool temperatures tend to suppress mite populations. Considerable natural control is provided by lady beetles (*Stethorus* spp.) and minute pirate bugs (*Orius* spp.). Predator mites, particularly *Kampimodromus aberrans* are important for managing populations of spider mite. Predator mites can be purchased and released within the orchard. This approach is much more feasible for home orchardists and small acreage hazelnut growers.

Management—cultural control

Spider mites thrive in dusty conditions; control dust on the orchard floor and on roads and headlands. *Home orchardists:* Mite populations can be physically reduced by spraying the tree with water. Population reductions may allow natural predators to gain control of an outbreak.

Management—chemical control: HOME USE

- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- bifenthrin (often as a mix with other ingredients).
- insecticidal soap—Some formulations are OMRI-listed for organic use.
- plant-derived essential oils (ex. cinnamon oil, clove oil, peppermint oil, cottonseed oil)—Some formulations are OMRI-listed for organic use and have shown efficacy against spider mites.
- pyrethrins (often as a mix with sulfur)—Some formulations are OMRI-listed for organic use.
- sulfur (as a mix with pyrethrins)—Some formulations are OMRI-listed for organic use.

Management—chemical control: COMMERCIAL USE

- abamectin (Agri-Mek, others) at 0.5 to 4.24 oz/A. PHI 21 days. REI 12 hr. Do not exceed two applications per season.
- acequinocyl (Kanemite 15 SC) at 21 to 31 oz/A. PHI 7 days. REI 12 hr. Aerial application prohibited, no less than 100 gal water should be used to apply. No more than 62 oz (0.6 lb ai) per season.
- bifenthrin—
  - Brigade WSB at 0.05 to 0.2 lb ai/A. PHI 7 days. REI 12 hr. Do not graze livestock on treated cover crops. Highly toxic to bees and toxic to fish and aquatic invertebrates.
  - Fanfare EC at 3.2 to 12.8 fl oz/A (0.05 to 0.20 lb ai/A). PHI 7 days. Do not graze livestock on treated cover crops. Highly toxic to bees and toxic to fish and aquatic invertebrates. WA only.
- bifenzate (Acramite 50 WS, others) at 0.75 to 1.5 lbs/A. PHI 14 days. REI 12 hr.
- etoxazole (Zeal) at 0.5 to 0.75 oz/100 gal water (2 to 3 oz/A). PHI 28 days. One application per season.
- fenpyroximate (Fujimite) at 2 pt/A. PHI 14 days. REI 12 hr.
- hexythiazox (Savey 50DF) at 3 to 6 oz/A. PHI 28 days. REI 12 hr. Does not significantly control adult rust mites. Apply at first sign of egg laying, before adult mites build up. Apply only once per season. Do not graze or feed livestock on cover crops growing in treated areas.
- pyridaben (Nexter) at 2.67 oz/100 gal water (10.67 oz/A). PHI 7 days. Do not exceed two applications per season.
- spirodiclofen (Envidor 2SC) at 16 to 18 fl oz/A. PHI 7 days. REI 12 hr.

Hazelnut—Tent caterpillar

Includes
Forest caterpillar (*Malacosoma disstria*)
Western tent caterpillar (*Malacosoma californicum*)

Pest description and crop damage The western tent caterpillar and the forest caterpillar are the main tent caterpillar pests in the PNW. These insects attack a wide variety of plants, including alder, ash, birch, cottonwood, and willow, as well as fruit trees and roses. The adult moths are stout-bodied, light to darker brown, and are active in early to midsummer. They are attracted to lights at night.

Larvae of the forest tent caterpillar are about 2 inches long, blue, with black spattered markings as well as white, footprint-shape marks. Larvae of the western tent caterpillar are hairy, dull yellow-brown, with rows of blue and orange spots on the body. Eggs of these moths are laid on twigs or buildings in masses. These are brown to gray, about 0.06 inch long, and look like polystyrene.

Larvae of both species feed in large groups on foliage of host plants and can do significant damage by defoliation. Larvae of western tent caterpillars build large silken tents over leaves on which they feed. Larvae of forest tent caterpillars build mats of webbing rather than tents. Larvae can defoliate small trees totally, which may not kill them, but it reduces growth and makes the trees more susceptible to diseases. Healthy trees usually will grow new leaves by midsummer.

Biology and life history The moths overwinter as egg masses on twigs or buildings. The eggs hatch in spring as buds break in April or May. The young larvae feed in groups for 5 to 6 weeks, growing larger and molting (shedding skins) four times. As they mature, they split into smaller groups and move to new feeding sites in the tree. The larvae pupate starting in mid-June, and the adults emerge 7 to 10 days later. The adults moths mate and females lay eggs that overwinter. There is one generation per year.

Pest monitoring Look for egg masses on twigs or other overwintering sites. Masses of young larvae are identified easily in early spring.

Management—biological control

Infestations of tent caterpillars occur cyclically as populations of the caterpillars and their predators rise and fall. Tent caterpillars have many natural enemies. Some birds eat the caterpillars and small mammals consume the pupae. The larvae of a tachinid fly parasitize the caterpillars.

Management—cultural control

Remove egg masses from twigs or other sites. Cut out infested twigs and dip them in a bucket of soapy water.

Management—chemical control: HOME USE

Spray in spring after overwintering eggs hatch, at about the time leaves are 0.75 to 1 inch long. Control is much more effective if sprays are applied when larvae are small.

- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- *Bacillus thuringiensis* var. *kurstaki*—Some formulations are OMRI-listed for organic use.
- bifenthrin (as a mix with other ingredients).
- emamectin benzoate
- insecticidal soap—Some formulations OMRI-listed for organic use.
- kaolin—Some formulations are OMRI-listed for organic use.
- lambda-cyhalothrin (often as a mix with other ingredients).
- pyrethrins (often as a mix with other ingredients)—Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin

Management—chemical control: COMMERCIAL USE

- azadirachtin + pyrethrins (Azera) at 2 pints/A. OMRI-listed for organic use. PHI 1 day. REI 12 hr.
- *Bacillus thuringiensis* var. *kurstaki*—See label for rates. PHI 0 days. Follow label instructions. Add a spreader-sticker to enhance control. Some formulations are OMRI-listed for organic use.
- methoxyfenozide (Intrepid 2F, generics) at 0.12 to 0.25 lb ai/A. PHI 14 days. REI 4 hr. Do not exceed 24 fl oz/A per application or 64 fl oz/A (1 lb ai/A) per season. Do not apply within 25 ft of an aquatic habitat, 150 ft if applied by air.
- pyrethrins 5% (PyGanic, Lynx) at 15 to 17 oz/A. No residual activity. PyGanic OMRI-listed for organic use. PHI 1 day. REI 12 hr.
- methoxyfenozide (Misc.) at 15 to 17 oz/A. No residual activity. PyGanic OMRI-listed for organic use. PHI 1 day. REI 12 hr.

Hazelnut— Tree cricket

Snowy tree cricket (*Oecanthus fultoni*)

Pest description and crop damage This tree cricket is very common in hazelnut orchards. The male produces the classic chirp that is often used in movie soundtracks, and the frequency of chirps is related to the ambient temperature. This pale green cricket carries its wings in a flattened position over the slender body. The hind legs are adapted for jumping and are elongated. The antennae are very long, surpassing the length of the body, which is approximately 0.75 inch for adults. Antennae have dark ovular markings on first and second antennal segments. The head has orange markings. Nymphs look like adults but lack wings. Tree crickets are more common in unsprayed and organic orchards. Tree crickets are omnivorous, and most of the feeding is on leaves and is inconsequential, but they also eat aphids (a beneficial effect) and they can damage nuts. Nut attacks typically leave a round divot or "scoop" in the shell from feeding. Because the mandibles or jaws are relatively weak, it is likely that nut attacks occur while the shells are still green and somewhat fleshy. Sometimes the tree cricket is able to chew through the shell and the kernel is consumed, leaving a jagged hole and empty shell. Adult females also oviposit (lay eggs) in the bark of smaller gauge hazelnut branches (3 inches in diameter or smaller). This is not economic damage, but it can leave scars that are easily confused with eastern filbert blight stromata. Each scar/hole contains a single egg, which

resembles a grain of rice (1/8 in) and is yellowish in color. Note that female cicadas are another insect that wound hazelnut bark for insertion of eggs and this damage can also be confused with eastern filbert blight.

Biology and life history Eggs laid in the branches in fall are the overwintering stage. Nymphs emerge in late spring and develop to adults by the end of the growing season. There has been little research on this pest in hazelnuts, but it is thought there is just one generation per season.

Management—chemical control: HOME USE

- carbaryl
- zeta-cypermethrin

Management—chemical control: COMMERCIAL USE

- carbaryl (Sevin XLR Plus) at 2 to 5 quarts/A. 4F and 80S formulations are also available. PHI 14 days. REI 12 hr. Extremely toxic to aquatic invertebrates and bees.

Hazelnut—Winter moth

Operophtera brumata

Pest description and crop damage The European winter moth was introduced to the PNW in 1958. Adult males are gray or off-white moths which are present in late fall and winter, hence the name. Female moths are wingless. The larvae are pale green with a light stripe down their sides, up to 0.5 inch long. Larvae damage young hazelnut buds and leaves. Symptoms of leaf feeding are distinct from leafroller larvae: leaves are tied together with silken threads but not rolled and leaves appear tattered. In commercial orchards, this insect seldom is a pest, possibly because management for other pests also control winter moth. Baited traps will consistently catch moths, but economic damage to orchards is relatively rare at this time.

Biology and life history Wingless females deposit 100 to 200 eggs on hazelnut stems or in crevices in bark in late fall and winter. Since the female cannot fly, populations of winter moth often are clumped, as all the eggs usually are deposited in one tree. The eggs hatch in early spring at the green tip stage, and larvae feed from then until petal fall. The larvae often drop on silken threads and are carried by the wind to new growth areas. They drop to the soil to pupate during the summer, and, after the first severe frost, the adults emerge. There is one generation per year.

Pest monitoring Check for larvae from March 15 to May 31, checking three terminals per tree and three leaf clusters per terminal. Each terminal is a sampling unit. Treat when infestation level is 20%. Commercial lures and traps are available and moths can be caught in high numbers. However, damage is not very common and apparently not highly corelated with the number of moths that are caught in traps.

Management—biological control

General predators such as lacewings, assassin bugs, tachinid flies, and spiders feed on the larvae, although populations are not always well regulated by these predators. Temperature may play a bigger role in controlling populations.

Management—cultural control

Home orchardists*:* Pick larvae when you find them, and prune out infested leaves.

Management—chemical control: HOME USE

- emamectin benzoate

Management—chemical control: COMMERCIAL USE

- *Bacillus thuringiensis* var. *kurstaki*—See label for rates. PHI 0 days. Follow label instructions. Add a spreader-sticker to enhance control. Some formulations are OMRI-listed for organic use.
- carbaryl (Sevin XLR Plus) at 2 to 5 quarts/A. Other formulations are also available. PHI 14 days. REI 12 hr. Extremely toxic to aquatic invertebrates.
- diflubenzuron (Dimilin 2L) at 12 to 16 fl oz/A. PHI 28 days. REI 12 hr. Extremely toxic to aquatic invertebrates. Do not apply within 25 ft of bodies of water.
- emamectin benzoate (Proclaim) at 3.2 to 4.8 oz/A. PHI 14 days. REI 12 hr.
- fenpropathrin (Danitol 2.4 EC) at 10.3 to 21.3 oz/A (0.2 to 0.4 lb ai/A). PHI 3 days. REI 24 hr. At least 50 gal water for ground applications. Note buffer requirements for use near aquatic zones.
- GS-omega/kappa-Hxtx-Hv1a (Spear-Lep) at 1 to 2 pints/A. Biological insecticide that should be tank mixed with equal parts of *Bt*. PHI 0 day. REI 4 hr.
- spinosad (Entrust SC) at 4 to 10 oz/A (0.06 to 0.16 lb ai/A). PHI 1 days. REI 4 hr. OMRI-listed for organic use.

Walnut Pests

Nik Wiman and Erica Chernoh

Latest revision—March 2024

INCLUDES MANAGEMENT OPTIONS FOR COMMERCIAL AND HOME USE

In all cases, follow the instructions on the pesticide label. The *PNW Insect Management Handbook* has no legal status, whereas the pesticide label is a legal document. Read the product label before making *any* pesticide applications.

Protect pollinators: See How to Reduce Bee Poisoning from Pesticides.

Note: Products are listed in alphabetical order and not in order of preference or superiority of pest control.

Walnut—Aphid

Includes
Dusky-veined aphid (*Panaphis juglandis*)
Walnut aphid (*Chromaphis juglandicola*)

Pest description and crop damage Walnut aphids are pale yellow, much smaller than the dusky-veined aphid, and feed on the lower surface of leaves. Dusky-veined aphids have dark banded spots on their backs and are found feeding along the mid-vein on the top surface of leaves. Both aphids suck plant juice and deposit honeydew. Feeding of the dusky-veined aphid causes the leaf midrib to turn black. The honeydew is toxic to the husk of some varieties and turns it black. High populations may lead to leaf drop and a loss of nut yield and quality. Aphid populations are most damaging in spring and early summer when nuts are developing rapidly.

Pest monitoring Begin observing shoots prior to budbreak, as management is best undertaken early while the aphids are small.

Management—biological control

In the 1980s, a parasitic wasp (*Trioxys pallidus*) was introduced, which has reduced problems with the walnut aphid substantially. In addition, aphids have many natural enemies including ladybeetles, *Geocoris* (big-eyed bugs), *Deraeocoris* (mirid bugs), syrphid fly larvae, and green lacewings. Avoid broad-spectrum insecticide applications when predators and parasitoids are active against aphids.

Management—cultural control

Aphid populations tend to be higher in plants that are fertilized liberally with nitrogen.

Home orchardists: Avoid excessive watering which, together with nitrogen applications, produces flushes of succulent growth. Control ants, which "farm" the aphids for their honeydew and protect them from predators.

Management—chemical control: HOME USE

Dormant-season spray

Apply only during dormant or delayed-dormant period. Use enough water to cover tree thoroughly including small limbs and shoots.

- dormant oil

Growing-season spray

Predators usually reduce aphid populations. Apply pesticides only when predators are few and aphid population is heavy and increasing.

- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- bifenthrin
- carbaryl
- esfenvalerate
- horticultural oil—Some formulations OMRI-listed for organic use.

- imidacloprid—Highly toxic to bees. Do not apply when bees are actively foraging, wait until after trees have flowered. Do not make more than one application a year. PHI 7 days.
- insecticidal soap—May require several applications to be effective. Some formulations are OMRI-listed for organic use.
- permethrin
- plant-derived essential oils (clove, garlic, peppermint, rosemary oil, etc.)—Some formulations are OMRI-listed for organic use and have shown efficacy against aphids.
- potassium laurate (often as mix with other ingredients)
- pyrethrins (often as a mix with other ingredients)—Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin

Management—chemical control: COMMERCIAL USE

Aphids seldom warrant control. Predators usually reduce aphid populations. Pesticide applications are advised only when predators are few and aphid population is heavy.

- acetamiprid (Assail 30SG) at 0.047 to 0.18 lb ai/A. No more than 4 applications and a maximum of 0.72 lb ai/A per growing season. Re-treatment interval 14 days. PHI 14 days.
- alpha-cypermethrin (Fastac EC) at 0.02 to 0.025 lb ai/A. Retreatment interval 7 days. Maximum 0.075 lb ai/A. PHI 7 days.
- azadiracthtin (Azasol, Azatin, others)—See label for rates. Some formulations are OMRI-listed for organic use. REI 4 hr.
- *Beauvaria bassiana* (Mycotrol ESO)—See label for rates. OMRI-listed for organic use.
- beta-cyfluthrin (Baythroid XL) at 0.19 to 0.022 lb ai/A. Maximum per 14 day and per season: 0.022 lb ai/A. PHI 14 days.
- bifenthrin (Brigade WSB) at 0.05 to 0.2 lb ai/A. PHI 7 days. REI 12 hr.
- bifenthrin/Abamectin B1 (Athena) at 7.5 to 20 fl oz/A. Retreatment interval 21 days. Maximum of two applications per season. PHI 21 days.
- clothianidin (Belay) at 0.05 to 0.1 lb ai/A. Maximum 0.2 lb ai/A. PHI 21 days.
- cyantraniliprole (Exirel) at 13.5 to 20.5 oz. Retreatment interval 7 days. PHI 5 days. REI 12 hr.
- deltamethrin (Delta Gold) at 0.02 to 0.033 lb ai/A. Maximum 0.165 lb ai/A. Retreatment interval 7 days. PHI 21 days.
- esfenvalerate (Asana XL) at 0.05 to 0.1 lb ai/A. PHI 21 days. REI 12 hr. Do not exceed 0.2 lb ai/A per season. Do not feed or graze livestock on treated orchard floors. Extremely toxic to fish and aquatic habitat.
- horticultural oil—Some formulations OMRI-listed for organic use.
- imidacloprid (Admire Pro) at 7 to 14 oz for soil application or 1.2 to 2.4 oz for foliar application. PHI 7 days. REI 12 hr. Generic formulations of imidacloprid are available.
- insecticidal soap (M-Pede) at 2% solution. PHI 0 days. Some formulations are OMRI-listed for organic use.
- lambda-cyhalothrin (Warrior II) at 0.02 to 0.04 lb ai/A. PHI 14 days. REI 1 day. Do not exceed 0.16 lb ai/A per season or 0.12 lb ai post bloom.
- malathion (Malathion 57% EC and others) at 0.2 to 0.4 oz/A or up to 2.5 lb ai/A. PHI 7 days. REI 24 hr.
- pyriproxyfen (Esteem 35WP) at 4 to 5 oz /A. PHI 21 days. REI 12 hr. Do not exceed two applications per season.
- spirotetramat (Movento) at 6 to 9 fl oz. PHI 7 days.
- sulfoxaflor (Transform WG) at 0.75 to 1.5 oz. PHI 7 days. REI 12 hr.
- tolfenpyrad (Bexar) at 17 to 27 oz. PHI 14 days. REI 12 hr.
- zeta-cypermethrin (Mustang, Mustang Max, Mustang Maxx) at 0.02 to 0.025 lb ai/A. Maximum of 0.125 lb ai/A per seaon. PHI 21 days.

Walnut—Codling moth

Cydia pomonella

Pest description and crop damage This is a gray tortricid moth with coppery spots on the wings and white or pink larvae up to 0.625 inch long that can damage walnuts. While codling moth is an important pest of walnuts in California, it is rarely a problem on walnuts grown in the Pacific Northwest. The type of injury varies with the time of infestation. Early season infestations arrest nut development and may result in heavy nut drop. Later in the season, feeding within the husk may stain nut shells but does not affect kernels, or larvae may enter the shell and destroy the kernel.

Biology and life history Codling moth overwinters as mature larvae in silken cocoons (hybernaculi) spun under loose bark, in the soil, or in litter at the base of the tree. Pupation takes place in the early spring, and adults emerge around the time of bloom. Adults are active only at dusk and dawn and lay eggs on leaves or occasionally on fruit. The larvae emerge from the eggs and search out the nuts to begin feeding. Sprays are typically applied to target the eggs and the young larvae before they enter the husk. Larvae may bore to the center of developing nuts to feed on the kernel. As they mature, they push frass out of the entry hole. After 3 to 4 weeks the nut may drop, and the larvae may leave the nut to seek a sheltered spot on the tree to spin cocoons. The larvae may overwinter in the cocoon, or they may emerge in 2 to 3 weeks as a new flight of adults. These adults represent a second generation that is active in July and August. In warm areas, there may even be a third flight of moths. Larvae produced by the late moth flight may penetrate nuts but they often do not complete development before harvest or winter.

Pest monitoring Pheromone traps can be used to monitor populations. They can be used to set damage thresholds and they can also be used to set phenology models. Your local Extension agent may be able to provide information on moth levels in your area. There is a very low threshold for damage, as minor infestations one year can turn into a major problem the next.

Management—biological control

A number of natural enemies have activity against codling moth so conservation biological control is important for maintaining low pest populations.

However, insect biological controls have not proven effective in controlling outbreaks of this pest. Sprays of *Bacillus thuringiensis* var. *kurstaki* (*Btk*) have not proven effective. Insecticidal granulosis virus (OMRI-listed) is effective against larvae and there are several commercial formulations including Cyd-X. Application of virus should be timed to egg hatch, or approximately 200 to 250 degree-days.

Management—cultural control

Black-light traps have shown some efficacy in small orchards for trapping the adult moths. Remove any infested fruit well before harvest, and destroy fruits to eliminate larvae. Remove brush and debris from the orchard, and remove bark scales from the tree to eliminate overwintering sites. Wrap the trunk with corrugated cardboard or burlap to trap migrating larvae. Periodic removal of these tree wraps to destroy cocooning larvae can help. A number of hand-applied and aerosol pheromone release devices are available for mating disruption of codling moth. This management tactic can be very successful on large orchard blocks (>10 ac) and moderate to low codling moth populations.

Management—chemical control: HOME USE

Spray timing depends on moth emergence. The first spray is usually when the average nut size is 0.375 to 0.5 inch in diameter.

- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use. Effective against eggs.
- carbaryl
- dodecadien-1-OL (Checkmate CM-XL 2.0 Dispenser)—Biochemical pheromone for mating disruption.
- esfenvalerate
- horticultural oil–Some formulations are OMRI-listed for organic use.
- insecticidal soap—May require several applications to be effective. Some formulations are OMRI-listed for organic use.
- kaolin clay (Surround® at Home®)—Applied as a spray to leaves, stems, and fruit, it acts as a repellant to some insect pests. Some formulations are OMRI-listed for organic use.
- gamma cyhalothrin (often as a mix with other ingredients)
- permethrin
- potassium laurate (often as mix with spinosad)
- pyrethrins (often as a mix with other ingredients)—Some formulations are OMRI-listed for organic use.
- spinosad—Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin

Management—chemical control: COMMERCIAL USE

Spray timing depends on moth emergence. The first spray is usually when the average nut size is 0.375 to 0.5 inch in diameter.

- acetamiprid (Assail 30SG) at 0.1 to 0.18 lb ai/A. No more than 4 applications and a maximum of 0.72 lb ai/A per growing season. Retreatment interval 14 days. PHI 14 days.
- alpha-cypermethrin (Fastac EC) at 0.02 to 0.025 lb ai/A. Retreatment interval 7 days. Maximum 0.075 lb ai/A. PHI 7 days.
- beta-cyfluthrin (Baythroid XL) at 0.016 to 0.019 lb ai/A. Maximum per 14 day and per season 0.022 lb ai/A. PHI 14 days.
- bifenthrin (Brigade WSB) at 0.05 to 0.2 lb ai/A. PHI 7 days. REI 12 hr.
- bifentrin/Abamectin B1 (Athena) at 7.5 to 20 fl oz/A. Retreatment interval 21 days. Maximum of 2 applications per season. PHI 21 days.
- carbaryl (Sevin XLR Plus) at 2.5 to 5 quarts/A. PHI 14 days. REI 12 hr. Extremely toxic to aquatic invertebrates.
- chlorantraniliprole (Altacor) at 3 to 4.5 oz. PHI 10 days. REI 4 hr.
- cyantraniliprole (Exirel) at 13.5 to 20.5 oz. Retreatment interval 7 days. PHI 5 days. REI 12 hr.
- cyfluthrin (Tombstone) at 0.031 to 0.038 lb ai/A. Maximum 0.044 lb ai/A per season. PHI 14 days.
- deltamethrin (Delta Gold) at 0.02 lb ai/A. Maximum 0.165 lb ai/A. Retreatment interval 7 days. PHI 21 days.
- diflubenzuron (Dimilin 2L) at 16 fl oz/A. Most effective if applied before egg-laying. Extremely toxic to aquatic invertebrates. Do not apply within 25 ft of bodies of water. Do not make more than 4 applications per season. PHI 28 days. REI 12 hr.
- dodecadien-1-OL (Checkmate CM-XL 2.0 Dispenser)—Biochemical pheromone for mating disruption. Dispense 120 to 200 hanging dispensers per acre, at or just before codling moth emergence.
- esfenvalerate (Asana XL) at 10 to 16 fl oz/A. PHI 21 days. REI 12 hr. Do not exceed 0.2 lb ai/A per season. Do not feed or graze livestock on untreated orchard floors. Extremely toxic to fish and aquatic habitat.
- lambda-cyhalothrin (Warrior II) at 1.28 to 2.56 fl oz/A (0.02 to 0.04 lb ai/A). PHI 14 days. REI 24 hr. Do not exceed 0.16 lb ai/A per season or 0.12 lb ai post bloom.
- methoxyfenozide (Intrepid 2F) at 0.19 to 0.38 lb ai/A. PHI 14 days. REI 4 hr. The higher rates in the recommended rate range may be required for extended residual effectiveness, high pest infestation levels, larger trees, or heavy dense foliage. Do not exceed 24 fl oz/A per application or 64 fl oz/A (1 lb ai/A) per season. Do not apply within 25 ft of an aquatic habitat, 150 ft if applied by air.
- methoxyfenozide + spinetoram (Intrepid Edge) at 6 to 12 oz/A. Apply at initiation of egg hatch, if necessary reapply after 14–21 days, but not before 14 days. PHI 7 days. REI 4 hr. No more than 12 fl oz/A/season.
- permethrin—
  - Ambush 2E at 16 to 24 oz/A. PHI 1 day. REI 12 hr. Extremely toxic to fish and aquatic habitat.
  - Pounce 3.2 EC at 8 to 16 oz/A. PHI 1 day. REI 12 hr. Extremely toxic to fish and aquatic habitat.
- pyriproxyfen (Esteem 35WP) at 4 to 5 oz /A. PHI 21 days. REI 12 hr. Do not exceed two applications per season.
- spinetoram (Delegate WG) at 1.5 to 1.75 oz/100 gal water (4.5 to 7 oz/A). PHI 14 days. Apply no less than one week apart, with a maximum 4 applications per season.

- spinosad (Entrust SC) at 4 to 10 oz/A. PHI 1 days. REI 4 hr. OMRI-listed for organic use.
- spinosad (Success Naturalyte) at 1 to 2 oz/100 gal water (4 to 8 oz/A.) PHI 1 day. Do not exceed 29 oz/A per season.
- zeta-cypermethrin (Mustang, Mustang Max, Mustang Maxx) at 0.02 to 0.025 lb ai/A. Maximum of 0.125 lb ai/A per seaon. PHI 21 days.

Walnut—Fall webworm

Hyphantria cunea

Pest description and crop damage Fall webworm is the most common tent-making caterpillar in North America and has a very wide host range that includes more than 100 deciduous trees and shrubs. Nut trees are among the preferred hosts. The adult moth has a wing expanse of 2 inches and is almost pure white with a few black spots. The larvae are variable in appearance, but in general are about 1 inch long and very hairy. Larvae have paired dark spots on each body segment. The larvae vary in color, being yellow or pale green with a black head, or a darker color with reddish-brown hairs and a red head.

Biology and life history The insect overwinters as a light-colored cocoon in protected areas like bark furrows or the sides of buildings. Adult moths emerge in late spring, and lay eggs on the undersides of leaves. The larvae skeletonize leaves and incorporate leaves and twigs into their tent. Mature larvae leave the plant and look for a protected place to overwinter. There is usually one generation per year, though in warm areas there may be more.

Management—cultural control

Cut out and destroy any developing tents.

Management—chemical control: HOME USE

- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- *Bacillus thuriniensis* var. *kurstaki*—Treat when larvae first appear. Use a spreader-sticker. Some formulations are OMRI-listed for organic use.

Management—chemical control: COMMERCIAL USE

- *Bacillus thuringiensis* var. *kurstaki*—See label for rates. Treat when larvae first appear. Use a spreader-sticker. Some formulations are OMRI-listed for organic use.

Walnut—Scale insects

Includes
Frosted scale (*Parthenolecanium pruinosum*)
European fruit lecanium scale (*Parthenolecanium corni*)

Pest description and crop damage The frosted scale is the most serious soft scale pest of walnuts. Mature scales are brownish, convex, and covered with frost-like wax. Fine waxy filaments may protrude from the base of the scale body. European fruit lecanium scale is similar to frosted scale but lacks the frosty wax coating. These insects suck plant juices, causing loss of vigor and potentially reducing nut yield and quality. They also produce copious amounts of honeydew, which can result in sooty mold buildup and decreased photosynthetic activity in trees. Low to moderate populations may be tolerated, but high populations can be damaging. In Oregon, insecticides are rarely used against scale but if needed would typically target the crawler stage, which tends to emerge in late-spring. Conditions permitting, a dormant or delayed-dormant treatment can also be used.

Biology and life history The frosted scale overwinters as a nymph on twigs and small branches. In spring it grows rapidly, becomes convex, forms a frostlike waxy cover, and secretes large amounts of honeydew. In late spring females lay many eggs, which fill the entire space beneath their cover, and die after egg production. The white waxy substance weathers away, leaving oval, dark brown covers that may be present for a year or more. Newly hatched nymphs or crawlers emerge from beneath the scale cover in late spring and settle mostly on the underside of leaves. Here they feed for the rest of the summer. In fall, the nymphs molt and move back to twigs.

Management—biological control

Parasitoid wasps typically keep populations under control and they attack all life stages. Avoid broad spectrum insecticides that may impact scale natural enemies and flare populations. Monitor parasitoid activity and time treatments to avoid interfering with them. Look for small emergence holes from nymphs and mature females and uncharacteristically dark nymphs that indicate that wasps are developing inside.

Management—cultural control

On small trees it may be possible to prune off some of the scale colonies. Control ants if they are abundant, as ants will protect scale from biological control in order to ‘farm’ scale for honeydew.

Management—chemical control: HOME USE

Control has not been necessary in the PNW for home orchards. This pest is held in check by natural factors. If control is needed, use:

Dormant-season spray

Apply only during dormant or delayed-dormant period. Use enough water to cover all the tree thoroughly including small limbs and shoots.

- dormant oil

Growing-season spray

- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.

- bifenthrin
- carbaryl
- horticultural oil—Some formulations are OMRI-listed for organic use.
- insecticidal soap—May require several applications to be effective. Some formulations are OMRI-listed for organic use.
- lambda-cyhalothrin (often as a mix with other ingredients)
- plant-derived essential oils (clove, garlic, peppermint, rosemary oil, etc.)—Some formulations are OMRI-listed and have shown efficacy against scale.
- permethrin
- pyrethrins (often as a mix with other ingredients)—Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin

Management—chemical control: COMMERCIAL USE

Control has rarely been necessary in the PNW. This pest is held in check by natural factors. If control is needed, use:

- azadirachtin (Azaguard Botanical, Neemix 4.5 and others)—See label for insecticide rates. REI 4 hr. Some OMRI approved formulations.
- buprofezin (Centaur) at 34.5 to 46 oz/A (1.5 to 2 lb ai/A). One application per season. Target crawler stage. PHI 60 days. REI 12 hr.
- clothianidin (Belay) at 0.05 to 0.1 lb ai/A. Maximum 0.2 lb ai/A. Retreatment 10 days. PHI 21 days.
- methidathion (Supracide 25W) at 11 to 12 lb/A. PHI 7 days. REI 2 to 14 days, depending on rate. Do not tank-mix with oils, which can injure trees. Do not graze. Liquid formulations are also available.
- methoxyfenozide (Intrepid 2F) at 0.12 to 0.25 lb ai/A. PHI 14 days. REI 4 hr. Apply at first sign of larval infestation. Do not exceed 24 fl oz/A per application or 64 fl oz/A (1 lb ai/A) per season. Do not apply within 25 ft of an aquatic habitat, 150 ft if applied by air.
- pyriproxyfen (Esteem 35WP and others) at 4 to 5 oz/A (0.872 to 0.109 lb ai/A). PHI 21 days. REI 12 hr. Do not exceed two applications per season. Do not apply more than 0.109 lb ai/A per season. Note ai available under additional labels.
- spirotetramat (Movento) at 6 to 9 fl oz. PHI 7 days.

Walnut—Walnut blister mite

Aceria erineus

Pest description and crop damage Very small eriophyid mite causes blister like swelling on upper leaf surface and yellowish or brown concave pocket on underside of leaf. These insects usually do not cause enough damage to warrant control.

Biology and life history This mite overwinters beneath bud scales. When the weather warms up, the mites feed beneath the leaves amongst the leaf hairs. Several generations occur during the summer, which attack new foliage as soon as it unfurls.

Management—biological control

Phytoseiid predator mites almost always keep mites under control if broad-spectrum insecticide applications are avoided. Heavy rain and cold weather also suppress mite numbers.

Management—cultural control

Broadleaf weeds like mallow, bindweed, white clover, and knotweed enhance mite numbers. Avoid excessive nitrogen applications, as this encourages mites.

Management—chemical control: HOME USE

Control has not been necessary in the PNW for home orchards. This pest is held in check by natural enemies. If control is needed, use:

- carbaryl
- horticultural oil—Some formulations are OMRI-listed for organic use.
- sulfur—Some formulations are OMRI-listed for organic use.

Walnut—Walnut husk fly

Rhagoletis completa

Pest description and crop damage The walnut husk fly is the most important pest of walnuts in the Pacific Northwest. This pest is native to the south-central United States but is now widespread throughout western North America. The walnut husk fly is about the size of a housefly. It has a yellow spot just below the areas where the wings are attached to the body, and the wings have three prominent dark bands, one of which extends around the wing to form a V-shape. The larvae/maggots are white and up to 0.19 inch long. Larvae feed in groups within the husk, which stains the nutshell, and lowers nut quality. Dark, soft blotches on maturing husks are symptoms of infestation. Blotches that are hard and dry are caused by walnut blight (a disease) and should not be confused with husk fly damage. In California, the ‘Franquette’ and ‘Mayette’ varieties and seedlings of ‘Manregian’ and ‘Carpathian’ are considered very susceptible to husk fly damage. The damage is largely cosmetic staining on the nutshell and is primarily a concern for in-shell walnuts, but a large infestation can affect kernels. Because eggs and maggots are protected in the walnut husk, and the insect spends considerable time under the soil, the adult stage is typically the target for management.

Biology and life history Walnut husk flies overwinter as pupae in the soil and adults emerge in early- to mid- summer. Female flies deposit eggs in groups of about 15 below the surface of the husk. The egg deposits show up as small black areas on the husk. Eggs hatch into white maggots within 5

days. The maggots feed inside the husk, enlarging the black area, which remains soft, unsunken, and smooth. The outer skin of the husk usually remains intact, but the fleshy parts decay and stain the nutshell. After feeding on the husk for 3 to 5 weeks, mature maggots drop to the ground and burrow several inches into the soil to pupate. Most emerge as adults the following summer, but some remain in the soil for 2 or more years.

Pest monitoring Traps are very effective and useful for timing management activity. Sticky, green, spherical traps look similar to developing nuts and attract the flies. Yellow sticky cards baited with ammonium carbonate "chargers" are also effective for trapping. Some sticky traps may come with the ammonium carbonate incorporated in the sticky material. These are the same traps useful for other *Rhagoletis* pest species including cherry fruit fly and apple maggot. Place traps high in the upper half of the canopy if possible by late May/early June. Make first treatment within 10 days after catches in fly traps show a sharp or steady increase over a 3-day period, probably early or mid-August. A phenology model is available from uspest.org to predict emergence of adults, oviposition (egg laying), and egg hatch, based on degree-day accumulation.

Management—biological control

Native parasites and predators do not effectively control this pest. There has been work on soil-applied entomopathogenic nematodes to target the prepupal/pupal stage but no recommendations have been developed.

Management—cultural control

Sanitation is important. Remove nuts from the orchard floor to help prevent the larvae from successfully pupating in the soil. Flail, mow or rake nuts that drop early and after harvest. Remove abandoned black walnut or English walnut trees. Ground barriers may help home orchardists, plastic tarps or heavy mulch layers in place during nut drop can prevent or inhibit larvae from entering the soil to pupate. Some pupae can remain in soil for more than one season so persistent sanitation is key to long term management.

Management—chemical control: HOME USE

Home orchardists may choose not to control the walnut husk fly and tolerate staining of shells. Loosen affected husks by packing nuts with a moist material for several days before hulling. Timely application of sprays is important in order to prevent adult flies from laying eggs (see sampling recommendations, above). Baits mixed with insecticides can reduce the need for good spray coverage for homeowners that don't have capacity to spray the canopy.

- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- esfenvalerate
- lambda-cyhalothrin (often as a mix with other ingredients)
- permethrin
- spinosad—Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin

Management—chemical control: COMMERCIAL USE

Timely application of sprays is important (see sampling recommendations, above). Efficacy of insecticides targeting adult flies can be enhanced by tank mixing commercial fruit fly baits, or use GF-120, a bait/insecticide formulation. Incorporating baits can also reduce the need for thorough spray coverage as flies will be attracted to droplets for feeding.

- acetamiprid (Assail 30SG) at 0.12 to 0.15 lb ai/A. Add a recommended rate of husk fly bait. No more than 4 applications and a maximum of 0.72 lb ai/A per growing season. Retreatment interval 14 days. PHI 14 days.
- alpha-cypermethrin (Fastac EC) at 0.02 to 0.025 lb ai/A. Retreatment interval 7 days. Maximum 0.075 lb ai/A. PHI 7 days.
- beta-cyfluthrin (Baythriod XL) at 0.0.19 to 0.022 lb ai/A. Maximum of 0.22 lb ai/A per season. PHI 14 days.
- bifenthrin (Brigade WSB) at 0.1 to 0.2 lb ai/A. PHI 7 days. REI 12 hr.
- bifentrin+abamectin B1 (Athena) at 13.5 to 20 fl oz/A. Retreatment interval 21 days. Maximum of 2 applications per season. PHI 21 days.
- chlorantraniliprole+lambda-cyhalothrin (Voliam Xpress) at 6 to 12.5 fl oz/A (suppression only). PHI 14 days. REI 24 hr. Minimum of 7 days between applications. Do not exceed a total of 31.0 fl oz of Voliam Xpress or 0.24 lb ai of lambda-cyhalothrin containing products or 0.2 lb ai of chlorantraniliprole containing foliar products per acre per growing season.
- clothianidin (Belay) at 0.05 to 0.1 lb ai/A. Maximum 0.2 lb ai/A per season. Retreatment 10 days. PHI 21 days.
- cyfluthrin (Tombstone) at 0.038 to 0.044 lb ai/A. Maximum 0.044 lb ai/A per season. PHI 14 days.
- deltamethrin (Delta Gold) at 0.02 lb ai/A. Maximum 0.165 lb ai/A. Retreatment interval 7 days. PHI 21 days.
- esfenvalerate (Asana XL) at 10 to 16 fl oz/A. PHI 21 days. REI 12 hr. Do not exceed 0.2 lb ai/A per season. Do not feed or graze livestock on treated orchard floors. Extremely toxic to fish and aquatic habitat.
- lambda-cyhalothrin (Warrior II) at 1.28 to 2.56 fl oz/A or 0.02 to 0.04 lb ai/A. PHI 14 days. REI 24 hr. Do not exceed 0.16 lb ai/A per season or 0.12 lb ai post bloom.
- malathion (Malathion 57% EC and others) at 0.4 to 0.6 oz/A or 2.5 lb ai/A. PHI 7 days. REI 24 hr.
- permethrin—
  - Ambush 25W at 16 to 24 oz/A. PHI 1 day. REI 12 hr. Do not graze livestock in treated orchards. Extremely toxic to fish and aquatic habitat.
  - Ambush 2E at 16 to 24 oz/A. PHI 1 day. REI 12 hr. Do not graze livestock in treated orchards. Extremely toxic to fish and aquatic habitat.
  - Pounce 3.2 EC at 8 to 16 oz/A. PHI 1 day. REI 12 hr. Do not graze livestock in treated orchards. Extremely toxic to fish and aquatic habitat.
- spinetoram (Delegate WG) at 1.5 to 1.75 oz/100 gal water (4.5 to 7 oz/A). PHI 14 days. Apply no less than one week apart, with a maximum 4 applications per season.
- spinosad (Success Naturalyte) at 1 to 2 oz/100 gal water (4 to 8 oz/A.) PHI 1 day. Do not exceed 29 oz/A per season.
- spinosad (Entrust SC) at 4 to 10 oz/A. PHI 1 days. REI 4 hr. OMRI-listed for organic use.

- spinosad bait (GF-120 NF) at 20 fl oz/A. PHI 0 days. REI 4 hr. Apply every 7 days. Can be applied from the air or with an all-terrain vehicle (ATV). Apply 0.8 to 1 gal/A with a D3 nozzle attached to an ATV. Apply at 10 to 12 mph, using the listed rate and nozzle size.
- zeta-cypermethrin (Mustang, Mustang Max, Mustang Maxx) at 0.02 to 0.025 lb ai/A. Maximum of 0.125 lb ai/A per season. PHI 21 days.

Note: For more information on the husk fly and trapping methods, see OSU Extension publication EM 8907, Growing Walnuts in Oregon (https://catalog.extension.oregonstate.edu/em8907), and WSU Extension publication FS039E, The Walnut Husk Fly (https://pubs.extension.wsu.edu/). Also see EM 8421, Pest Management Guide for Walnuts: Willamette Valley.