Pest Management Strategic Plan for Wine Grapes in Oregon

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Summary of Critical Needs

(Pest-specific and crop-stage-specific aspects of these needs, as well as additional needs, are listed and discussed throughout the body of the document.)

Research:

• Extensive research on red blotch virus, including the biology, ecology, latency, spread patterns, and management, as well as identification of virus vectors and effective vector-control strategies once identified.
• Develop an overall mite management plan for rust mites to include information on pest life cycle, identification, scouting, most effective control strategies, and best timing for control.
• Research effective organic-approved products for insect and disease control.
• Investigate the cause of sugar accumulation disorder (a.k.a. “sour shrivel” or “water berry”).
• Research various types of living mulches for the vine-row, including attraction to beneficials, water consumption, potential pest attraction, and efficacy for weed control.

Regulatory:

• Develop a more standardized testing and certification program for common pests of wine grapes, with strong, harmonized testing, certification, and quarantine standards to include the entire Pacific Northwest – including California, from which many plants come into Oregon – to encourage better quality screening at the source, and more confidence in clean plant material across states.
• Develop and enforce a regional quarantine for phylloxera through the Oregon Department of Agriculture, such as a “control area ordinance”, for the Walla Walla Valley and Southern Oregon regions, so that plants shipped or delivered to these regions would be required to be certified free of phylloxera.
• Develop clearly worded pesticide labels that allow for concentration-based application rates rather than acreage-based application rates.
• Create regional management zones for phenoxy herbicide use, to include all crops in a region, to reduce negative impacts to wine grapes.
Education:

- Educate growers, field workers, and consultants regarding the impacts of pesticides on beneficials and predators.
- Conduct widespread education regarding best management of phenoxy herbicide applications of surrounding crops to minimize damage to nearby wine grapes.
- Educate growers, field workers, and consultants on effective pesticide resistance management.
- Educate growers, field workers, and consultants on proper identification of various mite pests found in wine grape production, as well as life cycle information.
- Inform growers about certification and quarantine standards, what they mean, and how to best ensure the purchase of clean plants and stock.
- Educate growers, field workers, and consultants on best pruning practices to minimize infection and spread of trunk and stem diseases.
Process for this Pest Management Strategic Plan

In a proactive effort to identify pest management priorities and lay a foundation for future strategies, wine grape growers, commodity group representatives, pest control advisors, regulators, university specialists, and other technical experts from Oregon formed a work group and assembled this document. Members of the group met for a day in February 2016, in Portland, Oregon, where they documented critical needs, general conclusions, activity timetables, and efficacy ratings of various management tools for specific pests in wine grape production. The work group, along with additional people and work group members who were not present at the meeting, reviewed the resulting document. The final result, this PMSP, is a comprehensive strategic plan that addresses many pest-specific critical needs for the wine grape industry in Oregon.

The document begins with an overview of wine grape production, followed by discussion of critical production aspects of this crop, including the basics of Integrated Pest Management (IPM) in wine grapes. The remainder of the document is an analysis of vineyard pest pressures, organized by pest. Key control measures and their alternatives (current and potential) are discussed.

Descriptions of the biology and life cycle of each pest are described in detail at the beginning of each pest section. Also included are biological controls, cultural controls (including resistant varieties), and/or chemical controls (including pre-plant treatments). Within each major pest grouping (insects, diseases and weeds), individual pests are presented in alphabetical order, not in order of importance.

Trade names for certain pesticide products are used throughout this document as an aid for the reader in identifying these products. The use of trade names in this document does not imply endorsement by the work group or any of the organizations represented.
Wine Grape Production in Oregon

Production Statistics

On a national scale, Oregon is the third-largest wine-grape-producing state, yet remains focused on producing small-batch artisan wines. In fact, most Oregon wineries are relatively small, producing fewer than 5,000 cases a year. Oregon has 14 federally approved winegrowing regions (American Viticultural Areas, or “AVAs”), approximately 676 wineries, and 1,027 vineyard operations producing 72 varieties of grapes. In 2014, Oregon growers produced more than 78,000 tons of wine grapes on over 27,000 planted acres, with a total production value exceeding $168 million and total wine sales of $430 million.

![Photo credit: EESC Media, Oregon State University](image)

The top varieties grown in Oregon include Pinot Noir, Pinot Gris, Chardonnay, Riesling, Cabernet Sauvignon, Syrah, Merlot, Viognier, Gewürztraminer, Tempranillo, Pinot Blanc, and Cabernet Franc. Pinot Noir leads all varieties, accounting for 63% of harvested acreage and 58% of grapes processed to wine.
For the purposes of this PMSP, four distinct wine-growing regions in the state have been identified: the Willamette Valley, Southern Oregon, Mid-Columbia, and the Walla Walla Valley region of Eastern Oregon.

In 2014, the Willamette Valley region had approximately 694 vineyards on 19,295 acres, producing over 58,000 tons of grapes. Top varieties grown in this region are Pinot Noir, Pinot Gris, and Chardonnay.

Southern Oregon followed the Willamette Valley region in size, with 210 vineyards on 5,886 acres, producing 13,769 tons of grapes. Top varieties grown in this region based on acreage are Pinot Noir and Pinot Gris, but many of the local wineries are known for their warm-climate grape varieties, including Cabernet Sauvignon and Syrah.
The Mid-Columbia and Walla Walla Valley regions combined\(^1\) had 107 vineyards on 1,883 acres, producing 6,480 tons of grapes. Top varieties grown across these regions include Pinot Noir, Pinot Gris, Cabernet Sauvignon, and Syrah. These regions do overlap into Washington, thus their viticultural significance is greater than their Oregon numbers might suggest.

*General Production Overview*

Grafting of Vitis vinifera varieties to rootstocks of North American Vitis species, which is common practice in most production regions in Oregon despite a number of own-rooted plantings around the state, began as result of the Phylloxera epidemic in Europe in the 1880s. North American rootstocks are resistant to Phylloxera while Vitis vinifera (European grapevines) cultivars are not. Since then, growers planting vineyards with own-rooted Vitis vinifera faced the risk of infestation from this pest. In some climates in Oregon, such as Eastern Oregon’s Walla Walla Valley, grafting is a risky option. In this region, severe winter temperatures below the hardiness level of *Vitis vinifera* can cause damage to the phloem and buds on a regular basis, and as a result growers need the ability to retrain the vines directly from the roots, which isn’t possible with grafted rootstock.

Pruning methods vary regionally within Oregon. In the warmer summer climates of Southern Oregon and Eastern Oregon, vineyards are typically cordon-trained and spur pruned, although Southern Oregon also has significant cane-pruned acreage. In the cooler Willamette Valley, vines are more often head trained and cane pruned. Growers in the Mid-Columbia practice both spur and cane pruning, depending on the variety they are growing.

The majority of Willamette Valley vineyards are non-irrigated. In Southern and Eastern Oregon, most vineyards are irrigated due to hot, dry summers. The western side of the Mid-Columbia region tends not to use irrigation after establishment, but the dryer eastern side is generally irrigated using drip irrigation. Drip irrigation is also commonly used in Southern Oregon. Overhead irrigation and/or wind machines are used for frost control in some areas of the state, including Eastern Oregon and certain valleys of Southern Oregon (Rogue, Illinois and Applegate valleys). Overhead sprinklers are sometimes used for

\(^1\) The statistics for these two regions were presented in combination in the 2014 Oregon Vineyard and Winery Census report by Southern Oregon University Research Center (see references for citation).
cooling the canopy microclimate in the Walla Walla Valley, or for irrigating cover crops in the grass strip between the vine rows. Many grape acres in Southern Oregon are served by irrigation districts, which are generally not running water from October until April or May. Farming with water supplied by irrigation districts is a big factor in how growers are able to manage their vineyards.

Most vineyards have perennial cover between vine-rows or in every other row, alternating with tilled alleyways or an annual cover crop. The perennial cover is typically grass, legume, or a mix of legumes and grasses. Growers with these cover crops manage the space by mowing, leaving every other row unmowed to encourage the development of beneficial organisms, or to discourage the movement of certain pests into the canopy (leafhoppers, thrips, etc.). The use of flowering plants between rows can also encourage beneficial insects during the growing season.

As consumers look further into food production systems, many producers have been moving to organic-approved controls to manage pests. Organic management systems have proven to be successful in all regions of Oregon. However, they also introduce a higher risk of crop failure or reduced quality, particularly for growers in regions or locations with high disease pressure.

The majority of wine grapes grown in Oregon are used locally to produce Oregon wines.
Integrated Pest Management Strategies in Wine Grape Production

Integrated pest management is a decision-making approach to pest management that involves knowledge of the crop, the pest, the ecosystem, and the relationships among these components. The majority of wine grape growers in Oregon use IPM practices to control diseases, nematodes, insects, vertebrate pests, and weeds. The ultimate goal of IPM in Oregon vineyards is to ensure the production of a high-quality crop in an environmentally and economically sound manner. Oregon wine grape growers value the use of IPM practices, and try to avoid calendar-based pesticide sprays. Instead, many rely on field scouting, proper pest identification, prevention, cultural and biological practices, and the judicious use of pesticides that are the least toxic to the environment and beneficial organisms. Most growers are cognizant of, and appreciate, the important role that beneficial arthropods play in their vineyards for control of insect and mite pests, which results in their conscience decision to use pesticides only if absolutely necessary to protect the crop.

IPM practices for disease pest control in Oregon wine grape production include use of resistant or tolerant cultivars, scouting to identify a problem in its early stages of development, sanitation, plant spacing, proper pruning, and weed control. For example, opening up the plant canopy with proper pruning and removing weeds at the base of the plants allows for good air circulation and reduces the moisture that most disease organisms need to survive and multiply.

For insect pest control, widely used IPM practices in wine grape production include scouting, sanitation, judicious use of pest-specific pesticides, and preservation of habitat for beneficial arthropods. Field scouting and accurate pest identification allow for early detection of the insect pest, when control methods are usually more effective. Beneficial insects can help manage the pest populations, especially when the pest population is still low. If a pesticide treatment is deemed necessary, growers make an effort to use the pesticide at the optimum time for control (i.e., the stage that the pest is most vulnerable) and to choose a pesticide that is pest-specific rather than broad-spectrum to help protect beneficial arthropods that may be present.

IPM practices for weed control include scouting, cultivation, proper weed identification, and surface mulch or a weed fabric. Early detection of weed problems helps growers manage weeds more efficiently. If herbicides are
needed, they are used on a limited basis, and often used as a “spot-spray” only in the problem areas within the vineyard.

When applying pesticides, many winegrape growers and commercial applicators regularly calibrate application equipment to ensure proper and accurate delivery in order to avoid injury to the applicator, the environment, and vines. Educational workshops on sprayer maintenance and calibration for growers and field workers are common events in Oregon’s wine production regions.
Certification Programs used by Oregon Wine Grape Growers

There are a variety of certification programs used by Oregon wine grape growers, including Oregon’s LIVE (Low Input Viticulture and Enology) certification program, Salmon Safe, Demeter, Food Alliance, and organic certification. In general, certification programs are designed to promote wine grape production with the least amount of negative impact on the environment, soil, vineyard workers, beneficial arthropods, and quality of the vines, grapes, and the wine itself. In addition to promoting good management practices in the vineyard, the benefits of belonging to a certification program are often price and market; certification often results in a higher farm-gate price for the grapes and can open up markets for the grape crop itself, and for the wine that is sold to consumers.

Of the 1,027 vineyard operations in Oregon, more than 300 are LIVE certified, and over 60 are certified organic. Other certifiers at work in Oregon include Salmon Safe (all LIVE vineyards also meet Salmon Safe standards), Demeter (all Demeter certified vineyards are also certified organic), and Food Alliance.

Meeting the requirements of a certification program can sometimes present additional pest-management challenges for growers. Each program allows or does not allow certain practices or pesticides, which can leave the grower with fewer pest-management options than those not seeking certification. Nevertheless, these programs are voluntary and, once part of a program, the grower abides by their rules, regulations, and guidelines.
Wine Grape Crop Stages and Corresponding Pests

**Dormant:** rust mites, crown gall, trunk diseases, nematodes

**Delayed Dormant:** cutworms, rust mites, thrips

**Shoot growth:** leafhoppers, mealybugs, erineum and rust mites, thrips, crown gall, powdery mildew, trunk diseases

**Pre-bloom:** leafhoppers, mealybugs, erineum mites, rust mites, thrips, crown gall, powdery mildew, trunk diseases, nematodes

**Bloom:** leafhoppers, mealybugs, rust mites, thrips, Botrytis bunch rot, powdery mildew, leafroll and red blotch viruses

**Fruit set:** leafhoppers, mealybugs, rust mites, spider mites, thrips, Botrytis bunch rot, powdery mildew, leafroll and red blotch viruses

**Fruit growth:** leafhoppers, mealybugs, spider mites, thrips, powdery mildew

**Bunch close:** leafhoppers, mealybugs, spider mites, thrips, Botrytis bunch rot, red blotch virus

**Véraison (change of fruit color):** leafhoppers, mealybugs, spider mites, Botrytis bunch rot, leafroll and red blotch and viruses, birds

**Pre-harvest:** leafhoppers, mealybugs, Botrytis bunch rot, leafroll and red blotch viruses, weeds, birds

**Throughout the Season:** deer, gophers, voles

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<th>Growth Stage</th>
<th>Dormant</th>
<th>Delayed Dormant</th>
<th>1-5” shoots</th>
<th>6” shoots</th>
<th>Pre-bloom</th>
<th>Bloom</th>
<th>Fruit Set</th>
<th>Fruit Growth</th>
<th>Bunch Close</th>
<th>Véraison</th>
<th>Pre-harvest</th>
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Wine Grape Pests and Management Options

I. Major Pests

Insects, Mites and Nematodes
(Pests are listed in alphabetical order)

Cutworms
Climbing (Abagrotis orbis and Agrotis vetusta)
Winter cutworm (Noctua pronuba)
Redbacked cutworm (Euxoa ochragaster)
Spotted cutworm (Xestia c-nigrum)

Adult cutworms are dark gray moths, about one inch long, with a wingspan of about 1.5 inches. The larvae of these moths (caterpillars) grow to about 1.5 inches, and are generally a dull gray-brown. Larvae begin feeding on winter annual weeds during warm periods in February to March. By budbreak, they are nearly full grown. They remain under cover during the day (in cracks in the soil, plant debris, or under rough bark on the trunk), and climb vines at night to feed on buds and shoots. Not all cutworm species in vineyards will climb grapevines; if broadleaf weeds are present, many will stay on the vineyard floor. Mature larvae return to the soil and pupate, and moths emerge from the soil in May and June. There are one or more generations per year, but only the overwintering larvae population causes damage to grapevines.

Cutworm larvae injure grapevines primarily in early spring, at or shortly after budbreak, when they feed on buds and young shoots. When primary buds or shoots are destroyed, secondary buds may emerge, but fruitfulness of secondary shoots varies according to variety and often leads to reduced yields.

Cutworm infestations are usually localized within a vineyard, and often occur in the same places each year. Treatment of an entire vineyard is rarely necessary as damage is often localized and limited in size.

Sampling for cutworms is difficult, as they are nocturnal and difficult to locate; control decisions are usually based on the level of bud injury. Light traps can be used in winter to monitor for adults.
Climbing cutworms can be a problem in localized areas in the Walla Walla Valley but are not a widespread problem. For Willamette Valley growers, cutworms are a minor/sporadic pest, but when present can be a year-round problem. They are an occasional problem in Southern Oregon. In terraced blocks of grapevines, or other blocks with vines that can’t be worked underneath the vine-row, this pest can be more of a problem for growers, and can sometimes be a problem even in blocks where cultivation is possible. Cutworms have been an occasional problem in the Mid-Columbia region also. The greatest economic impact from cutworm damage often occurs in young vineyards and with newly grafted plants.

**Cultural control:**
- Proper timing of cultivation (early spring) under vines, to kill young larvae and reduce the risk of damage.
- Proper timing, method and choice of cover-crop planting.
- Retention of broadleaved weeds in spring to limit cutworm damage to vine buds and shoots.
- Disking between vine rows.
- “Stick-um,” Tanglefoot, or other sticky substances are applied to vine trunks to catch cutworms as they climb.
- Hand removal is sometimes used, but not practical on a large scale.

**Biological control:**
- Natural enemies of cutworms include predatory and parasitic insects, nematodes, pathogens, mammals, birds, and reptiles. Parasitic wasps are probably the most important group, but predatory beetles and parasitic flies are also important in biological control. Judicious use of pesticides helps conserve natural enemies.
- Birds can provide some level of control, as they readily seek out and feed on cutworm larvae.
- Parasitic nematodes are sometimes used and applied to the ground with spray equipment.

**Chemical control:**
Barrier sprays to grapevine trunks and posts, rather than spraying the plant canopy, are the preferred control strategy for cutworms. Barrier sprays are applied to the trunks, wire, posts, and the ground immediately beneath the vines, avoiding foliage as much as possible.
Barrier Sprays (commonly used)

- Bifenthrin (Brigade 2 EC and other brands): Applied to trunks and posts. Widely used, effective. Restricted-use pesticide. Frequent use of synthetic pyrethroid products like bifenthrin can lead to spider mite outbreaks.
- Carbaryl (Sevin 4F and other brands): Efficacious.
- Fenpropathrin (Danitol 2.4 EC): Applied to trunks and posts. Widely used, effective. Not recommended for use more than two times per season to avoid resistance. Restricted-use pesticide. Frequent use of synthetic pyrethroid products can lead to spider mite outbreaks.

Foliar Sprays (not widely used)

- Bacillus thuringiensis (Bt): OMRI-listed for organic use.
- Chlorantraniliprole (Altacor): used, good efficacy.
- Phosmet (Imidan 70W): An organophosphate insecticide; use is very limited.
- Spinetoram (Delegate WG): Spinosad more commonly used.
- Spinosad (Success or Entrust): Entrust is OMRI-listed for organic use. Somewhat efficacious and used by some growers.

Bifenthrin, carbaryl, fenpropathrin, and phosmet are broad-spectrum insecticides, and their use on foliage can adversely affect beneficial insect and mite populations, resulting in secondary outbreaks of spider mites and other pests. These products are used judiciously.

Critical needs for cutworm management in wine grapes

Research:
- Continued research on the potential for predatory wasps to help with control.
- Research the effects of timing and types of cover crops to reduce cutworm infestation.
- Research the potential for mating disruption of the adult moths.

Regulatory:
- Expand barrier spray options for various certification program criteria.

Education:
- Educate growers on general best practices for control of climbing cutworms, including proper scouting techniques and proper control timing, especially considering winter activity of the Winter Cutworm.
• Educate growers on the effects of timing and types of cover crops, once researched.

**Leafhopper**
Western grape leafhopper (*Erythroneura elegantula*)

Adult leafhoppers are about 0.12 inches long and are pale yellow with reddish and dark-brown markings. The eggs are bean-shaped and laid mostly on the undersides of leaves. Newly hatched nymphs are white.

Grape leafhoppers overwinter as non-breeding adults in plant debris and leaf litter. Adults emerge from overwintering sites in March, and feed on annual weeds on the vineyard floor. They move on to grape foliage after budbreak, and females begin laying eggs near late April. The first generation of nymphs feeds primarily on basal grapevine leaves from May to June, and produces a new generation of adults in July. The second generation of nymphs appears later in the month (feeding on outer canopy leaves) and produces the second adult generation in the latter half of August and September. (In very warm regions and years, a partial third generation may be produced). These adults form the overwintering population.

Leafhopper adults and nymphs pierce leaf cells and suck out the contents. Each feeding puncture leaves a white spot. Heavily damaged leaves turn yellow and brown, and in severe cases, fall off the vine.

The relationship between leafhopper populations and economic damage to wine grapes is not well understood in the Pacific Northwest, but it is clear that vines can tolerate quite large populations before suffering economic loss. This is particularly true for spring populations of overwintered adults and first generation nymphs, which confine their feeding activity to the basal six to eight leaves.

Although leafhoppers rarely compromise the canopy, they are a nuisance pest to workers and have not been ruled out as potential disease vectors. Thus, effective control is important. Leafhoppers are a problem pest in all of the Oregon wine grape regions.
Cultural control:
• Maximum productivity can be obtained from moderately vigorous vines with less canopy density, which are only moderately attractive to leafhoppers.
• Disking or tilling soil to remove weeds and vineyard debris in late winter to early spring.
• Early-season mowing of vegetative cover in the alleyway (grass, weeds, or cover crop).
• Green cover cropping with a variety of plants (reduces vine vigor which suppresses leafhopper populations).
• Alternate row mowing, to keep between-row vegetation green so that leafhoppers don’t migrate to grapevines in search of food.
• Leaving suckers on the vine until after the leafhoppers lay their eggs, so that late removal of suckers also removes the next generation of leafhoppers.
• Planting species attractive to *Anagrus* spp. in and around vineyard blocks.
• Removing suckers, basal leaves and/or lateral shoots during berry set and the two-week period following berry set (before adult leafhoppers emerge). In warmer growing areas, removing too many leaves can lead to sunburned fruit, so this practice is not as common.

Biological control:
• Several generalist insect and mite predators prey on leafhopper adults and nymphs. Among the most abundant are lacewings, predatory bugs, predatory beetles, and spiders.
• Microscopic parasitic wasps in the family Mymaridae are important natural enemies of grape leafhoppers. Recent research indicates three or four species belonging to the genus *Anagrus* that are potentially important in suppressing grape leafhopper populations. *Anagrus* spp. parasitizes leafhopper eggs and can cause up to 100% mortality in August to September. Anagrus is detected easily, since parasitized eggs of the leafhopper turn brick-red before the adult wasps emerge. Buprofezin (Applaud) is the only insecticide compatible with *Anagrus* spp.

Chemical control:
Note: Synthetic pyrethroids are not widely used to control this pest, as they disrupt natural enemies; neonicotinoids are preferred.
• Acetamiprid (Assail 30SG): Efficacious and used.
• Bifenthrin (Brigade and other brands): Restricted-use pesticide. Frequent use of synthetic pyrethroid products like bifenthrin can lead to spider mite outbreaks.
• Buprofezin (Applaud): Commonly used and effective, but timing is critical for successful pest management.
• Dinotefuran (Scorpion, Venom): Widely used, effective.
• Fenpropathrin (Danitol 2.4EC): Restricted-use pesticide. Frequent use of synthetic pyrethroid products like fenpropathrin can lead to spider mite outbreaks.
• Imidacloprid (Admire Pro, Provado, and other brands): Widely used, effective.
• Insecticidal soap (M-Pede and other brands): Low efficacy. Some formulations are OMRI-listed for organic use.
• Kaolin clay (Surround WP): Provides suppression only; supplemental controls are often needed for complete control. OMRI-listed for organic use.
• JMS Stylet Oil: Low efficacy. Some formulations are OMRI-listed for organic use.
• Sulfur: Efficacious.
• Thiamethoxam (Platinum): Widely used, effective.

Critical needs for leafhopper management in wine grapes

Research:
• Identify alternatives to neonicotinoid chemistries for leafhopper control that are more selective in their control with minimal persistence in the grape plant.
• Determine whether leafhoppers are a vector of grapevine viruses, which will then help determine management thresholds and control practices.
• Develop economic thresholds for leafhoppers specific to each growing region. If leafhoppers are found to be a virus vector, base thresholds on this information as well.
• Develop thresholds for leafhoppers specific to different generations of the insect, to help growers better understand which control options will be most effective.
• Research and develop more effective tools for controlling leafhopper, especially for those with LIVE or organic-certification restrictions.
• Develop alternative classes of chemical control products as well as “softer” products for leafhopper control to manage resistance.
• Research the efficacy of vacuum systems for leafhopper control.
Regulatory:
- Expedite the registration of new, effective chemical control options for leafhopper management that can also meet various certification program criteria.

Education:
- Educate growers on the potential for developing and sustaining parasitoid habitat to control leafhoppers.
- Educate growers on best host plants for attracting parasitic wasps.

Mealybug
Grape Mealybug (*Pseudococcus maritimus*)

The grape mealybug has a soft, oval, flattened, segmented body. The adult female is 0.25 to 0.5 inches long, pink to dark purple, with a white, mealy, wax secretion surrounding the body. Eggs are yellow to orange and laid in cottony egg sacs. Crawlers that hatch from them are tiny (0.06 to 0.12 inches long), and yellow to brown in color. Males and females look similar in early stages. The crawler stage of this pest is the most mobile and damaging.

Grape mealybugs overwinter as eggs or first instars under the loose bark of vines, which are the preferred feeding sites, making them inconspicuous to growers. Research has shown that in the Willamette Valley, as well as the Illinois and Umpqua valleys of Southern Oregon, there is generally a single generation, while in the Walla Walla Valley, and the Rogue Valley of Southern Oregon, there are populations that have two generations per year. As populations build, migrating populations may move to clusters during July and August, causing direct crop damage. Clusters in contact with the trunk or cordon are most susceptible to infestation. Some females maturing in mid- to late-August lay their eggs on fruit and leaves, while most return to old wood to overwinter and lay eggs there that will survive to the next season.

Grape mealybug contaminates fruit with cottony egg clusters, eggs, immature stages, adults, and honeydew produced by the adults. A black fungus (sooty mold) may grow on the honeydew and may make fruit unmarketable, even for winemaking. Of most concern in all regions is that grape mealybugs are primary vectors of the grapevine leafroll associated virus (GLRaV), and can spread the virus within and across vineyards, resulting in reduced crop yields and fruit quality over time. For this reason, it is important that growers are aware of
mealybug presence in their vineyards. Commercial pheromone traps are available to aid in effective monitoring for mealybugs.

For Oregon growers, mealybugs aren’t usually a significant pest alone, but as a vector for GLRaV, they do require management if the virus is present.

Currently available chemicals are effective for mealybug control, but resistance is a concern due to the current lack of diversity of chemistries.

**Cultural control:**
- To prevent movement and spread of mealybugs and virus within and between vineyards, growers restrict movement of fruit and manage grape waste properly.
- Use of certified planting material to avoid viruses.

**Biological control:**
- Parasitic wasps, predatory bugs, predatory beetles, lacewings, and spiders can take a considerable toll on mealybugs in vineyards that use few broad-spectrum pesticides. A lady beetle (*Cryptolaemus montouzieri*), the "mealybug destroyer," is considered an effective predator of mealybugs and is used by organic growers. However, ant populations can protect mealybugs and interfere with biological control agents.

**Chemical control:** (Growers are mainly using systemic products for mealybug control; although contact products can be more effective when mealybug isn’t a virus vector.)
- Azadirachtin (neem oil, Azasol, Neemix and other brands): Some formulations are OMRI-listed for organic use. Low efficacy in PNW vineyards.
- Buprofezin (Applaud): Not widely used due to low efficacy.
- Dinotefuran (Scorpion, Venom): effective, systemic, soil applied.
- Horticultural oil (several brands): Applied in late March or early April but not after budbreak. Not very effective.
- Imidacloprid (Admire Pro, Provado, and other brands): Moderate efficacy.
- Lime sulfur: widely used, especially for organic growers.
- Malathion (several brands): Does not provide effective control.
- Phosmet (Imidan 70W): Applied as a delayed dormant (pre-budbreak) spray. Does not provide good control.
- Spirotetramat (Movento): Widely used, very effective; systemic.
- Thiamethoxam (Platinum): soil applied, systemic, moderately effective.
Critical needs for grape mealybug management in wine grapes

Research:
• Given the current regulatory issues with neonicotinoid chemistries, mealybug control options might become more limited; alternatives to neonicotinoids for mealybug control need to be identified.
• Research and develop more tools for controlling mealybug, especially for those with LIVE or organic-certification restrictions.
• Research and develop alternative classes of chemical control products for mealybug to manage resistance.
• Examine the effect of ants on natural enemies of mealybugs, and develop methods of deterring ant populations to encourage biological control.

Regulatory:
• Expand approved chemical control options for various certification programs for management of mealybug.
• Encourage monitoring for Gill’s mealybug (found in a few vineyards in Southern Oregon), and vine mealybug (a potentially more serious pest species that is present in N. California), both discussed in “Emerging Pests” section of this document. Pheromone traps are available to monitor vine mealybug and could be used (possibly by ODA) as a means of early detection and prevention. Vine mealybug, and presumably Gill’s mealybug, can both serve as vectors for grape leafroll viruses.

Education:
• Update extension publications about, and develop new avenues to deliver information for, mealybug control.
• Educate growers on preventing the spread of leafroll viruses and the importance of managing mealybugs as vectors.
• Provide trainings in Spanish for workers who may be scouting for this pest.
• Educate growers on the importance of using “clean” planting material (and asking nurseries about their use of hot water treatments) to prevent the spread of viruses.

Mite, Erineum
Grape erineum mite (*Colomerus vitis*) (a.k.a. “blister mite”)
The grape erineum mite is microscopic, wormlike, and white-yellow in color. It overwinters between outer bud scales and bud tissue, and feeds on leaves during spring and summer. The upper leaf surface becomes blistered, and the lower leaf surface of the blister appears hairy and white, which is sometimes mistaken for fungal disease growth. The lower leaf surface turns from a white color early in the season to yellow or brown later in the season. When in very high populations, these mites have been found to form erinea on the upper surface of leaves and on flower clusters in early spring.

Colonies of erineum mites live in blisters (erinea) formed by their feeding on lower leaf surfaces. The blisters are comprised of masses of enlarged leaf hairs. These blisters protect mites from natural enemies as well as direct contact of pesticide sprays. As the population increases, some move to newly expanded leaves or lateral shoots, where they form new erinea. From mid-August until leaf drop, there is a movement from the erinea back to overwintering sites beneath the bud scales.

Erineum mites are a problem pest for Walla Walla Valley growers, and a minor problem in the Mid-Columbia region. In the Southern Oregon and Willamette Valley regions, erineum mites are more problematic than spider mites. In general, these mites are effectively controlled by using sulfur in a fungicide program, but they do have the potential to cause economic loss.

Chemical controls for erineum mites are usually ineffective due to mite protection within galls, but dormant-season oils and insecticides used for other pests can also help control this pest. Also, sulfur applications for powdery mildew usually keep mite populations under control. Chemical applications can prevent spread to emerging leaves.

**Cultural control:**
- Planting flowering plants to encourage beneficials.
- Field, equipment, and crop sanitation to prevent spread.

**Biological control:**
- Naturally occurring predatory mites and beetles are important biological control agents of these mites.

**Chemical control:**
• *Chromobacterium subtsugae* strain PRAA4-1 (Grandevo): A biologically based product. Not often used for erineum mites, but controls other mites. OMRI-listed for organic use.
• Lime sulfur: Commonly used.
• Oils: Sometimes used in early season.
• Spirodiclofen (Enidor): Used; effective.
• Spirotetramat (Movento): Effective; expensive so not widely used; sulfur is preferred treatment. Spirotetramat can provide control for other insects as well (such as phylloxera) due to its systemic distribution in the plant.
• Sulfur: Widely used, very effective.

**Critical Needs for erineum mite management in wine grapes**

**Research:**
• Identify additional effective materials and strategies for mite control.
• Develop a comprehensive management plan for all eriophyid mites, to include pest identification, understanding of overwintering sites, scouting, thresholds, most effective chemistries for different types of mites, and best timing for control, especially with products that allow only one use per season.
• While erineum mites are not always the source of economically significant damage, they can become problematic under certain conditions. More research regarding the conditions that lead to erineum mite flare-ups is needed.

**Regulatory:**
• None at this time.

**Education:**
• Educate growers on a comprehensive mite management plan once developed, including proper mite identification, to help growers know which mite and which life stages to target, and to determine the most effective chemistries and timing of control.
• Develop a process (e.g., a phone “app” or field ID guide) for pest identification, through which growers can send or view photos for fast pest ID from the field.
• Educate growers on the life cycle of the various types of eriophyid mites, as well as the impacts of hot, dry weather and dusty conditions on mite populations.
**Mite, Rust**
Grape rust mite (*Calepitrimerus vitis*)

Grape rust mites are tiny (0.1 to 0.2 mm long) and have a wormlike shape, much like the erineum mite. These mites are hard to see without magnification, and are difficult to decipher from other eriophyid mites. Rust mites are challenging for growers to identify on plant tissues because of their microscopic size and translucent color. The damage they cause to small shoots or leaves is usually the first indication of their presence.

Grape rust mites cause damage to newly growing plant tissue in spring. The mites move into the buds as soon as the scale breaks, some also overwinter in the buds. Shortly after budbreak, rust-mite-damaged shoots appear stunted, and depending on the grape cultivar, may have significant pubescence; a downy appearance with many fine plant hairs. Leaves are often crinkled and deformed. During late spring and early summer, rust mites are found mainly on leaves and can cause stippling. As the season advances, the stippling is often found on the youngest leaves at the shoot tips or on lateral shoots. High populations of rust mites on leaf surfaces can occur in mid-to-late summer and early fall. Signs and symptoms of feeding are first found as stippling but can lead to a purplish or blackish-green color which may transition to a bronze (red-brown) color late in the season.

Grape rust mites overwinter as adult females under the bark of the vine, in crevices and between the outer bud scales and bud tissue, and they migrate from these areas in early spring to developing shoots. Mites may congregate and feed on young susceptible shoots and flower primordia, then move on to opening foliage where they continue feeding during summer. Unlike most other mite species, grape rust mites feed on both the top and bottom surfaces of leaves.

Rust mites are a major pest for Walla Walla Valley growers. They are a major but transient pest in the Willamette Valley, having been more of an issue on younger vines in recent years. They are not a major pest in Southern Oregon or the Mid-Columbia region. Spur-pruned vineyards can experience worse problems than cane-pruned vineyards.

**Cultural control:**
- Use of flowering plants and alternate row mowing to encourage beneficials.
• Spot treatments to avoid treating whole areas in order to protect beneficials.

**Biological control:**
• Grape rust mites are subject to predation by a number of natural enemy species, particularly predatory mites. Sparse populations on leaves during spring and summer can be regulated by predatory mites, when predator-friendly chemicals are used judiciously in pest and disease management. The presence of grape rust mites during summer, and consequent increase in populations of predatory mites, may also enhance biological control of spider mites.

**Chemical control:**

*Spring to Early Summer*
• *Chromobacterium subtsugae* strain PRAA4-1 (Grandevo): A biologically based product. Not often used for rust mites, but controls other mites. OMRI-listed for organic use.
• Insecticidal soap (M-Pede and other brands): Not widely used. Some formulations are OMRI-listed for organic use.
• Lime sulfur: Not widely used.
• Neem oil (Trilogy): Not widely used. Poor efficacy. Some formulations are OMRI-listed for organic use.
• JMS Stylet Oil: Not commonly used. Stylet oil has limited efficacy in western Oregon in controlling rust mites, and use has resulted in increased erineum mite problems in early season. Some formulations are OMRI-listed for organic use.
• Sulfur (Microthiol Disperss, Kumulus DF, or other brands of wettable sulfur): Applied just before or during budbreak. Widely used, effective.
• Spiridoclofen (Envidor): Used, good efficacy.

*Late Summer*
(During late summer and early fall, mites begin migrating to overwintering sites and may be protected from sprays.)
• *Chromobacterium subtsugae* strain PRAA4-1 (Grandevo): A biologically based product. Not often used for rust mites, but controls other mites. OMRI-listed for organic use.
• Spiridoclofen (Envidor): Used, good efficacy.
• Wettable sulfur: good efficacy in reducing canopy populations of rust mite mid- to late-summer when populations are high.
Critical needs for rust mite management in wine grapes

Research:
• Identify additional effective materials and strategies for mite control, especially for organic-certified growers and growers working with other certification programs.
• Develop an overall mite-management plan to include pest identification, scouting, most-effective chemistries for different types of mites, and best timing for control, especially with products that allow only one use per season.
• Develop economic thresholds and better scouting techniques for all mites, but especially for rust mites, given their small size.
• Research life stages of rust mites and other eriophyid mites.
• Research the relationship between rust mites and vine damage, which is thought to be contradictory in some ways by growers; more definitive research is desired.
• Research best timing for various chemical controls.

Regulatory:
• ODA program monitoring for resistance in regions where few pesticides are used for control (based on certification programs or organic).

Education:
• Educate growers on a comprehensive mite-management plan, once developed, including proper mite identification to help growers know which mite and which life stage to target to determine most effective chemistries and timing of control.
• Develop a process (e.g., a phone “app” or field ID guide) for symptom identification, through which growers could send or view photos for fast pest ID from the field.
• Educate growers on the life cycle of rust mite and other eriophyid mites.
• As evidence shows that rust mites are present on nursery stock, sulfur applications during the first few years in new vineyards are necessary to prevent damaging populations from developing that can cause tissue damage and delayed canopy development.

Mite, Spider
McDaniel spider mite (*Tetranychus mcdanielii*)
Two-spotted spider mite (*Tetranychus urticae*)
Willamette spider mite (*Eotetranychus willametei*)
Adult spider mites are about 0.02 inches long. They have eight legs and an oval body. Spider mite eggs are spherical and translucent white when first laid.

Spider mites overwinter as fertilized females under bark or in soil debris. They move to young foliage when buds break in spring and produce many generations from spring to autumn. Females can lay up to 10 eggs per day and more than 200 during their lifetime. Egg-to-adult development can take 7 to 10 days during summer. They thrive under hot, dry conditions. Large colonies of mites produce webbing. Dispersal occurs mainly through wind transport.

Spider mites damage grape leaves by puncturing cells and sucking out the contents. This produces small yellow-white spots on the upper leaf surface. In heavy infestations, the spots coalesce and the leaf turns yellow or reddish-bronze.

Spider mites are a major pest for Walla Walla Valley growers, especially due to the hot, dry summer conditions of this region’s climate. Willamette mites are a particular problem in this region, from budbreak through harvest. Spider mites are generally not a problem in the Mid-Columbia region. In Southern Oregon, spider mites can be a major pest when present, but they are more sporadic in nature. Spider mites are a problem pest in the Willamette Valley that have been worsening during the past few years, and can be more of a problem in organic vineyards. Additionally, treatments for other mites have led to an increase in spider mites.

Whenever a spider mite problem does occur, it can often be traced to use of broad-spectrum insecticides and/or environmental conditions conducive to mite outbreaks (hot, dry, and dusty conditions). Spider mite outbreaks frequently occur in more arid regions where vines are dusty and/or water-stressed. Recent research also shows that multiple applications of sulfur for disease management (more than four to five times per season) tend to increase incidence and severity of spider mite problems by inhibiting the function of predators, particularly predatory mites (Phytoseiidae). Many Oregon vineyards use multiple sulfur applications per season, particularly when producing organically.

**Cultural control:**
- Use of water, oil-based products, or vineyard floor vegetation to control dust along vineyard roads and tracks.
• Where competition and low soil moisture is a concern, short, shallow rooted fescues are used as a less-competitive cover crop to control dust both in the vineyard and from roads (sheep fescue, 'Elf' perennial ryegrass, etc.).

**Biological control:**
- An extensive community of natural enemies successfully regulates spider mite populations, particularly when undisturbed by pesticides. Consequently, spider mite problems on grapes and many other crops are considered "secondary" pest problems resulting from the elimination or suppression of natural enemies. Spider mites are not often a problem in low-chemical-input vineyards or with the use of chemicals with low impact to beneficials, with the exception of sulfur, which can exacerbate spider mite issues.

**Chemical control:**
Acramite and Envidor are the most widely used miticides due to their efficacy and relatively high degree of safety to mite predators. All other products suppress predatory mite populations to a greater or lesser extent.
- Bifenazate (Acramite 50WS): Highly effective but use is not recommended more than once per season.
- *Chromobacterium subsugae* strain PRAA4-1 (Grandevo): A biologically based product. Not often used for spider mites, but controls other mites. OMRI-listed for organic use.
- Dicofol (Dicofol 4E and other brands): Old chemistry. Not used (requires a closed cab).
- Etoxazole (Zeal): Widely used. Effective.
- Fenbutatin-oxide (Vendex 50WP): Restricted-use pesticide. Old chemistry. Not used; harmful to predator mites.
- Hexythiazox (Onager, Savey): Only controls eggs and immatures.
- Insecticidal soap (M-Pede and other brands): Efficacy is variable. Some formulations are OMRI-listed for organic use.
- Pyridaben (Nexter and other brands): Not commonly used; harmful to predatory mites.
- Spirodiclofen (Envidor): Used, good efficacy.
Critical needs for spider mite management in wine grapes

Research:
- Identify more effective materials and strategies for mite control.
- Develop an overall mite-management plan to include pest identification, scouting, most effective chemistries for different types of mites, and best timing for control, especially with products that allow only one use per season.
- Research and identify more effective organic-approved fungicides (to help reduce sulfur use).
- Research on potential for ozone and other spray technology for pest control. Can ozone technology be effective without harming beneficials?).

Regulatory:
- None at this time.

Education:
- Educate growers on an overall mite-management plan once developed, including proper mite identification to help growers know which mite and which life stage to target to determine most effective chemistries and timing of control.
- Develop a process such as a phone “app” or field ID guide for pest identification, through which growers could send or view photos for fast pest ID from the field.
- Educate growers on the importance of rotation of chemical products.
- Educate growers on the importance of cultural controls for mite management including dust control, less cultivation, oiling of roads, etc.
- Further education for growers on importance of establishing minimal maintenance habitat for beneficials to maintain and enhance natural predator habitats in field.
- Educate growers on most effective ways to control spider mites.
- Educate growers on best management practices for different types of mites.
- Educate growers on the biology and life cycle of spider mites, especially to learn better control timing. Monitoring is time-intensive.
- Education on scouting for spider mites.
**Nematodes**
Dagger (*Xiphinema americanum*)  
Root-knot (*Meloidogyne hapla*)  
Ring (*Mesocriconema*)

Plant-parasitic nematodes are commonly found in wine grape vineyards in Oregon. In the western regions, the ring nematode is commonly encountered and has been demonstrated to reduce yield of grapes. The ring nematode is a migratory ectoparasite found only in soil. Damage to the grape plant by the ring nematode includes a reduction in fine root biomass resulting in lower vine vigor and crop yield.

Another migratory ectoparasite commonly found in wine grape vineyards throughout the state is the dagger nematode. Dagger nematodes were found in 85% of the vineyards surveyed in western Oregon. As virus vectors of Tobacco Ringspot and Tomato Ringspot viruses, which have been reported occasionally on grape in the PNW, dagger nematodes can be damaging at very low population levels. However, if the virus is not present, the nematode by itself may not be a problem.

East of the Cascades, the northern root-knot nematode is a plant-parasitic nematode of concern, being found at potentially damaging population levels in 25% of surveyed vineyards. The northern root-knot nematode is a sedentary endoparasite of which only second-stage juveniles (the infective stage) and adult males (which may be rare) are in soil. Spread to new areas is usually due to planting infected rooted plants or moving infested soil. Damage includes small distinct galls on roots, poor growth, shortened lifespan of the vine, and reduced yield. Affected plants are generally concentrated in circular or oval-shaped areas in the field.

West of the Cascades, populations of dagger nematode peak from February to April, so sampling is done during this period to increase the probability of detecting this nematode. For ring and root-knot nematodes, sampling is done at the end of the growing season when populations are highest. Dagger nematode populations may be very low in late summer, when other nematodes are abundant. Yields may be reduced when nematode populations reach high levels.
Cultural control:

- Weed free fallow period prior to replanting, especially on ground coming out of grapevines and other crops that are hosts for nematodes (e.g., alfalfa, mint, apple, cherry).
- Effective weed control practices to prevent virus introduction and/or spread from the nematode.
- Planting only rootstock and/or scion that have been tested and found to be nematode-tolerant and free of all known viruses.
- Maximizing vine health, through proper irrigation and fertilization, to better tolerate nematode infestations.
- Mulching.
- Use of mustards and brassicas as a cover crop.
- When removing plants, removing as much root material as possible.

Chemical control The key in managing nematodes on perennial crops such as grape is to protect new roots from nematode feeding. This allows roots to establish to the point they can tolerate nematode feeding after the chemical’s effects dissipate.

Preplant fumigation:

- 1,3-dichloropropene (various formulations including: Telone II, C-17, and C-35). Soil conditions where grapes are grown are often not conducive for optimum performance of this fumigant in the PNW. Not widely used. Restricted-use Pesticide.
- Allyl isothiocyanate (Dominus): Shank-applied at multiple depths to improve efficacy.
- Burkholderia spp. strain A396 (Majestene): A new, biologically based product; unknown efficacy.
- Metam sodium-generating products (Basamid G or Vapam): This product can be shank- or drip-applied. Not used due to toxicity concerns. Restricted-use pesticide.
- Paecilomyces lilacinus (MeloCon WG): A biologically based product. Unknown efficacy in Oregon.

Postplant nematicides:

- While there are several postplant nematicides labeled for use in Oregon on wine grapes, the efficacy of these products in the PNW is unknown
Critical Needs for nematode management in wine grapes

Research:
• Research pre- and post-plant nematicide treatments for efficacy in the Oregon.
• Identify rootstock material with resistance to the most important plant-parasitic nematodes found in Oregon.
• Develop preplant management strategies to reduce nematode populations prior to vineyard establishment.
• Research efficacy of *Burkholderia* spp. strain A396 (Majestene) and *Paecilomyces lilacinus* (MeloCon WG).
• Research potential interactions between nematodes and phylloxera in a replant situation.
• Research replant disorders based on nematode root injury.

Regulatory:
• Ensure that planting material produced in the Oregon and the Pacific Northwest is grown and propagated in areas free of plant-parasitic nematodes.

Education:
• Educate growers on the importance of soil testing for nematodes before planting (OSU’s Botany and plant pathology department offers this service) or when weak areas are found in vineyards.
• Educate growers on importance of planting nematode-resistant/tolerant rootstocks.

**Phylloxera**
Grape phylloxera (*Daktulosphaira vitifoliae*)

Grape phylloxera is a small, aphid-like insect that lives and feeds on the roots of grapevines, causing stunted growth, reduced vigor, and vine death of own-rooted *Vitis vinifera* grape varieties. Depending on the vineyard location and climate, death can occur within as few as three to 10 years, with mortality being quicker in drier climates where vines experience more nutrient and water stress. Vineyard decline has been a slower process in Oregon compared to other warmer, more arid regions, particularly because vines are under limited soil moisture or nutrient stress. Vines can be maintained for longer periods of time by reducing vine stress through proper management of nutrition and irrigation. (It
should be noted that the foliar forms of phylloxera are often not observed in *Vitis vinifera* vineyards in the Pacific Northwest.)

Because of the widespread nature of this pest, it is advised that vineyards be planted with vines grafted to phylloxera-resistant rootstock. Once an own-rooted *Vitis vinifera* vineyard is infested, there is no reversing the damage; only one phylloxera insect is needed to start an infestation within the vineyard.

Phylloxera has been confirmed in all wine grape-growing regions of Oregon with the exception of the Walla Walla Valley area of Eastern Oregon, although to date it has only been confirmed in one vineyard in the Mid-Columbia region. Growers in most Oregon growing regions primarily use vines grafted to resistant rootstock, which provides the only known sustainable control against this pest. In the Walla Walla Valley, and the Illinois Valley of Southern Oregon, however, the hard winter freezes make it more risky to use grafted stock, so own-rooted vines are planted. This would create significant problems should the pest take hold in these regions.

**Cultural controls:**
- Use of grafted vines where possible climactically.

**Biological controls:**
- None used at this time.

**Chemical controls:**
(Chemicals labeled for phylloxera control have limited efficacy in reducing populations or reversing the damage already done to infested vines.)

- Fenpropatrin (Danitol 2.4 EC): Rarely used. Foliar applications only; not applicable to grape phylloxera on the roots. Frequent use of synthetic pyrethroid products like fenpropatrin can lead to spider mite outbreaks.
- Sodium tetrathiocarbonate (Enzone): A soil-applied fumigant, best if used pre-planting or prior to re-planting, but not commonly used, as it kills all biota, including beneficial ones, within the treatment zone.
- Spirotetramat (Movento): Effective under certain conditions; expensive so not widely used.
- Thiamethoxam + chlorantraniliprole (Voliam Flexi): Rarely used. Foliar applications only; not applicable to grape phylloxera on the roots.
Critical needs for phylloxera management in wine grapes

Research:
• Determine whether phylloxera is a vector for viruses.
• Determine whether spirotetramat (Movento) applications can halt progression or even reverse damage.
• Research tolerance levels of certain rootstocks.
• Research and identify effective management programs to prolong vineyard life despite phylloxera presence.
• Research potential new chemistries for controlling phylloxera.

Regulatory:
• More stringent standards for clean planting material and quarantines, and potentially more pests added (phylloxera, leafroll virus, crown gall), to the current testing and screening process.
• Develop a regional clause through ODA for the Walla Walla Valley and Southern Oregon, upholding a quarantine for phylloxera so that plants shipped to this region would need to be certified. Because this pest is not considered a quarantine pest in Oregon, there are concerns regarding the potential for this pest to move into the Walla Walla Valley and Southern Oregon regions on Oregon-sourced planting material as well as material from elsewhere.

Education:
• Educate growers on the importance of clean rootstock; not moving vines.
• Educate ODA on the importance of protecting Oregon’s phylloxera-free regions from its spread.

GENERAL critical needs for control of ALL wine grape insect and mite pests mentioned above:
• Encourage various certification standards used by wine grape growers to account for both economics and availability of products; also considerations for mode of control (such as drip vs. spray, etc.). More options are needed for both. Whole-farm certification is also a challenging issue for some growers.
• More research on known and potential virus vectors, and how to effectively control them. For example, growers ask whether phylloxera, nematodes and other subsoil insects are vectors.
• Increase information and education on how to encourage beneficial insect populations, such as recent research on transferring cuttings from healthy areas of vineyard to areas lacking beneficials, etc.
• Educate growers regarding the use of sulfur and its detrimental impact on beneficial predatory-insect populations.
Diseases

**Botrytis Bunch Rot** (several organisms, mainly *Botrytis cinerea*)

Many fungal and bacterial organisms, of which *Botrytis cinerea* is the most important, can infect grapes and result in a bunch rot. *B. cinerea* has a large host range, and grows and sporulates on most of them. The fungus overwinters and oversummers on old cluster stems, canes, and mummified grapes. Spores spread by wind. Young, succulent shoots can be infected in spring, especially if injured by hail. Flower parts frequently are infected and can serve as a source of the fungus within the developing cluster. Wet weather favors infection and disease development, especially near harvest when canopies are dense and berries accumulate sugar. The fungus can quickly spread from berry to berry within ripening bunches, and can develop readily on wounded or split berries.

Infected shoots develop brown, water-soaked areas. These areas generally girdle the shoot, causing it to wilt and die back. The characteristic gray moldy growth of the fungus may or may not be present. Generally, damage to berries appears in late summer and autumn as small, brown spots on maturing berries. The berry skin may slip off easily when rubbed. Later, characteristic tufts of gray fungal growth appear on the surface of infected berries. Rotted berries are often near the center of the bunch; the rot then spreads quickly and may encompass most of the bunch. Other organisms may invade the berries later, producing a large variety of colors, smells, and tastes. Occasionally, immature berries may develop a soft brown rot early in summer.

The Cabernet Sauvignon variety grown in Oregon is the least susceptible to Botrytis bunch rot. Gewürztraminer is less susceptible than Chardonnay, Noir, and Riesling. Bunches that are more tight or compact are at higher risk of the getting the disease and expressing symptoms.

Botrytis is endemic in the Willamette Valley and Southern Oregon regions, particularly in wetter years, and is more of a sporadic pest in the Walla Walla Valley and Mid-Columbia regions. It is controlled fairly effectively with currently available fungicides and management practices, but in some years it is unavoidable, especially if wet weather occurs during harvest time. A few products used for controlling powdery mildew also control botrytis.
Resistance to fungicides is an issue with Botrytis, and especially with the loss of some current control options (boscalid, fenhexamid, etc.). Rotation with fungicides that have different modes of action is important. Botrytis control is generally not a major issue when pest-control programs are well thought out, but it can be very challenging for organic growers due to more limited control options.

**Cultural control:**
- Removal of leaves adjacent to clusters pre-bloom increases light and air penetration; this also aids in spray penetration and coverage (and can also help control powdery mildew).
- Use of an appropriate trellising system to increase aeration and sun exposure.
- Avoiding excessive vegetative growth through proper site selection, rootstock management and judicious use of water and nitrogen fertilizer.
- When adjusting yields by dropping fruit, growers remove clusters that are in contact with other clusters to help prevent spread.
- Effective management of powdery mildew, as powdery mildew predisposes berries to infection through the establishment of microscopic wounds on the fruit surface.
- Selecting cultivars or clones of a cultivar with loose cluster architecture.
- Efficient vineyard design (vine and row spacing, height of fruiting wire, row direction).
- Use of kelp for growth regulation.
- Dramatic leaf removal pre-bloom to create loose cluster structure.

**Biological control:**
- See section below on “Biologically based fungicides.”

**Biologically Based Fungicides:**
There are many different organisms formulated into commercial products that can be effective for Botrytis control under certain conditions. Sometimes they have demonstrated efficacy in the vineyard under low-to-moderate disease pressure.
  - *Aureobasidium pullulans* strains DSM 14940 and 14941 (Botector): Compatible with sulfurs, oils and a few fungicides, but not with many synthetic fungicides. Effective when used with low pressure spray systems.
  - *Bacillus amyloliquefaciens* strain D747 (DoubleNickel 55): Unknown efficacy; not widely used.
• *Bacillus subtilis* (Serenade, Serenade Max, Serenade Opti): Active ingredient is a small protein. Variable efficacy in tests conducted in western Oregon. Not widely used.
• *Reynoutria* spp. (Regalia): Not widely used. OMRI-listed for organic use.
• *Streptomyces lydicus* strain WYE C 108 (Actinovate AG): Not widely used. OMRI-listed for organic use.
• *Ulocladium oudemansii* strain U3 (Zen-O-Spore): Unknown efficacy; not widely used.

**Chemical control:**
• Azoxystrobin (Abound): Not widely used for botrytis; resistance concerns.
• Boscalid (Endura): Not used for bunch rot management if already using Pristine (boscalid + pyraclastrobin) for powdery mildew control.
• Captan: Moderately effective; not widely used. Several wineries and countries do not allow its use. Not recommended for use with oils, lime, or alkaline materials.
• Copper-based products are registered, commonly used and can be effective when timed correctly.
• Cyprodinil (Vangard 75 WG): Widely used, good efficacy when used alone.
• Dicloran (Botran 75W): Low efficacy; not used. Fruit marking can occur on some cultivars when combined with sulfur.
• Fenhexamid (Elevate 50 WDG): Effective, widely used.
• Fluopyram (Luna Privilege): Efficacy unknown; not widely used.
• Iprodione (Meteor, Nevada, Rovral, etc.): Good control when resistance is not a problem.
• JMS Stylet Oil: Only slightly effective alone; not widely used. Necrotic foliage may result if applied within 10 days of any sulfur application.
• Mancozeb products (Dithane, Manzate, Pro-Stick, or Penncozeb): Considered ineffective; not widely used.
• Polyoxin (Ph-D WDG, Oso): Considered fair-to-good in effectiveness; sometimes used in rotation with other fungicides for resistance management.
• Pyrimethanil (Scala, others): Effective; commonly used.
• Thiophanate-methyl (Topsin M WSB): Resistant fungi are widespread in the Willamette Valley of Oregon, which makes this product ineffective. Effective if resistance is not present.
• Trifloxystrobin (flint): Used, effective.
• Ziram: Low efficacy; not commonly used.
Combination Fungicides:

- Boscalid + pyraclostrobin (Pristine): Not used for bunch rot control if it is being used for powdery mildew control due to potential resistance issues.
- Cyprodinil + fludioxinil (Switch): Effective control; expensive so not widely used.
- Difenoconazole + cyprodinil (Inspire Super): Used; effective.
- Fluopyram + tebuconazole (Luna Experience): Not for use for bunch rot control if already being used for powdery mildew control. Efficacy against Botrytis is unknown.
- Hydrogen dioxide + pyroxyacetic acid (Oxidate): Used somewhat, limited efficacy.

Critical Needs for Botrytis bunch rot management in wine grapes

Research:

- Develop additional effective chemistries to control botrytis, which will also aid in resistance management.
- Verify growth regulation for effective Botrytis control under Oregon conditions.
- Research the efficacy of early leaf removal as a cultural control tactic for Botrytis management.
- Research the efficacy, mode of action, and potential for natural or synthetic hormones (such as kelp applications, “ProGibb” product) for Botrytis control.
- Resistance monitoring and testing of currently used chemistries.
- Research the inherent efficacy, and the best timing to achieve optimum efficacy, of chemical controls.
- Research inoculum sources in the field (compost, pomace, etc.) as sources of Botrytis infection.
- Research calcium use for reducing Botrytis through strengthening cell walls.
- Research persistence of agro-chemicals through harvest and processing.

Regulatory:

- None at this time.

Education:

- Educate growers on proper use of cultural practices to control Botrytis.
- Educate growers on importance of resistance management; specifically, rotation of FRAC groups to prevent or delay resistance development.
Crown Gall (Agrobacterium vitis, a.k.a. Rhizobium vitis)

Agrobacterium vitis (which may also be called Rhizobium vitis), is a bacterium that attacks only grape and chrysanthemum. The bacterium survives for years in old galls, infected vines, and infected plant debris in the soil. It can enter the plant through wounds, such as grafting wounds, mechanical or cold damage, or pruning cuts. More often than not, the bacterium has already infected the vascular tissues of symptomless grapevines. Although plants are systemically infected, with or without symptoms, the bacteria rarely are found in the vines' green shoot tips. The bacteria overwinter in the roots, and can re-populate aboveground portions in the spring.

This bacterium is a “genetic engineer’’ that modifies the grapevine to make it a home and produce a food source. Winter damage that causes minor wounds can trigger the infection process. After the bacterium enters a wound, a small piece of its DNA is transferred into the plant’s DNA. The foreign DNA transforms normal plant cells in the wounded area into tumor cells. Once transformed, tumor cells proliferate automatically and produce unique substances that the bacteria can use readily as a food source. The result is a gall, a disorganized mass of tissue.

The fleshy, hard galls are typically found on the trunk, located at the root crown of the plant, and on the first 2 feet of the vine above the soil line. Large galls may develop rapidly and completely girdle young vines in one season. Galled vines generally produce poor shoot growth, and vine portions above the galls may wilt and die due to the gall blockage. Few clusters develop on these shoots and if fruit does form, it often shrivels or will not ripen. Galls are rarely seen on roots but the bacterium may cause areas of dark necrotic lesions on the roots.

This disease is most common in the Walla Walla Valley, where freezing temperatures in winter can cause injury to the plant. This disease is also present and pervasive in Southern Oregon, but can be managed fairly effectively with current control options, including re-training the vine from below the gall. Crown gall is not as much of a problem in the Willamette Valley, although it can be more of a problem on young vines. With colder temperatures, issues can increase. Although it is sporadic in nature, crown gall can be a major problem in the Mid-Columbia region when present, especially in young vineyards. Nurseries can also be a source of crown gall infection.

Cultural control:
- Plant only crown gall-free vines.
• Prevention of vine injury, especially near the base of vines.
• Removal of diseased tissue or vines, including as much root material as possible.
• Resistant rootstocks are available, but grafting will not allow for retraining of vines after severe winter cold damage.
• Use of wind machines to raise surface air temperature during winter temperature inversions to prevent freeze injury to vines.
• Sanitation by sterilizing pruning tools between vines with bleach or shellac thinner.
• Sucker replacement in non-grafted plants.
• Use of a multiple trunk training system, which allows for trunk replacement without losing an entire vine.
• Avoid grafting over to a new cultivar on vines that are exhibiting crown gall symptoms.
• Hilling up over graft unions using soil berms.

**Biological control:**
• *Agrobacterium radiobacter* K84 (Galltrol): Does not prevent infections; can be effective on slowing spread of infection.
• Nonpathogenic *Rhizobium vitis*, strain ARK-1 and others, have been shown to be effective in research trials but are not commercially available.

**Chemical control:**
The efficacy of chemicals such as copper-based compounds, other chemicals and antibiotics is not satisfactory and thus not recommended.
• Gallex (2,4-xylenol +meta-cresol) can be painted on very young galls to reduce further development. Galls may return the next year or if treated late, may continue to develop. Not generally recommended for use because it is often too labor- and time-intensive to apply.

**Critical Needs for crown gall management in wine grapes**

**Research:**
• Develop better screening, testing and certification programs for nurseries to better ensure that nursery stock is free of crown gall bacterium.
• Research the use of “double trunking” – the use of a multiple trunk training system to allow for trunk replacement without the need for entire vine replacement – for crown gall management, especially in Southern Oregon.
• Develop more options for control of crown gall.
• Develop a quick and easy test for crown gall disease.
• Explore tolerant varieties and potential for breeding tolerance or resistance.
• Research use of genetic markers and other technologies to develop more pest-resistant plants.
• Research the use of insulation on trunks at graft union sites for crown gall prevention.
• Research use of white wash on the trunks to prevent extreme temperature change, reducing bark cracking and wounds.

Regulatory:
• Crown gall is no longer considered a quarantine pest because of its presence throughout Washington and Oregon, and thus, growers are concerned about certified plant material potentially being infected with crown gall. There is a strong need to include testing for crown gall as part of the certification process.
• Develop and encourage a more intensive and regulated “clean plant program” for nurseries, to ensure growers are buying clean plants.
• Offer federal assistance for own-rooted vines lost to crown gall infection (as opposed to just grafted vines, as is the current policy).
• Fast track successful biological management methods from other countries.

Education:
• Educate growers on the importance of buying certified clean stock, and the potential for buying infected vines, and how to prevent the loss of plantings because of this.
• Educate growers on how to avoid propagating materials from galled vines. Educate nurseries on the importance of detecting crown gall, and how to source wood that is free of crown gall for propagation purposes.
• Educate workers on how to better scout for and diagnose crown gall in the vineyard, during the growing season and before pruning.
• Educate growers on cultural practices that can contribute to spread of crown gall within vineyards, such as in-row cultivation which can cause mechanical damage.
• Educate growers on the importance of proper pruning techniques to prevent the spread of crown gall.
• Educate growers on the use of viticultural tactics, such as “double-trunking” for crown gall management.
• Educate growers on tolerant varieties, once identified.
Powdery Mildew (*Erysiphe necator*)

Formerly known as *Uncinula necator*, this fungal disease is common to all areas of the Pacific Northwest, including Oregon. European grape cultivars are commonly susceptible to powdery mildew. Other hosts include Boston ivy, Virginia creeper, and *Ampelopsis* (porcelain berry). The fungus may overwinter as a group of thin threads called hyphae, inside the vine's dormant buds or as small black bodies (chasmothecia) on the exfoliating bark of the vine.

Powdery mildew can attack all aboveground plant parts (green tissue). In early stages, whitish or grayish patches are on leaves and, if severe, ultimately cover both surfaces of the leaf. Colonies are more easily detected in full sunlight. Later in the season, the colony darkens and is peppered with minute black dots (chasmothecia). On fruit, the fungus at first may look grayish or whitish, but later has a brownish, russeted appearance. Infected fruit will crack and drop from the cluster. Even blossoms sometimes can be infected, causing them to dry up or fail to set fruit. When green shoots and canes are infected, the affected tissues appear dark brown to black in feathery patches. Patches later appear reddish brown on the surface of dormant canes. Spore traps are available to aid in detection.

Powdery mildew is a major disease for all four Oregon wine-growing regions. Controlling powdery mildew is generally not a major issue when pest control programs are well thought-out, but it can be a more difficult for organic growers. Resistance to many different fungicide groups has been documented for grape powdery mildew, which presents a need to carefully consider control programs. Poorly controlled powdery mildew infestations can also lead to Botrytis issues later in the season.

**Cultural control**

- Prevention of excess vigor through proper selection of rootstocks, training systems, and management of water and fertilization.
- Timely sucker control.
- Keeping canes cut back close to the top wire in a vertical trellis production system.
- Removal of leaves to control Botrytis bunch rot helps fungicide cover the clusters, which helps control powdery mildew.
- Managing ground cover in the early season to promote airflow.
- Management of sources of powdery mildew outside of the vineyard (such as susceptible vines found in landscapes and abandoned vineyards).
- Prebloom leaf removal to increase air and light penetration.
Chemical control:
Note: Resistance has been found in Oregon to FRAC 11 chemistries, and potential resistance is thought to be occurring with FRAC 3 products.

- Azoxystrobin (Abound): Used, effective; resistance concerns.
- Bicarbonate-based products (Armicarb, Kaligreen, MilStop): Commonly used; can be effective to suppress sporulation.
- Boscalid (Endura): Not used for powdery mildew if also being used for Botrytis bunch rot control.
- Copper formulations are registered but they are not generally recommended; they are not effective and not widely used for controlling powdery mildew.
- Fenarimol (Focus, Vintage, others): Limited use. Cannot be used with copper-based products.
- Horticultural mineral oils and plant oils: Not recommended for use before bloom as they can have a negative impact on predatory mites. Sometimes used after bloom.
- Kresoxim-methyl (Sovran): Used. Important to rotate with other fungicides that have different modes of action to prevent or delay resistance.
- Lime sulfur: Current labeled rate is not efficacious; used primarily during dormancy.
- Myclobutanil (Rally 40 WSP): Not widely used.
- Polyoxin D (Ph-D, Oso): Provides only mild suppression. Not widely used.
- Quinoxyfen (Quintec): Used, good efficacy.
- Soaps (M-Pede): Sometimes used early in the season as an eradicant for powdery mildew.
- Sulfur products: Widely used and efficacious.
- Tebuconazole-based fungicides (Orius, Tebucon, Tebuzol): Efficacy unknown; not used.
- Tetraconazole (Mettle): Efficacy unknown; not used.
- Thiophanate-methyl (Topsin): Resistant fungi, which may be prevalent in many vineyards, render this product ineffective.
- Trifloxystrobin (Flint 50 WG): Used. Important to rotate with other fungicides that have different modes of action.
- Triflumizole (Procure 480 SC): Used, good efficacy.

Combination Fungicides:
- Azoxystrobin + difenoconazole (Quadris Top): Not widely used. Efficacy is questionable.
- Boscalid + pyraclostrobin (Pristine): Widely used. Also provides control of Botrytis.
- Copper + lime + sulfur: A combination used by some growers and found to be effective.
- Difenoconazole + cyprodinil (Inspire Super): Efficacious and used by some growers.
- Fluopyram + tebuconazole (Luna Experience): Not recommended for use for powdery mildew control if already being used for Botrytis bunch rot control.
- Hydrogen peroxide + pyroxyacetic acid (Oxidate): Sometimes used as an eradicant toward end of season when damage to beneficials is less of a concern.
- Tebuconazole + sulfur (Unicorn DF): Efficacy unknown. Not used.
- Tebuconazole + trifloxystrobin (Adament 50 WG): Used by some growers, good efficacy. Some concerns about resistance.

**Biologically Based Fungicides** (use low pressure application to increase efficacy):

- “Banda de Lupinus albus doce”, or BLAD (Fracture): A new product derived from germinating sweet lupine plants. Efficacy unknown.
- *Bacillus pumilis* strain QST 2808 (Sonata): Commonly used, especially by organic growers.
- *Bacillus subtilis* GB03 (Companion): Unknown efficacy.
- *Bacillus amyloliquefaciens* strain D747 (DoubleNickel 55): Unknown efficacy; not widely used.
- *Reynoutria* spp. (Regalia): Commonly used, effective. OMRI-listed for organic use.
- *Bacillus subtilis* (Serenade, Serenade Max, Serenade Opti): Commonly used, especially by organic growers but efficacy tests in western Oregon show variable results.
Critical Needs for powdery mildew management in wine grapes

Research:

- Growers depend heavily on online weather tools and pest-prediction models (such as Ag Weather Net and USPest.org); funding for these tools needs to be continued and refined for better use in Oregon.
- More research is needed on the interactions between growth stages and the timing of fungicide applications.
- Develop more organic, soft or integrated options for powdery mildew control.
- Develop new chemical classes (FRAC classes different from current grape fungicides) to control powdery mildew and allow for rotation of products for better resistance management.
- Research on application methods and better targeting of control options.
- Research fungicide resistance: how broad is it, how is it characterized, does it decline or does it build?
- Develop an industry-wide alert system for powdery mildew occurrence.
- Develop a website that allows growers to see nearby trap counts.
- Research the potential for the incorporation of new sterilant products (such as “oxidate”, “zerotol”, etc.), to rotate into conventional disease-management regimes to break resistance cycle; research whether this could this be an effective treatment or if it would be too damaging to beneficials.
- Develop best management practices for dealing with hotspots within a vineyard without exacerbating resistance issues.
- Evaluate commonly used chemicals for resistance.
- Develop better protocol for treating infections to minimize resistance.
- Develop and support breeding programs that work toward identification of new and more resistant varieties, and new strains of existing popular varieties; evaluate the existing breeding programs in the PNW.
- Research use of copper during bloom to control powdery mildew.
- Test the concept of area-wide programs for better resistance management.
- Develop a sulfur formulation that can be applied in warmer temperatures and can be used later in the season without negatively impacting the fermentation process or other wine production aspects.
- Research the impact of spray adjuvants on the efficacy of sulfur, and the persistence of sulfur on the berries leading up to harvest.
- Research sulfur rates and spray timing (as well as other foliar products) and how they translate to concentration on the plant. There is a need to
change label rate recommendations, which are currently expressed on an acreage basis, to be concentration-based rates.

**Regulatory:**
- Encourage EPA to create labels that allow producers to adjust amount of product and water to be applied relative to planting regime; using canopy row volume and spray technology as standards.

**Education:**
- Educate growers on proper timing for optimum control of powdery mildew.
- Educate growers on the biology and life cycle of powdery mildew, as well as best management practices for control including the importance of scouting and rotation of fungicides to avoid resistance.
- Ensure that growers know how to find and use the IPM manuals that currently exist, such as the ones at OSU, WSU, and UC Davis.
- Educate growers regarding the fungicides used for powdery mildew control, specifically regarding when to use contact vs. systemic, and which adjuvants can be helpful.
- Educate growers on fungicide resistance, and how to best steward existing classes of products to prevent and manage resistance.
- Educate growers on presence of resistance to FRAC 11 products.
- Educate growers on risk management to minimize sprays and resistance risks.
- Conduct demonstration trials in southern Oregon regarding best timing of sulfur applications to avoid burning grapes.

**Trunk Diseases**
Bot canker
*Eutypa* dieback

Various members of several fungal families cause trunk diseases in grapevines, and multiple pathogens are often isolated from an affected vine. Symptoms are not sufficient to identify a particular cause. Trunk diseases should be considered a syndrome or disease complex, potentially involving members of the Botryosphaeriaceae, Diatrypaceae (such as *Eutypa*), and Togniniaceae (*Phaeacremonium, Phaeomoniella*) families, which have been found in association with diseased grapevines in Oregon.
Members of the Botryosphaeriaceae family, including multiple species of the fungus *Botryosphaeria*, are known to cause a range of symptoms, which have also been referred to as "Bot canker." These fungi cause perennial cankers and enter vines through fresh injuries such as natural cracks, pruning wounds, or any large cut to vines or trunks. Spores are released from pycnidia on diseased vines during rain or overhead irrigation. Spores can germinate in a fresh wound when temperatures are above 5°C (41°F). These fungi become established in the vine, slowly growing toward the roots. Spread is thought to be by movement of spores from within an infected vineyard, rather than from sources outside of it. Vines as young as five years old may be affected.

*Eutypa lata* is the fungus that causes *Eutypa* dieback. The disease is prevalent on wine grapes throughout the PNW. Incidence is especially high in older vineyards, where large pruning wounds were made to alter the training system. Infection occurs when airborne fungal spores contact fresh pruning wounds during or immediately following rain. Moderately infected vineyards can lose 19% to 50% of yield, severely affected vineyards 62% to 94%.

Losses occur from reduced vine productivity, poor yields and extra costs for cultural and chemical management. For bot canker, older vines will show wedge-shaped cankers in the trunk and vines, similar to those caused by *Eutypa*. On spur-pruned vines, infected spurs may not grow in the spring, or there may be growth followed by rapid wilt and collapse of the foliage. Some spurs may be dead, while others may produce apparently healthy foliage. Foliar symptoms of *Eutypa* include stunted spring growth and yellowed leaves. Young vines may show cankers, vascular discoloration, or dark streaking of the xylem. Symptoms may not appear on diseased vines for more than three years after infection. Cankers expand lengthwise in both directions from the wound and girdle and kill arms or trunks of infected vines in five to 10 years.

*Eutypa* and bot canker have been observed more frequently on wine grapes in the Willamette Valley. This is expected to increase as vineyards age and more acreage is planted. Also, the fungi can infect cherry trees, which are heavily planted within many of the same areas as wine grapes and can act as a reservoir of inoculum. These fungal organisms can attack many other hosts including many orchard crops such as *Prunus* spp., apples, pears, and walnuts, and plants grown as ornamentals or in riparian areas, such as big leaf maple and willow.

Trunk diseases are serious pest problems when present, and can determine the natural life of vineyards. Trunk canker diseases might be more of an issue as
vineyards age and become more in number and proximity. Sometimes damage isn’t noted for six to seven years, so new vineyards can become infected but not show symptoms for a long time.

Trunk diseases are present in all regions of Oregon, and need to be controlled. Sometimes cankers are absent, but short shoot growth and plant death indicates disease. Sporulation and spread is a major issue. Management tactics that work for Eutypa dieback will also work for Botryosphaeria cankers.

**Cultural control** Primarily used for trunk diseases before resorting to chemical controls:

- Marking of diseased vines for future removal in the spring, when symptoms are evident.
- Removal of diseased wood four to six inches below the canker, and training of new, healthy shoots into position.
- Removal and replacement of the vine if canker is below ground.
- Avoiding large pruning cuts when possible, and avoiding pruning during and before wet weather.
- “Double pruning” if pruning during wet weather by leaving a stub several inches long to be pruned off later during dry weather.
- Sanitation by removal and destruction of all large trunk or cordon pieces from the vineyard.
- Pruning later in the growing season; or other timing dependent on cultivar.

**Biological control:**

- None used at this time.

**Chemical control** Useful when retraining vines and making large trunk or cordon cuts.

- Boric acid: Often used immediately after pruning.
- Mechanical barriers: “Vitiseal” or other latex paint product painted on pruning wounds is a common practice.
- Myclobutanil (Rally 40 WSP): Commonly used as a spray directed onto cuts within 24 hours of pruning.
- Tetraconazole (Mettle 125 ME): Used as a spray directed onto cuts within 24 hours of pruning. Not widely used.
- Thiophanate-methyl (Topsin M WSB): Used as a spray directed onto cuts within 24 hours of pruning. Also may also be used as a paint on cut or
pruned surfaces. Not widely used. Use allowed under SLN OR-150009a and OR-150009b.

Critical Needs for trunk disease management in wine grapes

Research:
• More Oregon-specific research on trunk disease treatment, prevention, and cost-effectiveness.
• Survey each growing region in Oregon to determine which diseases are present in which regions.
• Research on movement and spread, within plant and between vines, by disease type.

Regulatory:
• Proper disposal of infected trunks can be problematic for growers due to “burn day” limitations, especially with wind considerations. Growers in the Walla Walla Valley need a nuisance pest license to allow for more rapid burning after infected plant material has been cut out.
• Continued monitoring of other potential trunk diseases present in other crops, such as Xylella, and its potential to spread to wine grapes.
• Fast track successful chemical or biological management methods from other states.

Education:
• Educate growers on identification of visual symptoms associated with trunk diseases.
• Educate growers, field workers, and others on the importance of proper pruning techniques starting at vineyard establishment, such as smaller cuts, double pruning, later-season pruning, impacts of wet weather during pruning, etc., to prevent the spread of trunk canker diseases.
• Educate growers on the importance of prevention and early detection and treatment of trunk diseases, and the importance of treating pruning wounds before symptoms are found.
• Create a better connection between growers and information and educational resources that are readily available.
Viruses

There are more than 70 virus and virus-like agents that infect grapevine worldwide. Relatively few of these are known to occur in Oregon. As an industry, it is important that growers do their part to keep Oregon vineyards free of the grapevine viruses that are not here. The key action that growers take is to ask for certified plants, and a list of viruses that have been tested for in the certification process. Not all 70 viruses will have been tested for in the certification program. The key viruses growers pay attention to are Red Blotch, Grapevine leafroll viruses, Nepoviruses, and viruses that cause trunk diseases, especially the Vitiviruses GVA, GVB, GVD, GVE, GVF.

Grapevine red blotch associated virus, Grapevine leafroll associated viruses and Tomato ringspot virus are the major viruses of grapevine known to occur in Oregon and cause disease. Grapevine rupestris stem pitting associated virus is widespread in Oregon and many other grape-growing areas of the world, and is generally thought to have very little impact on plant growth or fruit quality.

Grapevine leafroll viruses

There are five viruses that have been reported to cause leafroll disease in grapevines, and they are collectively called Grapevine leafroll-associated viruses or GLRaV. Of the viruses associated with leafroll disease, GLRaV-3 is the virus most often found in surveys in the Pacific Northwest, and has been traced to transmission by the grape mealybug. The soft scale has also been shown to be a vector of this virus.

Symptoms can take one to three years to develop after infection. Propagating vines from infected stock plants is another way these viruses are moved from one vineyard to the next. GLRaV-1 has even been found in ornamental grapes for sale at retail nurseries. It is critical that growers continue to use only certified wood when establishing vineyards. All plants entering Oregon and Washington must be certified free of leafroll viruses; although this does not fully guarantee that the disease is not present due to random testing.

Red grape cultivars that are positive for GLRaV have red basal leaves that may be most often observed during the later part of the growing season (September and October). Reddened leaves may also exhibit green veins (as opposed to red veins found in Red Blotch Virus vines). Foliage of white-fruit cultivars may have
subtle yellowing during late season. Leaf symptoms typically begin to appear around véraison (change of fruit color) on basal shoot leaves and progress up to younger leaves through the rest of the growing season. Other symptoms include delayed foliation in spring, downward curling or rolling of leaves, and less vigorous vine growth in adverse circumstances. Potassium deficiency mimics many of the symptoms caused by GLRaV.

An infected vine may produce fewer and smaller clusters of berries with reduced soluble solids. The grapes on red-fruit cultivars often have delayed and uneven ripening, which can lead to off flavors in wines. Yield losses of up to 50% to 70% have been observed in vineyards with this disease.

Some of the leafroll viruses can cause graft-union necrosis in grafted plants, usually when present in mixed infections. Symptom severity depends on the virus, rootstock and scion combination.

**Cultural control:**
- Planting healthy stock that has been tested and found to be free of all known viruses and diseases.
- Monitoring for, and if present, controlling for mealybug and scale, especially in vineyards where leafroll virus has been found.
- Removal and destruction of virus-infected vines (and sometimes adjacent vines), after treatment for mealybugs.

**Biological control:**
- None used at this time.

**Chemical control:**
- Vector control if a known vector is present in the vineyard.

**Critical Needs for leafroll disease management in wine grapes**

**Research:**
- Research effective control strategies for leafroll virus vectors.

**Regulatory:**
- Ensure cleaner new plant material through more rigorous testing and screening requirements for all nurseries, both in Oregon and beyond.

**Education:**
• Educate growers on how to scout, monitor, and identify leafroll virus.
• Encourage testing and early management response among growers.
• Educate growers on the process of buying certified plants, including:
  o How to find out “how clean” the plant material is by knowing what is being tested for.
  o The difference between certified plants and certified nurseries.
  o Clarification on which nurseries are testing for which pests.
  o Clarification on quarantine issues.

**Red blotch virus**

This disease is caused by *Grapevine red blotch-associated virus* (GRBaV), a distinct, graft-transmissible virus in the family Geminiviridae. The disease has been observed as distinct from that caused by Grapevine leafroll associated viruses since about 2006, and the virus was first characterized in 2012. A PCR-based diagnostic assay was developed in 2012.

Surveys in Idaho, Oregon and Washington vineyards have indicated the presence of this virus in many wine grape cultivars. Positive samples were collected from symptomatic grapevines of Merlot, Cabernet Franc, Pinot Noir, Cabernet Sauvignon, and Malbec. In addition, the samples of the white-fruited cultivars Viognier, Chardonnay, Roussanne, Semillon and Pinot Gris, which do not develop any red leaf symptoms, were also identified in Oregon vineyards. Grapes tested often had multiple viruses present, so symptoms may be associated with multiple viruses in those vines that test positive.

In red wine grape cultivars, leaf symptoms are described as small, irregular red-colored areas between major veins on mature leaves at the basal portion of the canopy of affected vines. Symptoms develop on leaves further up the shoots as the season progresses. The discolored areas on the leaves expand and coalesce with time to become reddish- or reddish-purple blotches that are strikingly apparent towards the end of the season. In some red-fruited cultivars, the veins may become red in contrast to the green veins usually observed with grapevine leafroll disease. Leaves with red or green veins can sometimes be observed on the same bush and the symptoms of this disease can be confused with grapevine leafroll disease. Multiple infections of different viruses are likely, and contribute to this confusion. At this time, there seems to be considerable variation in degree of reddening depending on cultivar and rootstock. White cultivars positive for the virus do not exhibit the symptom of reddening of leaves, though yields are reduced. In Chardonnay, leaves develop a chlorosis in late summer, which can
advance to necrosis later in the season. Vines that are positive for GRBaV often are not able to ripen fruit (have lower Brix) at harvest.

This is an important disease, especially in the Southern Oregon region. The vector is currently unknown, although a putative vector has been identified in California as of earlier this year (*Spissistilis festinus*). Since so little is known about this disease and its potential vectors, the only control tactics for dealing with the virus include prevention by planting clean stock and rogueing of diseased vines.

**Cultural control:**
- Start with clean plants, and plant healthy stock: clones of most rootstocks and cultivars that have been tested and found to be free of all known viruses are available, although Red Blotch is such a new disease that it might not yet be included in testing programs.
- Tagging or flagging positive vines for future monitoring and removal.
- Rogueing (removing) symptomatic plants as they appear.

**Biological control:**
- None used at this time.

**Chemical control:**
- Vector control if a known vector is identified and present in the vineyard.

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**Critical Needs for red blotch management in wine grapes**

**Research:**
- Research the biology, ecology, and management of red blotch, including a better understanding of the latency of the virus.
- Research the vectors for this virus (leafhoppers, nematodes, and phylloxera are all questioned) and research potential management options once vector(s) identified.
- Research effective controls for red blotch vector(s) once identified.
- Research economic thresholds for red blotch for determination of the need for plant vs. row removal.
- Research re-infection rate, spread patterns and dynamics, and best management strategies for dealing with infected blocks.
- Research other potential red blotch associated viruses, and develop lab tests to detect these viruses in plant stock.
- Research whether tolerance can be bred.
Regulatory:
- Better quality screening (ODA) and testing protocols (nurseries, growers); and screening of plants coming into Oregon, especially to include testing and screening for red blotch, and the capability of expanding testing to include additional strains as they are discovered.
- Develop a more standardized testing and certification program with strong, unilateral certification standards to include the entire Pacific Northwest (including California, from which many plants come into Oregon), to encourage better quality screening and more confidence in clean plant material across states. Certification standards should be equal across the region.

Education:
- Encourage testing and early management response.
- Educate growers on the process of buying certified plants, including:
  - How to find out “how clean” the plant material is by knowing what is being tested for.
  - The difference between certified plants and certified nurseries.
  - Clarification on which nurseries are testing for which pests.
  - “Certified” does not always equal “virus-free”.

**Tomato ringspot virus** (a.k.a. *Grapevine degeneration disease*)

Tomato ringspot virus (ToRSV) is a nematode-transmitted virus in the genus *Nepovirus*. Of the seven viruses in this genus that have been reported from vineyards in North America, only ToRSV has been reported in Oregon. In the northeastern United States, this virus causes a grapevine decline in some self-rooted *V. vinifera* cultivars and some interspecific hybrids. In California, ToRSV can cause Grapevine yellow vein disease, where portions of the leaf blade develop a chlorosis or yellowing symptom. In Oregon, ToRSV has been associated with a graft-union necrosis that leads to plant death in three to four years. Initially, the plants appear weakened and stunted, with the stunting becoming increasingly severe until the plant dies. To date, the virus has only been identified in several vineyards in the Willamette Valley. The nematode vector, *Xiphinema americanum*, is widespread in Oregon vineyards, thus the potential for this virus becoming increasingly important is a concern. This nematode on its own is not a concern in grapevines, however, if the virus is present then the nematode as a vector is a serious concern. This virus spreads very slowly in the field due to slow movement of the vector. Thus, spot treatment can be effective in controlling this disease.
Cultural control:
• Planting healthy stock. Clones of most rootstocks and cultivars that have been tested and found to be free of all known viruses are available.
• Removal and destruction of virus-infected vines and three to four adjacent vines.
• Use of cover crop to reduce movement of soil in the vineyard by machinery as moving soil can result in virus-carrying nematodes being moved to a new section of the vineyard.

Biological control:
• None used at this time.

Chemical control:
• Vector control if X. americanum and ToRSV are present in the vineyard.

**Critical Needs for ToRSV disease management in wine grape**

Research:
• Research the susceptibility of rootstocks to virus infection.
• Research the reaction of different scions and rootstock combinations to ToRSV.

Regulatory:
• Ensure cleaner new plant material through more rigorous testing and screening requirements for nurseries.

Education:
• Ensure growers can accurately diagnose the symptoms of ToRSV, encourage testing and early management response.
• Educate growers on the process of buying certified plants, including:
  o How to find out “how clean” the plant material is by knowing what is being tested for.
  o The difference between certified plants and certified nurseries.
  o Clarification on which nurseries are testing for which pests.
Weeds

Major weeds of concern for Oregon wine grape growers are grass weeds: (annual bluegrass [Poa annua], ryegrass, bentgrass, Bermuda, and Johnson grass), false carrot, blackberry, puncturevine, yellow starthistle, Russian thistle, Canada thistle, field bindweed, equisetum (horsetail), morning glory, nutsedge, and poison oak.

Vegetation management in vineyards is determined by site-specific environmental factors. Weed competition and interference must be minimized within the vinerow, while trafficability and soil conservation are required in alleyways between rows. Most vineyards have grass between rows (dwarf fescue is common), thus weeds can be an issue either in this grass, or under-vine. Weeds are a particular problem when present under vine rows. Some weeds, such as thistle and false carrot, can grow up into the vinerow and end up in the fruit zone, which becomes an economic problem.

Cultural control:

- Cultivation: Tillage is used to control annual weeds and suppress perennial weeds. Tilling is sometimes done to every other alleyway in alternate years to ensure trafficability during harvest. Growers alternate cultivation in the vine row with herbicide application to minimize resistance. Undervine cultivation is frequently used to control weeds.
- Flame weeding: Propane flame is used to sear small broadleaf weeds, but this practice reduces only surface vegetative growth of grasses and perennial weeds.
- Use of soil mulch (mounding of soil undervine).
- Mowing or flailing: Mowing or flailing alleyways.
- Mulches: Organic mulches (like sawdust), polyethylene film, or woven or spun-bonded fabrics are used, as well as a living mulch in vinerow (such as arugula or another annual crop).
- Sucker management: Remove unwanted shoots which emerge at the base and on the trunk of vines during the early part of the growing season; this can also help remove a large portion of leafhopper eggs prior to hatch if done after leafhopper eggs have been laid.
- Sheep are sometimes used to control weeds in vineyards, especially in terraced blocks, and always before budbreak.
**Biological control:**
- Release of cinnabar moth to control tansy ragwort.

**Chemical control:**
*Glyphosate* is commonly used for site preparation ahead of planting. There are many different herbicides registered for use in wine grapes; choosing an herbicide during vineyard establishment, or for use in established vineyard, depends on target weed type and species, known efficacy, cost, and other factors.

**For new plantings**

**Soil-active preemergent herbicides:**
- Isoxaben (Trellis): Commonly used.
- Napropamide (Devrinol): Not used.
- Oryzalin (Surflan): Used somewhat.
- Oxyfluorfen (Goal 2XL): Commonly used.
- Pendimethalin (Prowl H20, Prowl 3.3, and other brands): Prowl 3.3 is registered for nonbearing crops; Prowl H20 for bearing. Not used.
- Trifluralin (Treflan and others): Not used.

**Postemergence contact and translocated herbicides:**
- Clethodim (Select Max, Envoy, others): Grass herbicide. Nonbearing only.
- Diquat (Reglone): Nonbearing only. Not used.
- Fluazifop (Fusilade DX): Used for fine fescue control.
- Glyphosate (various product names): Commonly used.
- Sethoxydim (Poast): Grass herbicide. Commonly used, especially in vine row.

**For established plantings**

**Soil-active preemergent herbicides:**
- Dichlobenil (Casoron CS and Casoron 4G): Not widely used.
- Diuron (Karmex and others): Commonly used.
- Indaziflam (Alion): Commonly used.
- Napropamide (Devrinol 50DF): Not widely used.
- Norflurazon (Solicam): Not used.
- Oryzalin (Surflan): usage unknown.
- Pendimethalin (Prowl H20): usage unknown.
- Pronamide (Kerb): Commonly used, especially if grass weeds are a concern.
- Simazine (Princep): Used somewhat.
• Trifluralin (various products): Commonly used, especially if grass weeds are a concern.

Herbicides with both pre- and postemergent activity:
• Flazasulfuron (Mission): Used somewhat.
• Flumioxazin (Chateau): Widely used.
• Oxyfluorfen (Goal 2XL and Goal Tender): Commonly used.
• Rimsulfuron (Matrix FNV): Commonly used.
• Sulfentrazone (Zeus XC): Commonly used.

Postemergent contact and translocated herbicides:
• Bentazon (BasaGran herbicide): Nonbearing only.
• Carfentrazone-ethyl (Aim EC): Commonly used.
• D-limonene (lemongrass oil) (Avenger AG):
• Glufosinate ammonium (Rely 280): Widely used but expensive.
• Glyphosate (various products): Commonly used.
• Pyraflufen (Venue): Efficacy questionable. Not widely used.
• Paraquat (Gramoxone Inteon): Not widely used. Safety concerns.
• Sethoxydim (Poast): Low efficacy but used as it is only grass herbicide registered for use in bearing vineyards.

Sucker control in nondormant grapes:
• Oxyfluorfen (Goal 2XL, Galigan): Commonly used.
• Carfentrazone-ethyl (Aim EC): Commonly used.
• Caprylic and capric acid (Suppress): A contact, nonselective herbicide. Commonly used, especially by organic growers, but expensive. OMRI-listed for organic use.

Note on managing herbicide resistance: Dependence on glyphosate in many vineyards is exerting strong selection pressures on weed populations and may ultimately lead to weeds that are resistant to glyphosate. Several alternative, nonselective herbicides (listed above) have different sites of action and can be applied in rotation with glyphosate to reduce the risk of selecting for weeds that are resistant to glyphosate.

Steps taken to avoid or manage glyphosate resistance:
• Use other means to manage weeds, such as cultivation, mowing, and flailing.
• Use preemergence herbicides where possible. Consider use of other nonselective herbicides, such as glufosinate or paraquat with PPO inhibitors for burndown control.
• To delay development of resistance, use the full, labeled rate of glyphosate.
• If continuing to use glyphosate in vineyards with resistant weeds, tank-mix glyphosate with other herbicides and make the application when the weeds are small.
• Do not let weeds go to seed. In the case of weeds that outcross, do not let weeds produce pollen.

Critical Needs for Weed Management in wine grapes

Research:
• Identify effective alternative control options for glyphosate-resistant weeds.
• Develop biocontrol options for puncturevine.
• Develop a handbook of best management practices for controlling major weed pests.
• Identify effective alternatives for post emergent, systemic weed control.
• Identify effective alternatives for dandelion control.
• Continue research on products that could be effective alternatives to 2,4-D for broadleaf control, (such as new iron chelate products).
• Develop effective herbicides for organic growers that are also more economically viable.
• Pursue registrations for more grass-specific products for use in bearing vineyards (Sethoxydim/Post is currently the only grass herbicide registered for use in bearing vineyards).
• Pursue more effective herbicides for thistle, as well as bindweed and other hard-to-control weeds.
• Research efficacy of use of the Bindweed Moth (*Tyta luctuosa*) for bindweed control. Bindweed Moth is currently established in one area in the Willamette Valley but its impact on field bindweed populations is not fully known.
• Research and assess different types of living mulches for water consumption, potential for pest attraction, and efficacy for weed control.

Regulatory:
• Permit more preemergent herbicides for use under LIVE certification.
• Some certification programs require rotation of chemicals, but have few chemical choices allowed; thus rotation is difficult for some growers.
Expand options in certification programs to allow for rotation to manage resistance.

- While not a direct pest issue, herbicide damage from phenoxy herbicide drift from neighboring crops, especially pasture, is a serious concern to some wine grape growers. Implement a timeframe restriction on use, and also promote non-volatile forms. Label phenoxy herbicides as restricted-use pesticides in Oregon (similar to Walla Walla Valley).
- For Walla Walla Valley, attach the phenoxy herbicides restrictions to phenology models for grapes, not calendar months.
- Encourage ODA to offer testing that detects herbicide residues at a lower level than is currently offered.

**Education:**
- Educate growers on best management practices for weed control, once developed, including information on how and when to treat problem weeds.
- Educate growers to redefine what are considered weeds and action thresholds.
- Educate growers on biologically-based products that are active on St. Johnswort, tansy ragwort, and scotch broom.
- Educate neighbor growers of wheat, grass seed, Christmas tree, etc., on timing and impacts of phenoxy herbicides on wine grapes, as well as the importance of good application practices including timing and formulations.
- Educate growers on the use of seaweed extracts to reverse the effects of phenoxy herbicides.
Vertebrate Pests

**Bears**

Bears can be problematic in the Southern Oregon region, coming into vineyards to feed on fruit but also damaging vines. They are currently controlled using fences and sometimes radios (the constant talking/music repels them).

**Birds**

Robins, European starlings, and cedar waxwings are the main bird pests feeding on fruit in Oregon vineyards.

A variety of strategies are used to manage bird predation. Birds are usually controlled with netting (when affordable), Mylar balloons, flags, cannons and other sound devices, or falconry. Some vineyards are 100% netted but usually just over the fruit zone; it’s expensive and labor-intensive. Sound devices are common but can upset neighbors, and birds can become habituated to the sounds. Control methods are used in moderation and varied to prevent habituation.

**Deer**

Deer cause vine damage, and cause the most damage in the spring when they feed on new shoots. Fencing the vineyard perimeter is a common control method, as is the use of deer repellant taped on nylon and hung around sensitive areas. A kaolin product like “Surround” sprayed on young vines for insect control often keeps deer from feeding on new shoots.

**Rodents (gophers, ground squirrels, voles, field mice)**

Rodents are a problem pest, especially with young vines. They damage vines by chewing on the trunk and damaging the cambium. Voles can be especially problematic in areas with undervine weed issues and cause more girdling than if the soil under the vines is kept vegetation free. Mulching in the vine rows can also contribute to vole problems.

The main controls include chemical baits containing zinc phosphide, and trapping. Ground squirrels can be a nuisance to equipment and laborers because
of the mounds and holes they create. Gophers have become a major pest issue in the Walla Walla Valley in recent years. Voles can be a particular concern in some years in the Willamette Valley. Trapping is often used to control rodents.

**Turkeys**

Wild turkeys cause damage to vineyards when feeding on fruit. Control options are currently very limited. In some regions, trellis systems with higher heads have been effective.

**Critical Needs for vertebrate pest management in wine grapes**

**Research:**
- Conduct trials to increase the efficacy of electronic distress call devices such as “Bird Gard”.

**Regulatory:**
- Clarify regulations related to rodent control including trap and kill, relocation, protected species, etc.

**Education:**
- Educate growers and consultants on how to use bird distress call devices more effectively to improve amount of control.
Minor and Sporadic Pests

Insects

**Branch and twig borer** (*Melalgus confertus*)

Borers are especially problematic in vineyards situated in close proximity to riparian areas or woodlands. They have a wide host range but can particularly infest older vineyards where vines have large pruning cuts and old wood to infest. Both adults and larvae damage the vine. Larvae bore into older canes and pruning cuts where they live until they emerge as adults. Adults burrow into the base of new shoots in spring to feed. The burrowing into the tissues causes shoots to wilt and die. Severe infestation can result in crop losses, and damage can be significant. While the infestation usually occurs in older vineyards, it has been observed in young vineyards (less than 10 years of age) in western Oregon, particularly when located near old orchards, abandoned vineyards or riparian areas.

Adults are long, brownish black and are visible early in the season (spring). They are between 0.4 to 0.7 inches long. Females are slightly larger than males. Larvae live within the cane or shoot for nearly a year before they emerge the next spring. Corrugated cardboard traps placed at the base of the vine trunk can be used to capture the pest at night.

This is an occasional, minor pest for the Southern Oregon region, and can be problematic in the Willamette Valley.

**Cultural control:**
- Ensure proper sanitation, such as removal and destruction of pruning brush from the vineyard before budbreak and leaf emergence in the spring.
- Removal and destruction of any alternate hosts from fence lines or dead shrub and debris piles from the vineyard area.

**Biological control:**
- An entomopathogenic nematode, *Steinernema carpocasae*, is often used for biocontrol of twig borers. A commercial preparation of the nematode must be applied to burrow holes before budbreak in order to be effective.
Chemical control:
*It is difficult to control twig borers with chemical insecticides due to their burrowing nature. There is only a small window of opportunity to apply insecticides: when adults are mobile and have not yet laid their eggs within the shoot or cane.*

- Carbaryl (Sevin 4F and other brands): Sometimes used, but must be avoided if mite outbreaks are a concern.

**Critical needs for branch and twig borer management in wine grapes**

No critical needs were noted at this time.

**Flea beetle**

Flea beetle is a sporadic pest in the Walla Walla Valley that comes in waves from year to year. Hosts are alfalfa and canola, from which the flea beetle migrates to vineyards in the spring. Flea beetles seem more attracted to younger vines and can be problematic in young vineyards, causing stunted plants.

**Cultural control:**
- None used at this time.

**Biological control:**
- None used at this time.

**Chemical control:**
- Often treated with pyrethroids/pyrethrins.

**Critical needs for flea beetle management in wine grapes**

No critical needs were noted at this time.

**Root weevil**

This is a sporadic pest in the Willamette Valley region, especially in younger vineyards, and can be very problematic when present. Nursery plants contaminated with root weevil can have compromised roots.

No specific management strategies, chemical, biological or cultural, are listed for root weevil control in wine grapes. If needed, one of the many insecticides
registered for use in wine grape for control of other grape pests would be used if root weevil populations warranted treatment.

Critical needs for root weevil management in wine grapes

Education:
• Educate growers on the importance of buying clean plants.

No research or regulatory needs were noted at this time.

Scale
European Fruit Lecanium Scale (*Parthenolecanium corni*)

This scale assumes many sizes, shapes, and colors. The typical form is almost hemispherical, shiny brown, smooth, and approximately 0.12 to 0.19 inches long. Eggs are oval and pearly white. The young vary from yellow to pale brown.

Adult females may be found on leaves or grape bunches, but mostly on shoots of current growth or on 1- to 3-year-old wood. Males have not been observed. Females lay eggs under their bodies. As the female dies, the body shrinks and an egg-filled pocket is formed. As more eggs are laid, the walls of the scale's body becomes hard and, after death, brittle. Young scales overwinter in a juvenile state on 1- to 3-year-old wood. They mature in late spring, when eggs are produced. Hatching continues during early to midsummer. There is one brood per year. Scale is not a targeted pest for pest management, but as a vector for leafroll virus, it needs to be controlled when virus is present. It is usually controlled when growers are treating for mealybug.

Cultural control:
• Similar to cultural controls for mealybug (see page 22).

Biological control:
• Although biological controls of European fruit lecanium scale have not been studied, parasitic wasps generally parasitize scale insects heavily.

Chemical control:
• Horticultural oil (various products): Scales are best controlled in the dormant season. Sprays can also help control mealybugs. Some formulations are OMRI-listed for organic use.
• Imidacloprid (Admire Pro and other brands): moderate efficacy.
Critical needs for scale insect management in wine grapes

No critical needs were noted at this time.

**Thrips**

Grape thrips (*Drepanothrips reuteri*)
Western flower thrips (*Frankliniella occidentalis*)

Thrips commonly found on grapes are approximately 0.04 to 0.6 inches in size. Adult thrips have feather-shaped wings. Nymphs are wingless and usually yellow-orange. They usually appear at bloom as they feed on pollen and tender tissues. However, thrips have been found in early spring in Oregon vineyards, much earlier than bloom. Thrips may scar very young berries as early as fruit set. Later, the scars can restrict berry growth, producing oddly shaped or scarred berries. Occasionally, large populations of thrips may damage shoots and leaves in spring, particularly when cool conditions restrict plant growth. Damage caused by thrips during this period has been reported to be similar to that of rust and bud mites (leaf deformation and shoot scarring). Damage is usually minor and cosmetic on wine grapes in the Pacific Northwest. Extremely high populations that cause greater damage are usually found in vineyards located near alternative wild hosts.

Western flower thrips appear to be the most important species on grapes in the Pacific Northwest. This species has up to five or six generations per year. Populations usually peak during spring, which may be a result of migration into vineyards from surrounding host plants that are beginning to senesce. Thrips overwinter as adults or nymphs. Adult thrips feed on pollen as well as plant tissues. Scarring has been observed on stem, leaf and berry tissue in Oregon.

Grape thrips overwinter as virgin females in the soil, and populations peak in midsummer. This species may be mostly responsible for young-leaf and new-growth damage during summer.

Thrips are an occasional pest problem in all Oregon wine grape growing regions and can sometimes cause economic damage.

**Cultural control:**
- None used at this time.
**Biological control:**
Little is known about natural control of thrips in vineyards. Some predatory mites, predatory bugs, and spiders are known to feed on them.

**Chemical control:**
- **Azadirachtin (neem oil, Neemix and other brands):** Some formulations are OMRI-listed for organic use.
- **Kaolin clay (Surround WP):** Used for suppression only; supplemental controls may be needed for complete control. OMRI-listed for organic use.
- **Insecticidal soap (M-Pede and other brands):** This is a contact insecticide, and efficacy is related to the solution concentration and contact with the pest. Some formulations are OMRI-listed for organic use. Not recommended for use on Calmeria or Italia grape varieties.
- **Spinetoram (Delegate WG):** Not widely used.
- **Spinosad (Entrust or Success):** Not widely use. Entrust is OMRI-listed for organic use.

**Critical needs for thrips management in wine grapes**

**Research:**
- Develop economic or action thresholds for thrips that also address difficulties in scouting and monitoring (because of their frequent movement within vineyards).
- Develop best practices for when and how to best treat for thrips, including guidance on when to use spot treatment versus whole-field control.
- Research on whether the “netting effect” from thrips can cause cracking on fruit.

**Education:**
- Educate growers on best practices for thrips management once developed.
- Educate growers on early identification techniques.

No regulatory needs were noted at this time

**Diseases**

**Armillaria Root Rot** (*Armillaria mellea*)
Armillaria root rot is a fungus that infects vine roots. Often found in vineyards planted on newly cleared land, this root pathogen is native to Oregon and the Pacific Northwest, where it occurs on the roots of many forest tree species including Douglas-fir, madrone, oak, willow, and yellow pine. It also attacks black and red raspberries and trailing berries. Other agronomic hosts include currants, gooseberries, nut trees, roses, strawberries, stone fruits and many rosaceous plants. The host range includes over 500 species of woody plants, making its common name of "oak root fungus" misleading.

This fungus may form mushrooms at the base of infected vines in fall and winter. The fungus spreads vegetatively, below ground, which leads to the formation of groups of dead and dying plants called "disease centers." The fungus can survive on woody host roots long after the host dies. Its vegetative fungal tissue (mycelium) decomposes root wood for nutrients as it grows.

When infected plants are removed, infected roots that remain below ground serve as a source of inoculum for vines planted in the same location. Infection occurs when grape roots come in direct contact with partially decayed tree roots and are colonized by mycelium. Infection can also occur when grape roots contact rhizomorphs (black, shoestring-like fungal structures) that grow out from partially decayed roots and through the soil. Once vine roots are infected, whether they are living or dead, they serve as a source of inoculum for neighboring vines. The infection process takes months to happen. Spread between neighboring vines may take more than 10 years to occur. The disease negatively affects vine mineral-nutrition status and fruit quality.

Mildly symptomatic grapevines are distinguishable from healthy grapevines only by having shorter canes. Severely symptomatic grapevines not only have shorter canes, but their leaves are dwarfed and may be chlorotic.

This disease is not a major issue for growers in Oregon, but is present at times, and the infected area of the vineyard usually cannot be planted again.

**Cultural control:**
- Girdling large trees before removal to hasten decay of roots.
- Clearing soil of stumps and large roots after removal of above-ground vegetation.
- Burning all woody debris.
- Lining trenches with plastic sheeting to help reduce inoculum from an adjacent planting.
• With drip irrigation, moving drip-line emitters away from the trunk and in between plants after first year of planting.
• Permanently removing soil in a 3-foot radius around the crown and main vine root area.
• Removal and destruction of severely infected vines.
• Avoid replanting, if possible, where infected vines have been removed.

**Biological control:**
• None used at this time.

**Chemical control:**
• None used at this time.

**Critical needs for Armillaria management in wine grapes**

**Research:**
• Develop effective fumigation options for Armillaria control; preferably for use as a spot treatment.

No biological or educational needs were noted at this time

**Phomopsis** (a.k.a., Cane and leaf spot)

This disease is caused by *Phomopsis viticola*, a fungus. The fungus overwinters in the previous year's cane growth. Fruiting bodies of the fungus (pycnidia) produce many spores in the spring, which are released during rain events when the bark is wet. Spores are then rain-splashed to developing shoots. Young, rapidly growing tissues are most susceptible.

In the dormant season, infected canes may become bleached, and numerous black fruiting bodies (pycnidia) may develop all along the cane's basal region. This is the most common symptom in Oregon; however, other nonpathogenic fungi can cause similar cane bleaching. Small leaf spots also can occur early in leaf development, which can severely crinkle or misshape the leaf. Fruit rot has not been observed in Oregon or other parts of the Pacific Northwest. The variety ‘Mueller-Thurgau’ is known to be susceptible to this disease.

**Cultural control:**
• Infected canes are removed from the vineyard during normal pruning operations in the dormant season.
Biological control:

- None used at this time.

Chemical control: This disease is not common and thus not often controlled chemically. Below is a list of registered chemistries.

- Azoxystrobin (Abound): Effective.
- Captan: Very effective.
- Copper products (Nu-Cop): Not used.
- Kresoxim-methyl (Sovran): Effective, used.
- Mancozeb products (Dithane, Manzate Pro-Stick): Good efficacy. Disease may be called "dead arm" on some labels.
- Trifloxystrobin (Flint): Efficacy is fair.
- Ziram: Good efficacy.

Combination Fungicides (not widely used for phomopsis):

- Azoxystrobin + difenoconazole (Quadris Top): Solo azoxystrobin products more commonly used. Bosalid + pyraclostrobin (Pristine): More commonly used for other diseases, not phomopsis.
- Mancozeb + copper: (ManKocide): Solo mancozeb products more commonly used.
- Tebuconazole + trifloxystrobin (Adament): Efficacy unknown; not used.

Critical needs for Phomopsis management in wine grapes

Research:

- Research the possible links between Phomopsis cane and leaf spot and trunk diseases.

No regulatory or educational needs were noted at this time.

Sour rot

Sour rot can be caused by any number of primary or secondary pathogens, but is most commonly associated with various fungi, acetic acid bacteria, and fruit fly maggots. The "sour" smell is typically associated with the invasion of the bacteria *Acetobacter* and *Glucanobacter*. The vinegar smell is due to both gluconic acid as well as acetic acid. If fruit is initially damaged as a result of excessive rain, excessive wind or other diseases or insect pests, many secondary invasions by
fungal and bacterial microorganisms can occur. Sour rot typically does not spread from cluster to cluster, but can result in whole cluster loss.

Sour rots can be a significant problem regardless of harvest weather conditions. They are associated with varieties with compact clusters and varieties that are aromatic (and thus, attract insects). Conditions that favor development of grapevine powdery mildew or Botrytis bunch rot can also favor sour rot development.

Sour rot is best described as a "wet rot" in ripening grape clusters. Typical symptoms include a brown discoloration of the fruit and wet or oozing berries, coupled with the smell of vinegar and the presence of fruit flies. Sour rot is often confused with (and in many cases associated with) the early stages of Botrytis bunch rot, but can be distinguished by the associated "sour" smell. As a general distinction, Botrytis bunch rot is a dry, fuzzy rot of ripening fruit, whereas sour rot is considered a wet rot because it grows inside the berries in the pulp.

This is a sporadic pest in the Willamette Valley and Mid-Columbia regions, particularly in certain varieties.

**Cultural control:**
- Dropping or removing affected clusters preharvest to help prevent inadvertent picking of diseased fruit.
- If sour rot symptoms are severe, growers pick as early as possible to reduce the amount of spoiled fruit on the vines.

**Biological control:**
- None used at this time.

**Chemical control:**
"Once sour rot begins in a vineyard, it cannot be controlled. Therefore, the primary tactic in managing sour rot is prevention of fruit damage as a result of other diseases and pests."
- Chemical control of insects and other diseases reduces the likelihood of berry cracking or wounds, which helps reduce occurrence of sour rot.

**Critical needs for sour rot management in wine grapes**

**Research:**
- Identify effective detection, control options, and treatment for this disease.
• Research the biology, life cycle, management, and prevention of sour rot.
• Research potential vectors of sour rot in addition to fruit flies and wasps.

**Education:**
• Educate growers on biology, life cycle, prevention, and effective control strategies once identified.

No regulatory needs were noted at this time.
Emerging Pests

**Brown marmorated stink bug** (*Halyomorpha halys*)

Brown marmorated stink bugs (BMSB) have been increasing in commercial wine grape growing regions in the Northern Willamette Valley and have been found in many vineyards. It has been found in residential areas in Southern Oregon, but has not yet moved into the agricultural areas. It is present and increasing its distribution in the Mid-Columbia region, but has not yet become a vineyard pest. It has been found in two Walla Walla Valley vineyards to date.

This pest could pose a significant risk to fruit quality if populations increase. BMSB crawl into clusters close to harvest, resulting in a problematic aromatic taint during wine processing. Monitoring for BMSB is possible using commercially available pheromone traps placed close to surrounding vegetation. Alternate hosts include English holly, broadleaf maple, tree of heaven and empress tree. BMSB populations tend to build up during the latter portion of the season, and move from surrounding vegetation into vineyards and onto grape clusters.

**Cultural control:**
- None used at this time.

**Biological control:**
- None used at this time.

**Chemical control:**
- None used at this time.

**Critical needs for BMSB management in wine grapes**

**Research:**
- More research is needed on effective strategies for removing the bugs from the grape clusters before crush.
- More research is needed on how to better target host plants (maple and catalpa) as a means of controlling BMSB populations.
- Continued research on the potential for using a parasitoid from Asia for control, and its potential impacts on the native stinkbug.
• Determine how many of the insects are necessary to compromise the quality of wine made from BMSB-contaminated fruit and determine the tolerable level.
• Continued research on thresholds for BMSB-contaminated fruit on wine quality.

Education:
• Develop best management practices for BMSB, such as planting a green strip or buffer zone (which might also offer control for other pests such as mealybug).
• Educate winemakers on the development of BMSB thresholds, and impacts on wine quality.

No regulatory needs were noted at this time.

**European grapevine moth**

This pest is present in the Napa Valley area of California. An extremely extensive (and expensive) eradication program has been successful in almost eliminating this fruit-feeding moth, but if it were to move into Oregon, it could become a problematic pest.

Cultural control:
• None used at this time.

Biological control:
• None used at this time.

Chemical control:
• None used at this time.

**Critical needs for European grapevine moth management in wine grapes**

Education:
• Educate growers on this pest and how to identify it.

No research or regulatory needs were noted at this time.
**Gill’s mealybug**

This mealybug was recently identified for the first time in Oregon. It has been found in a few vineyards in Southern Oregon. Gill’s mealybug is established in California and is has become a pest in some Northern California vineyards. Unlike vine mealybug, the controls for grape mealybug have proven effective for this species. There is also evidence that natural enemies can assist in controlling populations of Gill’s mealybug. There is currently no pheromone for this mealybug. Since its numbers are increasing and it can vector viruses, it is an important emerging pest.

**Cultural control:**
- None used at this time.

**Biological control:**
- None used at this time.

**Chemical control:**
- None used at this time.

**Critical needs for Gill’s mealybug management in wine grapes**

**Research:**
- Determine effective controls for this pest.

No regulatory or educational needs were noted at this time.

**Light brown apple moth**

This is an emerging insect pest in the Willamette valley whose status needs to be monitored.

**Cultural control:**
- None used at this time.

**Biological control:**
- None used at this time.

**Chemical control:**
- None used at this time.
Critical needs for light brown apple moth management in wine grapes

Education:
• Educate growers on this pest and how to identify it.

No research or regulatory needs were noted at this time.

Pierce's disease

Pierce's disease, which has been a high-profile and rapidly increasing disease in California and other southern states, has been found in pears in the Hood River and Willamette Valley areas. The PNW climate may be too cold for the pathogen to survive. An efficient vector (the glassy-winged sharpshooter, GWSS) was found in California during the mid-1990s. Unlike the blue-green sharpshooter, GWSS is not restricted to riparian areas. The presence of GWSS is having a huge impact on producers in Southern California. Several GWSS were found near western Oregon ornamental nurseries in 2000. An extensive survey that fall of 291 samples from vineyards, native hosts, and nurseries did not find any evidence of the causal bacterium, Xylella fastidiosa subsp. fastidiosa. Periodic tests of grape and various woody plants with scorch symptoms have been conducted since then, and no Xylella has been detected; however, Xylella has been found recently in a nursery in the Willamette Valley region.

Symptoms of Pierce's disease first appear as water stress in midsummer. Leaves become slightly yellow or red along margins in white and red varieties, respectively, and eventually leaf margins dry or die in concentric zones. Fruit clusters shrivel or raisin. Dried leaves fall, leaving the petiole attached to the cane. Wood on new canes matures irregularly, producing patches of green, surrounded by mature brown bark. Pinot Noir and Cabernet Sauvignon have highly regular zones of progressive marginal discoloration and drying on blades. Usually only one or two canes will show Pierce's disease symptoms late in the first season of infection. Symptoms gradually spread along the cane from the point of infection out toward the end and more slowly toward the base. Cane tips and roots may die back. Vines deteriorate rapidly after symptoms appear. Shoot growth in infected plants becomes progressively weaker as symptoms become more pronounced.

Symptoms appear when a significant amount of xylem becomes blocked by the bacteria's growth. Any other problem that blocks, inhibits or limits water from
getting to the leaves will produce similar symptoms. Dryland grapes grown in western Oregon during the drought of 2001 displayed some of these same symptoms. Fungal cankers, damaged trunks, girdling roots, gopher damage, herbicide injury and root rots also can produce similar symptoms.

**Cultural control:**

- None used at this time.

**Biological control:**

- None used at this time.

**Chemical control:**

- Control the vector, GWSS, when present.

**Critical needs for Pierce’s disease management in wine grapes**

**Research:**

- Research effective prevention and treatment of this disease.
- Determine whether the present strain of *Xylella* is a threat to grapes, and to what extent; gather regionally specific data including hosts.
- Determine whether vines with Pierce’s disease can survive the winter in Oregon – can the bacteria survive the cold temperatures of our regions?

No regulatory or educational needs were noted at this time

**Spotted wing drosophila** (*Drosophila suzukii*)

Adult spotted wing drosophila (SWD) can be found feeding and laying eggs on grapes directly before harvest, especially when the berry surface area is cracked due to insect damage, bird damage or Botrytis. Research has shown that drosophilid flies may vector spoilage bacteria under these conditions, thereby influencing fruit quality. Growers should take necessary steps to ensure minimal berry damage: virtually no fully intact berries collected in vineyard studies had SWD eggs or larvae developing in them. A very small portion of damaged berries may contain eggs and an even smaller portion of eggs manages to develop to adulthood. However, research continues to determine the effect of seasonal differences on SWD populations.
This insect has had no known commercial impact on wine grapes in Oregon to date. Generally the fruit skin of wine grapes are thick enough that penetration with the female ovipositor is difficult. However, drosophila (both *suzukii* and *melanogaster*) can carry the bacteria for sour rot and create issues in wine production.

**Cultural control:**
- None used at this time.

**Biological control:**
- None used at this time.

**Chemical control:**
- None used at this time.

**Critical needs for spotted-wing drosophila management in wine grapes**

**Research:**
- Research the potential impacts on wine quality from spotted-wing and other drosophila present on grapes (based on increase and spread of spoilage bacteria).

**Education:**
- Educate growers on how to monitor for SWD.

No regulatory needs were noted at this time.

**Sugar accumulation disorder (a.k.a. “sour shrivel” or “waterberry”)**

Sugar accumulation disorder (SAD; formerly called berry shrivel) is the most common form of shrivel. SAD causes poor berry coloration and low sugar accumulation, and is triggered after véraison. SAD fruit typically have lower pH, berry weight, and Brix compared to normally developing fruit. Berries may contain up to 70 to 80% less sugar than healthy berries and are often shriveled. Unlike bunch stem necrosis, the rachis remains healthy. With both diseases, berries near the cluster tips are often more affected than berries at the stem end.

SAD occurs in many wine grape varieties, both red and white. No consistent patterns are discernible in a vineyard or a vine. In some vineyards, the whole vine may be affected, with some clusters shriveled and others not shriveled but
having lower sugar and pH. In other cases, normal clusters on SAD vines may be healthy with normal sugar and pH levels. Vines affected in one year may or may not be affected the next year. Damage can range from 5% of vines to 25% or more in a given year. No pathogen has been identified, although it is possible that a pathogen may be involved. University of California experiments found that healthy buds grafted onto SAD vines developed SAD fruit; also, SAD was able to spread from grafted buds to affect an entire vine.

The causes of SAD and bunch stem necrosis are not fully understood. Studies have shown that both disorders are likely associated with death of phloem tissues in the rachis that prevents water and sugar transport into the berries, and there may be a gradual transition between the two disorders. With bunch stem necrosis, necrotic lesions result in reduced water and sugar transport into the berries. With SAD, transport is also reduced, but without the rachis dying. No methods for control of SAD or bunch stem necrosis have been developed.

The only strategy recommended at this time is to monitor vineyards with a history of SAD before harvest and drop affected clusters.

**Cultural control:**
- None used at this time.

**Biological control:**
- None used at this time.

**Chemical control:**
- None used at this time.

**Critical needs for SAD management in wine grapes**

**Research:**
- Research the cause(s) of this disorder, and effective treatments.

No regulatory or educational needs were noted at this time.

**Vine mealybug**

This is a major invasive insect pest in California; it has not yet been found in Oregon but may become an issue in the future. Grape mealybug management strategies will likely not be as effective on vine mealybug, as there are more generations per year of the vine mealybug. Thus, if this pest becomes a
established in Oregon, it has the potential be more problematic than grape mealybug. Pheromone monitoring can be done for vine mealybug, and OSU and ODA should be encouraged to assist in a program for early detection and prevention.

**Cultural control:**
- None used at this time.

**Biological control:**
- None used at this time.

**Chemical control:**
- None used at this time.

**Critical needs for vine mealybug management in wine grapes**

**Research:**
- Research the potential for the use of nematodes for vine mealybug control.

**Education:**
- Educate growers on how to monitor for this mealybug.

**Regulatory:**
- Encourage OSU and ODA to assist in a program for early detection and prevention.

**Winter cutworm (*Noctua pronuba*)**

Although adult *Noctua pronuba* moths have been in Oregon for more than a decade, they have never been an agricultural concern. However, for the first time in this region, there have been increasing reports of damage by winter cutworm, the larval stage of the large yellow underwing moth. The pest is called winter cutworm because it can actively feed throughout the fall and winter. The specific cause of this year’s outbreak is uncertain. Similar patterns have occurred in Michigan and Idaho, where adult moths are common, but damage by larvae appears suddenly and is intense.

This cutworm is a potential emerging pest that can be very destructive to cover crops, both clover and grass crops. Wide swaths of damage are evident because this species moves en masse, like armyworms. So far, winter cutworm damage
has been detected between rows, on cover crops, and in grassy or weedy areas adjacent to vineyards. Other climbing cutworms (Xestia c-nigrum, Euxoa ochrogaster, Abagrotis orbis) can damage emerging shoots at bud break, but winter cutworm feeding on buds has not yet been confirmed in Oregon. A recent survey of Washington vineyards found N. pronuba feeding only on weeds but found a related species, N. comes, feeding on vines at night.

Cultural control:
• None used at this time.

Biological control:
• None used at this time.

Chemical control:
• None used at this time.

Critical needs for winter cutworm management in wine grapes

Research:
• Research on life stages, pest damage, and effective controls.

No regulatory or educational needs were noted at this time.
References

5. Sugar Accumulation Disorder: http://www.lodigrowers.com/sugar-accumulation-disorder-sad-affecting-several-vineyards/
Activity Tables for Oregon Wine Grapes: Willamette Valley Region

Notes:
An activity may occur at any time during the designated time period but generally not continually curing that time period.

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Activity Tables for Oregon Wine Grapes:
Southern Oregon Region

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Activity Tables for Oregon Wine Grapes:
Walla Walla Valley Region

Notes:
An activity may occur at any time during the designated time period but generally not continually curing that time period.
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# Activity Tables for Oregon Wine Grapes: Mid-Columbia Region

**Notes:**

An activity may occur at any time during the designated time period but generally not continually curing that time period.

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# Seasonal Pest Occurrence for Oregon Wine Grapes: Willamette Valley Region

**Notes:**

“X” = times when pest management strategies are applied to control these pests, not all times when pest is present.

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## Seasonal Pest Occurrence for Oregon Wine Grapes: Southern Oregon Region

**Notes:**
“X” = times when pest management strategies are applied to control these pests, not all times when pest is present.

### Insects and Nematodes

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### Diseases and Viruses

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# Seasonal Pest Occurrence for Oregon Wine Grapes:
## Walla Walla Valley Region

**Notes:**
"X" = times when pest management strategies are applied to control these pests, not all times when pest is present.

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Seasonal Pest Occurrence for Oregon Wine Grapes: Mid-Columbia Region

Notes:
“X” = times when pest management strategies are applied to control these pests, not all times when pest is present.

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Efficacy Ratings for INSECT, MITE, and Nematode Management Tools in Oregon Wine Grapes

Rating scale: E = excellent (90–100% control); G = good (80–90% control); F = fair (70–80% control); P = poor (< 70% control); ? = efficacy unknown in [crop] management system—more research needed; * = used but not a stand-alone management tool; BLANK = not used for this pest; chemistry or practice known to be ineffective; x = see individual pest section for further comments.

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<td>Horticultural oil</td>
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<td>Imidacloprid (Admire, Provado)</td>
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<td>Insecticidal soap (M-Pede)</td>
<td>F</td>
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<td>Thrips control also</td>
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<td>Kaolin clay (Surround)</td>
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<td></td>
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<td>Lime sulfur</td>
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<td>Metam sodium (Basamid)</td>
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<td>Neem oil</td>
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<td>Old OP chemistry not used.</td>
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<td>Pyridaben (Nexter)</td>
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<td>Spinetoram (Delegate)</td>
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<td>Spinosad (Success)</td>
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<td>Spirodiclofen (Envidor)</td>
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<td>G</td>
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<tr>
<td>Spirotetramat (Movento)</td>
<td>E</td>
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<tr>
<td>Sulfur</td>
<td>G</td>
<td>G-E</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Soil applied and systemic.</td>
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<tr>
<td>Thiamethoxam (Platinum)</td>
<td>G</td>
<td>F-G</td>
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Unregistered/New Chemistries

None at this time.

Biological

| Paecilomyces lilacinus (MeloCon WG): | ? |

95
<table>
<thead>
<tr>
<th>MANAGEMENT TOOLS</th>
<th>Cutworm</th>
<th>Leafhopper</th>
<th>Mealybug</th>
<th>Erineum mite</th>
<th>Rust mite</th>
<th>Spider mite</th>
<th>Nematodes</th>
<th>COMMENTS</th>
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</thead>
<tbody>
<tr>
<td>Burkholderia spp. strain A396 (Majestene):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>Cultural/Non-Chemical</td>
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<td></td>
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<td>Clean cultivation</td>
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</tr>
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<td>Cover crop management</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td>*</td>
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</tr>
<tr>
<td>Dust control</td>
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<td></td>
<td></td>
<td></td>
<td>*</td>
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<td></td>
</tr>
<tr>
<td>Effective weed control</td>
<td>*</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Sanitation</td>
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<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoot/sucker/leaf removal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
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</tbody>
</table>

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Efficacy Ratings for Disease and Virus Management Tools in Oregon Wine Grapes

Rating scale: E = excellent (90–100% control); G = good (80–90% control); F = fair (70–80% control); P = poor (< 70% control); ? = efficacy unknown, more research needed; BLANK = not used for this pest; * = used but not a stand-alone management tool; x = see individual pest section for further comments.

<table>
<thead>
<tr>
<th>MANAGEMENT TOOLS</th>
<th>Botrytis</th>
<th>Crown gall</th>
<th>Powdery mildew</th>
<th>Trunk diseases</th>
<th>Red blotch virus</th>
<th>Leafroll virus</th>
<th>COMMENTS</th>
</tr>
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<tbody>
<tr>
<td>Registered Chemistries</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Azoxystrobin (Abound)</td>
<td></td>
<td>G</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Resistance concerns</td>
</tr>
<tr>
<td>Azoxystrobin + difenoconazole (Quadris Top)</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Not used</td>
</tr>
<tr>
<td>Bicarbonate (Armicarb)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Efficacy questioned; can suppress sporulation.</td>
</tr>
<tr>
<td>Boscalid (Endura)</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Not widely used.</td>
</tr>
<tr>
<td>Boscalid + pyraclostrobin (Pristine)</td>
<td>P</td>
<td>F-G</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Botrytis resistance concerns; no longer widely used</td>
</tr>
<tr>
<td>Captan</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No longer used; foreign market concerns</td>
</tr>
<tr>
<td>Copper</td>
<td>F-G</td>
<td>P</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td>Used by some; correct timing is critical.</td>
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<tr>
<td>Cyprodinil (Vangard)</td>
<td>E</td>
<td></td>
<td></td>
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<tr>
<td>Cyprodinil + fludioxinil (Switch)</td>
<td>E</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Limited used due to cost.</td>
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<tr>
<td>Dicloran (Botran)</td>
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<tr>
<td>Difenoconazole + (Inspire Super)</td>
<td>G-E</td>
<td>G-E</td>
<td></td>
<td></td>
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<td></td>
<td>Used by some growers.</td>
</tr>
<tr>
<td>Fenarimol (Focus)</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Incompatible with copper limits use.</td>
</tr>
<tr>
<td>Fenhexamid (Elevate)</td>
<td>E</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Fluopyram (Luna Privilege)</td>
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<tr>
<td>Fluopyram + tebuconazole (Luna Experience)</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td>Efficacy questioned; not used</td>
</tr>
<tr>
<td>Gallex</td>
<td></td>
<td>x</td>
<td></td>
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<tr>
<td>Ipodione (Rovral)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Good efficacy if resistance is absent.</td>
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<tr>
<td>Kresoxim-methyl (Sovran)</td>
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<td></td>
<td></td>
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<td>Widely used</td>
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<tr>
<td>Mancozeb (Manzate)</td>
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<td></td>
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<td></td>
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<tr>
<td>Myclobutanil (Rally)</td>
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<td>Widely used</td>
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<tr>
<td>Oils</td>
<td>G</td>
<td></td>
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<td></td>
<td></td>
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<td>Used in early season</td>
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<tr>
<td>Polyoxin (Ph-D)</td>
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<td>Pyrimethanil (Scala)</td>
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<tr>
<td>Quinoxyfen (Quintec)</td>
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<tr>
<td>Soaps</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
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<td>Used in early season.</td>
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<tr>
<td>Sulfur</td>
<td>E</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Most common product used for powdery mildew control</td>
</tr>
<tr>
<td>Tebuconazole (Tebuzol)</td>
<td>?</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Tebuconazole + sulfur (Unicorn)</td>
<td>?</td>
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<td></td>
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<tr>
<td>Tebuconazole + trifloxystrobin (Adament)</td>
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<td>Used by some; resistance concerns</td>
</tr>
<tr>
<td>Tetraconazole (Mettle)</td>
<td>?</td>
<td>x</td>
<td></td>
<td></td>
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<td>Thiophanate-methyl (Topsin)</td>
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<td>Resistance concerns for powdery mildew</td>
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<tr>
<td>Trifloxystrobin (Flint)</td>
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<td>Resistance concerns for powdery mildew</td>
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<tr>
<td>Triflumizole (Procure)</td>
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<tr>
<td>Ziram</td>
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Unregistered/New Chemistries
<table>
<thead>
<tr>
<th>MANAGEMENT TOOLS</th>
<th>Botrytis</th>
<th>Crown gall</th>
<th>Powdery mildew</th>
<th>Trunk diseases</th>
<th>Red blotch virus</th>
<th>Leafroll virus</th>
<th>COMMENTS</th>
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<tbody>
<tr>
<td>None at this time.</td>
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<td>Regalia (Reynoutria spp.)</td>
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<td><strong>Cultural/Non-Chemical</strong></td>
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<tr>
<td>Canopy management (shoot thinning and leaf pulling)</td>
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<tr>
<td>Cultivar/rootstock selection</td>
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<td>*</td>
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<tr>
<td>Fertilization management</td>
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<tr>
<td>Irrigation management</td>
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<tr>
<td>Sanitation</td>
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<td></td>
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<td>*</td>
</tr>
</tbody>
</table>

* Indicates tools that are effective against the respective disease.
### Efficacy Ratings for WEED Management Tools in Oregon Wine Grapes

**Rating scale:**
- **E** = excellent (90–100% control)
- **G** = good (80–90% control)
- **F** = fair (70–80% control)
- **P** = poor (<70% control)
- **?** = efficacy unknown—more research needed
- **BLANK** = not used for this pest
- *** = used but not a standalone management tool.**

Note: Weed size or stage of growth is an important consideration with most post-emergence herbicides.

In “Type” column, Pre = soil-active against pre-emerged weeds; Post = foliar-active against emerged weeds.

<table>
<thead>
<tr>
<th>MANAGEMENT TOOLS</th>
<th>Type</th>
<th>ANNUAL BROADLEAVES</th>
<th>BIENNIALS</th>
<th>PERENNIAL BROADLEAVES</th>
<th>GRASSES</th>
<th>COMMENTS</th>
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<tr>
<td>Registered Chemistries</td>
<td></td>
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</tr>
<tr>
<td>Bentazon (Basagran)</td>
<td>POST</td>
<td>F</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>F</td>
</tr>
<tr>
<td>Carfentrazone-ethyl (Aim)</td>
<td>POST</td>
<td>F</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>F</td>
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<tr>
<td>Clethodim (Select Max)</td>
<td>POST</td>
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<tr>
<td>D-limonene (lemongrass oil)</td>
<td>POST</td>
<td>F</td>
<td>F</td>
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<td>P</td>
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<tr>
<td>Dichlobenil (Casoron)</td>
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<td>F</td>
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<td>F</td>
<td>F</td>
</tr>
<tr>
<td>Diquat (Reglone)</td>
<td>POST</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>Diuron (Karmex)</td>
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<td>P</td>
<td>F</td>
<td>G</td>
<td>G</td>
<td>P</td>
</tr>
<tr>
<td>Flazasulfuron (Mission)</td>
<td>PRE/POST</td>
<td>?</td>
<td>F</td>
<td>G</td>
<td>G</td>
<td>?</td>
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<td>Fluazifop (Fusilade)</td>
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</tr>
<tr>
<td>Flumioxazin (Chateau)</td>
<td>PRE/POST</td>
<td>F</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>F</td>
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<tr>
<td>Glufosinate ammonium (Rely)</td>
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<td>G</td>
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<tr>
<td>Glyphosate</td>
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<td>G</td>
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<td>Indaziflam (Alion)</td>
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<td>F</td>
<td>E</td>
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<tr>
<td>Isoxaben (Trellis)</td>
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<td>Napropamide (Devrinol)</td>
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<td>Norflurazon (Solicaam)</td>
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<tr>
<td>Oryzalin (Surflan)</td>
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<td>G</td>
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<td>P</td>
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<tr>
<td>Oxfluorfen (Goal)</td>
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<td>G</td>
<td>G</td>
<td>G</td>
<td>F</td>
</tr>
<tr>
<td>Paraquat (Gramoxone)</td>
<td>POST</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>Pendimethalin (Prowl)</td>
<td>PRE</td>
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<td>G</td>
<td>F</td>
<td>F</td>
<td>P</td>
</tr>
<tr>
<td>Pronamide (Kerb)</td>
<td>PRE</td>
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<td>BIENNIALS</td>
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<td>Mallow</td>
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<td>False dandelion, spotted cassar</td>
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