

**A Pest Management Strategic Plan
for
Winegrape Production in California**

**Prepared for the
California Winegrape Industry,
United States Department of Agriculture,
& United States and California Environmental Protection Agencies**

**By the
California Winegrape Work Group**

June 2009

Contacts:

Karen Ross, President
California Association of Winegrape Growers
(800) 241-1800
karen@cawg.org

Table of Contents

Executive Summary	3
Work Group Members	4
Top Priorities	5
Production Facts and Background	8
Foundation for the Pest Management Strategic Plan	11
Vineyard Establishment	12
Dormancy (December – mid March)	18
Bud Break to Start of Bloom (mid March – early June)	29
Bloom to Veraison (early May – early August)	45
Veraison to Harvest (early July – early November)	59
Post Harvest (August – November)	70
Efficacy Tables for Pest Management Tools	79
Insects and Mites	79
Nematodes	82
Diseases	83
Weeds	86
Toxicity Table for Natural Enemies	88
Generalized Farming Activity Table	89
Pest Occurrence Tables by Region	90
References	95

Executive Summary

The United States Environmental Protection Agency (EPA) continues to re-register pesticides under the requirements of the 1996 Food Quality Protection Act (FQPA) by examining dietary, ecological, residential, and occupational risks. EPA's regulatory focus on the organophosphate, carbamate, and B₂ carcinogen pesticides has created uncertainty as to their future availability. At some point, EPA may propose to modify or cancel some or all uses of these chemicals on winegrapes. Additionally, the regulatory studies that EPA requires may cause some registrants to voluntarily cancel certain registrations rather than incur additional costs.

Moreover, the continued focus on organophosphate risks may lead some winegrape processors to require that growers not use them. California's winegrape growers avoid organophosphates because of adverse impacts on natural enemies and concerns about human and environmental safety. However, it is important to maintain registered uses for critical/crisis pest management situations such as those for the glassy-winged sharpshooter, vine mealybug, and potential new threats.

A work group consisting of growers, commodity groups, regulators, University of California specialists, and other technical experts met May 5, 2008 at the University of California, Davis. The purpose was to identify research, regulatory, and educational needs for winegrapes in California with reference to possible regulatory actions regarding pesticides and FQPA. The discussion and priorities identified at, and subsequent to, the meeting were used as the basis for this updated California Winegrape Pest Management Strategic Plan (PMSP).

An important objective of the California winegrape community is to encourage growers to adopt sustainable vineyard and winery practices, evidenced by the ongoing, and highly successful, California Sustainable Winegrowing Program. This program and related activities at state and regional levels demonstrate a long-term commitment to speeding the adoption of reduced-risk pest management and the critical needs identified in this strategic plan are an important step towards this.

Crucial to sustainability is anticipating that regulatory restrictions and continuing environmental concerns (e.g., water and air quality), as well as population growth in traditional farming areas which create challenging rural-urban relationships, will impact the future availability of pest control products. The United States Department of Agriculture, EPA, land-grant universities, and the winegrape community must continue to work together to proactively identify and resolve research, regulatory, and educational needs for reducing the reliance on higher-risk pesticides and promoting sustainable pest management practices.

Work Group Members

Bryan Anthony, Wentz Family Estates
Berny Borges, Monterey Pacific
Laura Breyer, Sonoma County Winegrape Commission
Joe Browde, California Sustainable Winegrowing Alliance
Kent Daane, University of California, Berkeley
Nick Frey, Sonoma County Grape Growers Association
Jon Holmquist, Constellation Wines US
Cindy Johnson, Brown-Forman Corporation
Rick Melnicoe, USDA Western Integrated Pest Management Center
Emilio Miranda, Allied Grape Growers
Glenn McGourty, University of California, Davis
Julie Nord, Napa Valley Grape Growers
Cliff Ohmart, Lodi-Woodbridge Winegrape Commission
Steve Quashnick, Wilbur-Ellis Company
Karen Ross, California Association of Winegrape Growers
Sara Savary, Crop Care Associates, Inc.
Ann Thrupp, Fetzer Vineyards
Jim Wells, Environmental Solutions Group, LLC

Funding for this effort was provided by the Western Integrated Pest Management Center and the California Association of Winegrape Growers. In-kind contributions were provided by many of the participating individuals and organizations. The mention of any specific product by common or trade name does not imply endorsement by the Work Group or the organizations represented.

Top Priorities for Pest Management in California Winegrapes

The following priorities must be addressed to ensure the long-term viability of the California winegrape industry.

Research:

1. Develop the infrastructure to quickly identify, react to, and manage exotic pests prior to their establishment in California. Accordingly, the California Association of Winegrape Growers (CAWG) supports the formation of an Invasive Species Council, as proactive public relations and education on exotic pest issues is critical. Programs formed for similar initiatives include the MedFly Task Forces at the County Agricultural Commissioner and community level.
2. Need more research on producing high quality, basic plant material to improve plant health and prevent transmission of diseases and pests.
3. Increase research on systems approaches to pest management through improved understanding of the responses of diverse pests and natural enemies to: a) irrigation management, b) fertilizer rate, c) canopy management, d) soil health, e) habitat management, and f) cover cropping.
4. Find new sustainable control tactics and strategies for vine mealybug.
5. Determine impacts of old and new pesticide chemistries, including insect growth regulators, on natural enemies. Identify research done or underway. Some pertinent information for older chemistry is known based on limited research and grower experience. Ensure more comprehensive information is available for new, more novel chemistries when first registered. Nick Mills (University of California, Berkeley) is being funded by the California Department of Food and Agriculture (CDFA) to summarize current understandings of pesticide-natural enemy interactions and should be finished in 2009.
6. Improve understanding of the relationship between the soil environment, especially its microbiology, and nematode population dynamics and damage.
7. Improve understanding of nematicidal properties of diverse mustard species, including those used as cover crops.
8. Need more research and technology for post-plant management of nematodes.
9. Increase understanding of the pros and cons of cover cropping.
10. Need more research on relieferal viruses and disease-insect-plant interactions.
11. Develop technology to prevent vine infection with Pierce's disease (PD). A relevant PD-Board funded project conducted by Steve Lindow (University of California, Berkeley) has produced promising results; follow-up to focus on whether additional work is needed.
12. Determine and demonstrate more environmentally friendly, cost-effective herbicides (particularly organically approved) and other weed management tactics and develop guidelines for weed tolerance. Because of minimal relevant work and numerous challenges, it may be difficult to establish traditional, practical economic thresholds for weeds in winegrapes. Nevertheless, a consensus about a yard-stick approach to weed tolerance may be reached.
13. Develop economic thresholds for spider mites. Mills and Daane (University of California, Berkeley) have relevant work underway.
14. Develop resistance management programs for all arthropod pests.
15. Identify new products and/or methods for managing Eutypa dieback/Bot canker, of practical use for large and small acreages. One useful development by Doug Gubler (University of California, Davis) involves the multifaceted strategy of double pruning and the treatment of pruning wounds with Topsin-M, B-Lock, or Rally.
16. Develop new and more efficient technologies for applying chemical and non-chemical products (e.g., biologicals - considering the carbon footprint). There have been improvements but few

new technologies.

Regulatory:

1. Register additional pre-plant alternatives to methyl bromide. Methyl iodide has limited registration in the US and registration in California is pending. Azides and dimethyl disulfide, while not nearly as effective as methyl bromide, are potential alternatives not yet registered in the US.
2. Minimize adverse impacts of regulations for mitigating volatile organic compound (VOC) emissions from pesticides on the viability of winegrower business. Fumigant application methods are being restricted in some production areas because of VOC emissions. The full impact of the regulations and subsequent adaptation measures are unknown at this time.
3. Register new products for managing vine mealybug, for which control has been constrained by international export concerns. Full registration of Movento for international markets may not occur for two or three years likely because of delays in approving maximum residue levels (MRLs), especially for exports to Japan. The Valent product Clutch looks promising but restrictions on residues exist for some countries (see regulatory priority 9 below).
4. Work with regulatory agencies to negotiate a statewide sustainable plan to comply with requirements for agricultural discharge waivers. An alternative compliance option that rewards growers involved in sustainable winegrowing programs exists for the Central Coast. A similar arrangement has not been established statewide. Currently, a region by region approach is necessary as waiver requirements vary regionally.
5. Work with regulatory agencies to negotiate a sustainable plan to comply with requirements for air quality improvement (i.e., VOC compliance verification program). The goal is to institute a grower-friendly, rewarding, alternative compliance approach built around a commitment to the Sustainable Winegrowing Program. This compliance alternative would involve use of innovative, sustainable agricultural practices that address environmental concerns.
6. Expedite the registration of environmentally friendly, cost-effective products.
7. Continue collaboration with the Sulfur Task Force and state and local regulators to ensure compliance with requirements for maintaining sulfur products and uses. Better application technology for decreasing drift and improving on-target deposition is needed.
8. Accommodate new and better technologies for applying pest control products, and modify product labels accordingly.
9. Improve MRL development by ensuring timely residue studies and a more efficient process through Codex or with trading partners.
10. Ensure that CDFA increases pest inspections and is more proactive with exclusion programs.
11. Minimize impacts of the completed United States Environmental Protection Agency Reevaluation Eligibility Decision (RED) for fumigants on the viability of winegrower business. Mitigation measures have not been finalized but inevitably will affect pre-plant fumigation practices.

Education:

1. Obtain a better understanding of research initiatives elsewhere in the world and determine means to share and collaborate.
2. Continue grower education on sustainable pest management practices. Expand the number of growers involved in the successful California Sustainable Winegrowing Program and using its Code of Sustainable Winegrowing Practices Self-Assessment Workbook and/or other self-assessment tools. The Code documents best management practices (BMPs) based on the

combination of best-understood science and expert practitioner experience. Certification involving the Code and Sustainable Winegrowing Program likely will involve a commitment to the program's process-based cycle of continuous improvement, i.e., assessment, the interpretation of performance, farm planning, and the implementation of change.

3. Increase grower education on systems approaches for pest management, including impacts of irrigation and moisture, fertilization, cover cropping, canopy management, habitat management, dust management, and other measures on the population dynamics of pests and natural enemies.
4. Better educate growers and pesticide applicators about various sprayer technologies and their effective operation (proper calibration and application use rates, timing, coverage, and placement). Education should include the preparation and distribution of pertinent educational material and at LEAST annual how-to-calibrate "road shows" or demonstrations. Accordingly, the Coalition for Urban and Rural Environmental Stewardship (CURES) holds calibration workshops and spray tables are online.
5. Continue educating growers and pesticide applicators about mitigating pesticide drift and associated complaints and compliance with requirements for pesticide use reporting.
6. Work with the University of California to ensure land grant universities support growers in resolving regulatory challenges and remaining competitive on a global basis.
7. Continue educating growers, pest control advisors, and workers on identifying, monitoring, and advanced IPM approaches for vine mealybug.
8. Continue educating growers and pest control advisors on the importance of using pest monitoring and economic thresholds (i.e., data-driven decision making) as the foundation for pest management.
9. Improve cross-commodity collaboration to promote BMPs and deter invasive pests.
10. Effectively educate consumers, regulators, and public interest groups about pest management practices and negotiate alliances with them to provide third-party credibility.
11. Organize a group to develop relevant public education initiatives if the use of genetically modified organisms (GMOs) is anticipated for winegrapes.
12. Develop a response to potential inquiries regarding pesticide residues in wine. Although residue testing and responses are done independently to protect brand equity, an appropriate generic response will enhance industry wide public relations.
13. Demonstrate to the winegrowing industry how to utilize the MRL database website: www.mrldatabase.com. Associated information can help identify and proactively address potential issues in export markets.
14. Better educate growers and nursery staff about the critical need to produce high quality, basic plant material to improve plant health and prevent transmission of disease and pests. Education should relate to suitcase selections of budwood from other countries, field selection of budwood without cleanup, ongoing treatments of nursery stock to control vine mealybug and viruses, and related topics.

Production Facts and Background

Winegrape production is a major agricultural business in California. In 2007, winegrapes were produced on 523,000 acres, accounting for 3,247,477 tons. The total tonnage of all grapes crushed – wine, table and raisin-type – for wine and concentrate was 3,674,426 tons. There are 4,600 winegrape growers and 2,687 wineries that contribute to making wine the number one finished product in California with an estimated overall economic impact of \$51.8 billion per year as a sum of total spending. California supplies about 90% of the country's total processing grape production and utilization.

Grapes are grown in all areas of California with the exception of the high country. The San Joaquin Valley is the major production area for table grapes, raisins, and winegrapes. Other areas having significant production are the northern coastal counties of Napa, Sonoma, Lake, and Mendocino and the central coastal counties of Santa Clara, Monterey, Santa Cruz, San Luis Obispo, and Santa Barbara. Smaller, but significant, clusters of vineyards are found in the southern coastal counties of San Diego and Riverside, the Sierra Foothills and elsewhere throughout the state. Each area has distinct climatic and geologic characteristics that lead to different cultural and pest management practices.

Major grape growing regions can be summarized as follows:

North Coast: *About 12% of winegrape production.* Includes Lake, Mendocino, Napa, and Sonoma counties, and portions of Marin and Solano counties. The North Coast region is located north of San Francisco. It consists of mountains, hills, valleys, and plains that are all influenced by their proximity to the Pacific Ocean. The relatively flat valley floor vineyards are prone to spring frost with silty, clay loam soils relatively high in organic matter. The hillsides above the valley floor consist of steep to rolling land with variably shallow or rocky soils requiring contour planting or contour terracing to control erosion.

Central Coast: *About 11% of winegrape production.* Includes Alameda, Contra Costa, Monterey, San Luis Obispo, Santa Barbara, San Benito, Santa Cruz, Santa Clara, San Mateo, and Ventura counties. The Central Coast region is located south of San Francisco, from Livermore to Santa Ynez. This area is comprised of rolling hillsides or benchlands with soils ranging from sandy loams to gravelly clay loams relatively high in organic matter.

South Coast: *About 0.1% of winegrape production.* Includes winegrape growing areas primarily in Los Angeles, San Bernadino, San Diego, and Riverside counties. The South Coast region is located between Los Angeles and San Diego and includes the area from Escondido to Temecula. In this region, soils are often low in organic matter. Vineyards are frequently planted on sandy soils or hillsides that need stabilization from erosion.

The Sierra Nevada: *About 0.5% of winegrape production.* Includes Nevada, Placer, El Dorado, Amador, Calaveras, Tuolumne, and Mariposa counties. This region is almost entirely a California mountain range that extends along the eastern edge of the Central Valley. The area stretches from Nevada County in the north to Mariposa County in the south – a distance of over 200 miles. Unique characteristics of the foothills include warm and sunny days, cool nights, and relatively cool growing conditions with full sunlight and the absence of summer fog at higher elevations. Soils are primarily granitic.

Sacramento Valley/Northern San Joaquin Valley: *About 29% of winegrape production.* Includes San Joaquin, Colusa, Glenn, Sacramento, Merced, Stanislaus, Yolo, and Yuba counties, with production almost exclusively focused on wine, with a minimal amount of raisin and table grape production. The Sacramento Valley extends from Redding to south of Lodi, including the Sacramento Delta area. The Northern San Joaquin Valley consists of the inland area from Stockton to Merced. Light to medium textured soils with low organic matter predominate in this region. Most vineyards are planted on flat land.

Southern San Joaquin Valley: *About 47% of winegrape production.* Includes Fresno, Kings, Tulare, Kern, and Madera counties. This region focuses on a mixture of grape production, with table and raisin grapes produced in addition to wine grapes. The Southern San Joaquin Valley region is the inland area from south of Merced to the Tehachapi Mountain Range. Light to medium textured soils with low organic matter predominate. Most vineyards are planted on flat land.

The United States Environmental Protection Agency (EPA) continues to re-register pesticides under the requirements of the 1996 Food Quality Protection Act (FQPA) by examining dietary, ecological, residential, and occupational risks. EPA's regulatory focus on the organophosphate, carbamate, and B₂ carcinogen pesticides has created uncertainty as to their future availability. At some point, EPA may propose to modify or cancel some or all uses of these chemicals on winegrapes. Furthermore, the additional regulatory studies that EPA requires registrants to complete may cause some companies to voluntarily cancel certain registrations rather than incur additional costs of the required studies. In addition, the continued focus on organophosphate risks may lead some winegrape processors to require that growers not use them.

In addition to ramifications from federal pesticide regulatory programs, California growers in some regions face increasing regulatory constraints from requirements for the reduction of volatile organic compound (VOC) emissions from pesticide use and from requirements aimed at reducing or eliminating pesticide residues in surface water. A Federal Reregistration Eligibility Document (RED) for fumigants will be issued in spring 2009 that could significantly affect pest control options for winegrape growers.

In 1998, the California Association of Winegrape Growers (CAWG) began a model, statewide approach to public-private partnering on pesticide issues by working with EPA and the University of California Sustainable Agriculture Research and Education Program to establish the California Grape Partnership. Led by grower organizations, state and federal agencies, university specialists, and environmentalists, the Partnership confronted concerns about pesticides, especially those targeted by FQPA, and envisioned practical responses for positioning the industry on a path of increasing sustainability. Significant contributions by the Partnership include the first (1999) and second (2002) California Winegrape Crop Profiles and the first California Winegrape Pest Management Strategic Plan (PMSP, 2000). CAWG later convened a similar workgroup that produced a second PMSP in 2004.

These Crop Profiles and PMSPs enabled CAWG to lead in establishing and improving two important statewide programs involving pesticides and pest management – the California Winegrape Pest Management Alliance and the California Sustainable Winegrowing Program. The Alliance, funded by the California Department of Pesticide Regulation (CDPR) and EPA, was a grower-driven partnership implemented from 2000 to 2003 for sharing reduced-risk practices, focused on powdery mildew and weeds. Alliance activities subsequently were merged with the more comprehensive Sustainable Winegrowing Program, which began in 2001 and is an ongoing

collaboration led by CAWG and the Wine Institute to enhance the adoption of sustainable winegrowing practices from ground to bottle.

At the regional level, California's winegrape growers have a history of leadership in the adoption of new technologies, alternative pest management systems, and integrated farming systems. Regional organizations have been involved in a number of projects to promote the adoption of pest management practices that minimize human health and environmental risks. Examples include those by the Lodi-Woodbridge Winegrape Commission, the Central Coast Vineyard Team, the Sonoma County Winegrape Commission, and the Napa Sustainable Winegrowing Group.

An important CAWG objective is to encourage growers to adopt sustainable vineyard practices, as exemplified by its leadership in the Winegrape Pest Management Alliance and Sustainable Winegrowing Program, whose combined activities have markedly reduced risks associated with pest management. In addition, the strategic vision articulated by Wine Vision and the National Grape and Wine Initiative (strategic plans of the American wine and winegrape community) is to be leaders in sustainable practices. The winegrape community continues to demonstrate a long-term commitment to increasing the adoption of reduced-risk pest management and the critical needs identified in this third PMSP are an important step towards this.

Increasing numbers of growers are adopting sustainable (includes organic and biodynamic) practices, partly reacting to the growing public/consumer interest in environmentally and socially responsible approaches. Furthermore, more growers are certifying their operations – 10,000 acres of vineyards in Lodi were certified sustainable under the Lodi Rules program in 2008 and a recent Central Coast Vineyard Team press release stated 3,000 acres were certified under their Sustainability in Practice program. For organic production, an estimated 7,875 acres of winegrapes are certified in California (CDFA, 2003). The actual number of organic acres is likely to be higher, since some winegrape growers use organic practices but are not certified.

Crucial to sustainability in California winegrape production is anticipating that regulatory restrictions and continuing environmental concerns (e.g., water and air quality), as well as population growth in traditional farming areas which create challenging rural-urban relationships, will impact the future availability of pest control products. The United States Department of Agriculture, EPA, land-grant universities, and the winegrape community must continue to work together to proactively identify research, regulatory, and educational needs for reducing the reliance on higher-risk pesticides.

The Work Group

A work group consisting of growers, commodity groups, regulators, University of California specialists, and other technical experts met May 5, 2008 at the University of California, Davis. The purpose was to review and update elements of the PMSP. The discussion and priorities identified at and subsequent to the meeting were used as the basis for this document.

The group noted that the majority of winegrape growers do not use organophosphate insecticides, because of adverse impacts on natural enemies and concerns about human and environmental safety. Nevertheless, it was emphasized that registered uses should be maintained for critical/crisis pest management situations such as those for the glassy-winged sharpshooter, vine mealybug, and potential new threats.

FOUNDATION for the PEST MANAGEMENT STRATEGIC PLAN

The remainder of this document is an update to the chronological analysis of pest pressures and their management from vineyard establishment through the seasonal stages of vine growth and development. Key control tactics, associated concerns, and future research, regulatory, and educational needs are highlighted. Differences among production regions are discussed as appropriate.

VINEYARD ESTABLISHMENT

The vineyard establishment interval is considered to extend from the initiation of pre-planting activities through the third year after planting (3rd leaf). Focus here, however, will target the time frame from pre-planting through planting, that period involving most of the unique considerations and practices in pest management. The few differences between early post-planting and thereafter (bearing vines; years four and beyond) are addressed in the sections partitioned by stages of vine growth and development.

The predominant pests of concern and specifically managed from pre-planting through planting are grape phylloxera, mealybugs, nematodes, oak root fungus, and weeds. Decisions to apply pesticides (fumigants) generally are based on expected problems from nematodes and/or oak root fungus.

FARMING ACTIVITIES

- Extraction of old vineyards/other crops.
- Fallow.
- Soil ripping, disking, and leveling (as necessary).
- Soil sampling for nematodes.
- Fertilization.
- Fumigant and/or herbicide applications.
- Selection of appropriate rootstocks and scions based on soils, climate, nematode and disease resistance, market expectations, etc.
- Planting, mowing, and disking cover crops (green manure).
- Installation of trellis and irrigation systems.
- Planting vines (spring).
- Installation of grow tubes.
- Irrigation.
- Training of vines.

INSECTS

Grape Phylloxera

Grape phylloxera feed on grape roots, stunting or killing vines. Phylloxera cause greater injury in areas with heavier clay soils, although problems occur in all winegrowing regions. Phylloxera can be managed culturally and/or chemically, but the only reliable means for control is the planting of resistant rootstocks. Pre-plant applications of fumigants targeting nematodes or oak root fungus may provide limited suppression of existing phylloxera in replanting situations. Post-plant insecticides provide suppression only, due to the difficulty in penetrating the heavy clay soils that the pest prefers and because populations rebound quickly. Although insecticides may be applied throughout the year, best timing generally is associated with rapid root growth during the spring and/or fall (early post harvest).

Chemical control

- None directly recommended for pre-plant use.
- Pre-and post-plant biofumigation; promising future alternatives.

Cultural control

- Resistant rootstocks; best method of control.
- Rootstock resistance management; limits exposure of resistant stocks to high phylloxera populations.
- Clean propagation material.
- Crop residue management; minimize roots remaining in soil after removal of infested vineyards as phylloxera can survive for years on residual roots.
- Irrigation and fertilization; reduces vine stress, especially in the hot Central Valley.
- Sanitation; remove soil from equipment before moving among vineyards.
- Addition of organic material to soil (e.g., via cover crops); may mitigate vine stress.

Biological control

- None.

Mealybugs

Pseudococcus species (grape, obscure, and long-tailed mealybugs) and vine mealybugs cause problems. Vine mealybug (a species from the genus *Planococcus*) is a serious new pest, occurring in winegrowing areas of the San Joaquin Valley, Central and North coasts, and Sierra Foothills. Intensive efforts are being devoted to limit the spread of vine mealybug and improve IPM programs. Mealybugs can transmit grape viruses, reduce vine growth, and render grapes unmarketable by contaminating clusters with their life stages, honeydew, and sooty mold (honeydew is the substrate). Vine mealybug is of key concern because it has a high rate of population increase, an ability to excrete excessive honeydew, a portion of the population is always secluded under bark or on roots, few natural enemies, and multiple hosts. Vine mealybug can be found living on roots of grapes in soil as deep as two feet, especially when tended by ants or in sandy soils. Insecticides may be applied during delayed dormancy, spring, summer, and post harvest. Optimal timing of treatment(s) depends on the species and should be made when more susceptible life stages (crawlers and young nymphs) are exposed on plant surfaces. Natural enemies suppress mealybugs, so tactics used to control honeydew-seeking ants (e.g., tillage, contact insecticides, bait stations) can enhance natural control.

Chemical control

- None.

Cultural control

- Clean propagation material.
- Hot water treatment of nursery stock.

Biological control

- None.

Needs for Insect Management during Vineyard Establishment:

Research:

- Find products for effectively managing phylloxera.

Regulatory:

- Expedite registrations of new materials for phylloxera.

Education:

- Ensure grower understanding that all planting material requires preventive measures to eliminate vine mealybug.
- Continue education on drift mitigation and management, and associated complaints.
- Educate growers and pesticide applicators about sprayer technologies (including electrostatic) and their effective operation (proper calibration and application use rates, timing, coverage, and placement).

NEMATODES

Root feeding by plant-parasitic nematodes reduces water and nutrient uptake, which can decrease vine vigor and yield. The five most important species or groups are root knot nematode, ring nematode, dagger nematode, root lesion nematode, and citrus nematode. Although causing only occasional yield reduction, the dagger nematode is the most destructive because it vectors grapevine fanleaf virus. Chemical (pre or post plant) and/or cultural tactics are used for control. Post-plant nematicides may be applied throughout the year, but, best timing generally is associated with rapid root growth during the spring and/or fall (early post harvest).

Chemical control

- Methyl bromide, provides excellent control, but officially phased out in 2005 although some use continues under Critical Use Exemption process established by Montreal Protocol.
- 1,3-dichloropropene (Telone II); often excellent control, but proper soil moisture at treatment is critical as too much moisture can disrupt performance.
- Metam sodium (Vapam); only fair control because of limited soil movement.

Cultural control

- Resistant rootstocks.
- Long-term fallow.
- Cover crops; selective plantings can minimize buildup of problematic species.
- Soil fertility and irrigation management; improves vine vigor.
- Addition of organic matter to soil; may mitigate vine stress.

Biological control

- None.

Needs for Nematode Management during Vineyard Establishment:**Research:**

- Determine if population shifts of virulent biotypes are developing on resistant rootstocks.
- Develop new resistant rootstocks.
- Find a replacement(s) to methyl bromide for pre-plant use.
- Elucidate effectiveness of cover cropping mustards for suppressing nematode populations.

Regulatory:

- Expedite registrations of new materials, e.g., methyl iodide (iodomethane), azides, dimethyl disulfide (DMDS).

Education:

- Continue education on drift mitigation and management, and associated complaints.
- Educate growers and pesticide applicators about sprayer technologies (including electrostatic) and their effective operation (proper calibration and application use rates, timing, coverage, and placement).

DISEASES**Oak root fungus (Armillaria root rot)**

This disease leads to nonproductive vines that frequently die within two to four years. Grape roots acquire inoculum from the preceding orchard crop or nearby oak trees.

Chemical control

- Methyl bromide; good control, but officially phased out in 2005 although some use continues under Critical Use Exemption process established by Montreal Protocol.
- Sodium tetrathiocarbonate (Enzone); fair control, but restricted use material.
- Metam sodium (Vapam); fair control, but restricted use material.

Cultural control

- Minimizing oak tree removal to limit infected root fragments in the vine rooting zone.
- Removing infected vines and root pieces from oak trees.
- Avoiding planting vines near potential hosts.
- Excavating root collar to first layer of lateral roots and leaving exposed for at least one year; redo as needed.

Biological control

- *Trichoderma* spp.

Needs for Disease Management during Vineyard Establishment:**Research:**

- Find new products for effectively managing oak root fungus.

Regulatory:

- Expedite registrations of new materials for oak root fungus.

Education:

- Educate growers and pest control advisors about oak root fungus and its relationship with oak trees.
- Continue education on drift mitigation and management, and associated complaints.
- Educate growers and pesticide applicators about sprayer technologies (including electrostatic) and their effective operation (proper calibration and application use rates, timing, coverage, and placement).

WEEDS

Weeds may be managed with chemical and non-chemical tactics and combinations prior or proximal to planting. It is particularly important and easier to manage the more difficult-to-control species before planting, especially perennials like field bindweed, johnsongrass, dallisgrass, bermudagrass, and nutsedge. Care must be taken to avoid exposing roots of newly planted vines to pre-emergent herbicides and to prevent green shoots from being contacted by non-selective, post-emergent materials, e.g., glyphosate (Roundup) and paraquat (Gramoxone).

Herbicides are often a significant portion of the pest control budget. Pre-emergent herbicides have limited windows of application to ensure incorporation by rain, and some pose environmental concerns, such as the contamination of ground and surface water. Glyphosate (Roundup), glufosinate-ammonium (Rely), and paraquat (Gramoxone) are important post-emergent herbicides that control a wide-spectrum of grassy and broadleaf weeds. A number of herbicides are also available for non-bearing vines.

Besides herbicides, mechanical removal of under-the-vine weeds is used but its frequency is based on region, vineyard size, and soil type. Mechanical control often requires an investment in additional equipment, not always economically viable. However, organic winegrape growers rely mostly on mechanical cultivation, using under-the-vine tillage equipment. This approach has proven to be economical for them. Other non-chemical options include flaming, mulches, and cover crops (including under the vine).

Many growers maintain cover crops between rows primarily to manage soils but also to prevent weeds from invading vine rows. Factors limiting greater adoption of cover crops include concerns about decreased crop vigor, greater water and fertilizer requirements and overall costs, and increased problems with perennial weeds such as bermudagrass, bindweed, and johnsongrass. Moreover, cover crops may increase problems with vertebrate pests such as voles and gophers.

Chemical control

Pre-emergent Herbicides

- Simazine (e.g., Princep); inexpensive, but ground water issues and associated restrictions.
- Oryzalin (e.g., Surflan).
- Diuron (e.g., Karmex); ground water issues and associated restrictions.
- Oxyfluorfen (Goal); relatively high VOC emissions, but concern minimized if applied outside May-October window (new formulation should be lower VOC).
- Dichlobenil (Casoron).
- Napropamide (Devrinol).
- Norflurazon (Solicam); ground water issues and associated restrictions.
- Pronamide (Kerb).
- Trifluralin (e.g., Treflan); relatively high VOC emissions, but concern minimized if applied outside May-October window.
- Isoxaben (Gallery) and thiazopyr (Visor); non-bearing vines only.
- Flumioxazin (Chateau) and rimsulfuron (Matrix).
- Pendamethalin (Prowl); non-bearing vines only, emulsifiable concentrate formulation has relatively high VOC emissions, but concern minimized if applied outside May-October window (Prowl H2O, new low VOC formulation now registered for bearing vines).

Post-emergent Herbicides

- Glyphosate (Roundup); widely used, non-selective material.
- Paraquat (Gramoxone); non-selective material.
- Glufosinate-ammonium (Rely).
- Sethoxydim (Poast).
- Sulfosate (Touchdown); non-selective material.
- 2,4-D; only used pre-planting or during dormancy.
- Clethodim (Prism), diquat (Reglone), fluazifop-p (Fusilade), and MSMA; non-bearing vines only.
- Carfentrazone-ethyl (Shark).
- Pyraflufen-ethyl (Venue).
- Organic products (e.g., soap-based (Scythe), acetic acid formulations, clove (e.g., Matram2) and other essential oils, and corn gluten); not very efficacious, rarely used.

Cultural control

- Cultivation (generally under the vine).
- Mowing or “weed whacking”.
- Soil solarization; some small-scale use before planting.
- Mulches.
- Cover crops.
- Propane flaming; infrequently used during vineyard establishment.

Biological control

- Domesticated animals (sheep, geese, chickens, goats, etc.).
- Puncture vine weevil; releases and preservation of established populations.

Needs for Weed Management during Vineyard Establishment:

Research:

- Develop more environmentally friendly, cost-effective control measures (especially organically approved).
- Need more basic work on economic thresholds that account for differences in vine density and rootstock vigor.
- Conduct life cycle analyses comparing carbon footprints of mechanical vs. herbicide programs for under-the-vine weed management.

Regulatory:

- Expedite registration of environmentally friendly, cost-effective herbicides.

Education:

- Continue grower and pest control advisor education on weed management options.
- Enhance grower and pest control advisor education about strategies for resistance management and discuss examples of resistance already developed.
- Continue grower and pest control advisor education on means to prevent off-site movement of herbicides.
- Continue education on drift mitigation and management, and associated complaints.
- Educate growers and pesticide applicators about sprayer technologies (including electrostatic) and their effective operation (proper calibration and application use rates,

timing, coverage, and placement).

DORMANCY (December – mid March)

FARMING ACTIVITIES (may occur during dormancy)

- Pruning.
- Vine tying.
- Trellis maintenance.
- Erosion control.
- Brush chopping and/or burning.
- Berm sweeping.
- Mowing or disking.
- Collection of crop phenological data (pruning weights and bud counts).
- Irrigation.
- Planting or replanting.
- Monitor for European fruit lecanium and evidence of parasitism.
- Pesticide applications and/or other pest controls.

INSECTS AND MITES

Insect and mite management during dormancy includes cultural tactics that decrease problems with mealybugs, European fruit lecanium, omnivorous leafroller, orange tortrix, cutworms, and branch and twig borer. Delayed-dormant insecticides may be applied for mealybugs or to control honeydew-seeking ants, enhancing the natural control of mealybugs and European fruit lecanium.

Mealybugs

Pseudococcus species (grape, obscure, and long-tailed mealybugs) and vine mealybugs cause problems. Vine mealybug (a species from the genus *Planococcus*) is a serious new pest, occurring in winegrowing areas of the San Joaquin Valley, Central and North coasts, and Sierra Foothills. Intensive efforts are being devoted to limit the spread of vine mealybug and improve IPM programs. Mealybugs can transmit grape viruses, reduce vine growth, and render grapes unmarketable by contaminating clusters with their life stages, honeydew, and sooty mold (honeydew is the substrate). Vine mealybug is of key concern because it has a high rate of population increase, an ability to excrete excessive honeydew, a portion of the population is always secluded under bark or on roots, few natural enemies, and multiple hosts. Vine mealybug can be found living on roots of grapes in soil as deep as two feet, especially when tended by ants or in sandy soils. Insecticides may be applied during delayed dormancy, spring, summer, and post harvest. Optimal timing of treatment(s) depends on the species and should be made when more susceptible life stages (crawlers and young nymphs) are exposed on plant surfaces. Natural enemies suppress mealybugs, so tactics used to control honeydew-seeking ants (e.g., tillage, contact insecticides, bait stations) can enhance natural control.

Chemical control (delayed dormant)

- Chlorpyrifos (Lorsban); excellent control and, if target soil surface, can control ants, but application timing and frequency restricted, disruptive to natural enemies, associated with surface water contamination, could be Prop. 65 listed, and emulsifiable concentrate formulations have high VOC emissions (low VOC formulation granted a 24(c) registration

in California).

- Buprofezin (Applaud); effective, but not used if vine mealybug eradication is objective.

Cultural control

- Bark stripping and treatment; costly, but effective in improving efficacy of pesticide applications.
- Tillage; enhances natural control by destroying ant mounds.
- Equipment and general vineyard sanitation; prevents spread to non-infested areas.

Biological control

- Avoiding pesticides disruptive to natural enemies of *Pseudococcus* mealybugs.

European fruit lecanium

The European fruit lecanium (i.e., brown apricot scale) produces honeydew that can result in excess sooty mold on berries and leaves. At high densities, lecanium feeding can stunt vine growth. Indigenous parasitoids and predators generally suppress lecanium to sub-economic levels. Management includes monitoring, preserving natural enemies, and insecticide applications as necessary. Parasitism of nymphs should be monitored during late dormancy and necessary insecticides should target crawlers (first instars), present May through June.

Chemical control

- No direct applications recommended because a less-susceptible insect growth stage is present and crucial not to disrupt action of natural enemies.

Cultural control

- Controlling honeydew-seeking ants via tillage or chlorpyrifos (Lorsban); enables optimal impact by natural enemies.

Biological control

- Avoiding pesticides that disrupt natural biological control.

Omnivorous leafroller and orange tortrix

These lepidopterous pests feed on leaves, flowers, and developing berries. More importantly, damaged berries are susceptible to secondary invasion by rot organisms. Omnivorous leafroller predominantly is a pest of the San Joaquin Valley and North Coast. Orange tortrix can be a problem in coastal regions.

Chemical control

- None.

Cultural control

- Vineyard sanitation; destroy and/or bury overwintering hosts (weeds, old dried clusters, and ground duff).
- Cultivation (under the vine).

Biological control

- Avoiding insecticides disruptive to natural enemies.

Cutworms and grape bud beetle

Cutworms are infrequent pests occurring in small pockets of vineyards and damaging vines by feeding on buds and young shoots. Most vines compensate for this injury by developing shoots from secondary buds and/or increasing berry size. Spot treatment with insecticides may be necessary around bud break. Grape bud beetle occurs in localized areas of the San Joaquin Valley where emerging adults aggregate and feed on opening buds, requiring occasional spot treatments.

Chemical control

- None.

Cultural control

- Timely weed destruction; removes hosts.
- Furrow or flood irrigation; exposes cutworms to natural mortality factors at soil surface.
- Cultivation (under the vine).

Biological control

- Avoiding insecticides disruptive to the many natural enemies.

Branch and twig Borer

The branch and twig borer is a minor pest and generally is suppressed sufficiently by decreasing the availability of dead or dying vines or other wood used for establishment sites. Insecticides rarely are applied for this pest alone.

Chemical control

- None.

Cultural control

- Brush removal and destruction (e.g., chopping and shredding); prior to adult emergence in March.
- Removal and destruction of dying portions of vines; achieved during pruning.
- Maintaining healthy vines; minimizes establishment sites.

Biological control

- None.

Needs for Insect and Mite Management during Dormancy:

Research:

- Further evaluate mealybug natural controls, such as predators and parasitoids.
- Better understand how to optimally manage ants, therefore suppressing mealybugs.
- Continue ant control research.
- Determine impacts of insect growth regulators on natural enemies.
- Develop economic thresholds for vine mealybug, especially after parasites become established.
- Develop improved application methods for chlorpyrifos (Lorsban) to alleviate runoff concerns.
- Find effective substitutes to chlorpyrifos (Lorsban) for controlling vine mealybug.

Regulatory:

- Retain chlorpyrifos (Lorsban) for vine mealybug control until registering an efficacious alternative.
- Ease standards for obtaining Special Local Needs and Section 18 exemptions.

Education:

- Provide information on alternative pest control methods as they become available.
- Educate growers and pest control advisors about interactions between ants and vine mealybug and how to manage ants.
- Educate growers, pest control advisors, and field workers (in Spanish and English) on monitoring for vine mealybug and European fruit lecanium.
- Educate growers on how to prevent spread of pests by using certified nursery stock.
- Continue education on drift mitigation and management, and associated complaints.
- Educate growers and pesticide applicators about sprayer technologies (including electrostatic) and their effective operation (proper calibration and application use rates, timing, coverage, and placement).
- Teach growers, pest control advisors, and workers to recognize the newly introduced light brown apple moth, ensuring its rapid eradication.

DISEASES

During dormancy, cultural controls such as removing non-harvested clusters, pre-pruning and pruning, berm sweeping, and occasionally French plowing assist in managing diseases. Fungicides may be applied for powdery mildew, Eutypa dieback/Bot canker, Phomopsis cane and leafspot, and esca (black measles).

Powdery mildew

Powdery mildew is the most significant disease affecting winegrapes. It is estimated that powdery mildew is present in virtually all vineyards each year, the only variable being the severity of infection. Fungicides may be applied during dormancy to reduce over-wintering inoculum, but powdery mildew predominantly is treated from bud break to veraison. The use of the mildew index, determined via a temperature-driven disease forecasting model, helps optimally time fungicide applications for preventive treatment, often reducing applications. Field monitoring is essential for identifying symptoms of the disease to supplement decision making for preventive and curative treatments. Sulfur products are key tools for management. Sterol inhibitor chemistry remains an important alternative mode of action, despite evidence of resistance.

Chemical control

- Lime-sulfur; good to excellent control.
- Narrow range oils (e.g., JMS Stylet Oil (excellent control), Saf-T-Side (good control)).
- Copper fungicides.
- Potassium bicarbonate (e.g., Kaligreen).

Cultural control

- Pruning for optimal canopy architecture (e.g., leaf removal at cluster set); enables good pesticide coverage and a canopy microclimate possibly less conducive to mildew development.

Biological control

- None.

Eutypa dieback/Bot canker

Both diseases are associated with pruning wounds with symptoms most visible in vines 10 or more years old. The common symptom is the development of darkened cankers in the vascular tissue of infected wood. Symptoms specific for *Eutypa dieback* in the spring are delayed shoot emergence and chlorosis, stunting, and tattering of leaves. The primary symptom of Bot canker is dead spur positions.

Chemical control

- Thiophanate-methyl (Topsin-M).
- Myclobutanil (Rally); application submitted for Special Local Need registration at 6 oz/A applied by tractor.

Cultural control

- Pruning to remove cankers.
- Timely pruning in February or March; inoculum reduced and wounds heal rapidly.
- “Double pruning” (two-pass approach includes early pre-pruning then a more precise final pruning in late dormancy); enables efficient deployment of workforce, excellent control of all 17 pathogenic fungi entering pruning wounds, and should provide 100% control when coupled with a fungicide application.

Biological control

- *Trichoderma* spp.

Phomopsis cane and leafspot

Phomopsis is common in regions with spring rains occurring after bud break. The fungus overwinters as pycnidia and new infections begin when rain splashes spores onto developing green tissues. Leaves, clusters, and other shoot tissues can become infected.

Chemical control

- Lime-sulfur; good to excellent reduction of overwintering inoculum.

Cultural control

- None.

Biological control

- None.

Esca (black measles)

Esca typically occurs in older vines and is caused by a complex of fungal pathogens that propagate in old, rotted vascular tissue. Spores released from these tissues reinfect vines through pruning wounds. Symptoms are most prevalent during July and August. Leaves of infected vines often display chlorotic interveinal areas. Severely infected vines can experience leaf drop, cane dieback, and cracked and dried fruit. Young esca, also known as Petri disease or young vine decline, is a related disease in young vines that likely originates from infected nursery stock.

Chemical control

- Lime-sulfur; must be thoroughly applied to cracks and crevices.
- Thiophanate-methyl (Topsin-M); apply immediately to cut or pruned surfaces.

Cultural control

- None.

Biological control

- None.

Needs for Disease Management during Dormancy:

Research:

- Find new products and methods for managing powdery mildew and Eutypa dieback/Bot canker.
- Determine the relationship between Phomopsis infection and cankers.
- Determine effects of vineyard sanitation practices on the fungal complex causing esca (black measles).

Regulatory:

- Expedite registrations of suitable chemicals for controlling Eutypa dieback/Bot canker and esca.
- Register soaps and boric acid (e.g., B-Lock) as pruning-time treatments for Eutypa dieback/Bot canker.
- Ease standards for obtaining Special Local Needs and Section 18 exemptions.

Education:

- Provide information on alternative pest control methods as they become available.
- Continue education on drift mitigation and management, and associated complaints.
- Educate growers and pesticide applicators about sprayer technologies (including electrostatic) and their effective operation (proper calibration and application use rates, timing, coverage, and placement).

WEEDS

Weeds constitute the major pest challenge during the dormant season. Weeds may be managed with chemical and/or non-chemical tactics at this time. Herbicides often are a significant portion of the pest control budget. Pre-emergent herbicides have limited windows of application to ensure incorporation by rain, and some pose environmental concerns, such as the contamination of ground and surface water. Glyphosate (e.g. Roundup), glufosinate-ammonium (Rely), and paraquat (Gramoxone) are important post-emergent herbicides that control a wide-spectrum of grassy and broadleaf weeds. A number of herbicides are also available for non-bearing vines. Care must be taken to avoid exposing roots of newly planted vines to pre-emergent herbicides and to prevent green shoots from being contacted by non-selective, post-emergent materials.

Besides herbicides, mechanical removal of under-the-vine weeds is used but its frequency is based on region, vineyard size, and soil type. Mechanical control often requires an investment in additional equipment, not always economically viable. However, organic winegrape growers rely

mostly on mechanical cultivation, using under-the-vine tillage equipment. This approach has proven to be economical for them. Other non-chemical options include flaming, mulches, and cover crops (including under the vine).

Many growers maintain cover crops between rows primarily to manage soils but also to prevent weeds from invading vine rows. Factors limiting greater adoption of cover crops include concerns about decreased crop vigor, greater water and fertilizer requirements and overall costs, and increased problems with perennial weeds such as bermudagrass, bindweed, and johnsongrass. Moreover, cover crops may increase problems with vertebrate pests such as voles and gophers.

Chemical control

Pre-emergent Herbicides

- Simazine (e.g., Princep); inexpensive, but ground water issues and associated restrictions.
- Oryzalin (e.g., Surflan).
- Diuron (e.g., Karmex,); ground water issues and associated restrictions.
- Oxyfluorfen (Goal); relatively high VOC emissions, but concern minimized if applied outside May-October window (new formulation should be lower VOC).
- Dichlobenil (Casoron).
- Napropamide (Devrinol).
- Norflurazon (Solicam); ground water issues and associated restrictions.
- Pronamide (Kerb).
- Trifluralin (e.g., Treflan); relatively high VOC emissions, but concern minimized if applied outside May-October window.
- Pendamethalin (Prowl); non-bearing vines only; emulsifiable concentrate formulation has relatively high VOC emissions, but concern minimized if applied outside May-October window (Prowl H₂O, new low VOC formulation now registered for bearing vines).
- Isoxaben (Gallery) and thiazopyr (Visor); non-bearing vines only.
- Flumioxazin (Chateau) and rimsulfuron (Matrix).

Post-emergent Herbicides

- Glyphosate (Roundup); widely used, non-selective material.
- Paraquat (Gramoxone); non-selective material.
- Glufosinate-ammonium (Rely).
- Sethoxydim (Poast).
- Sulfosate (Touchdown); non-selective material.
- 2,4-D; only used pre-planting or during dormancy.
- Clethodim (Prism), diquat (Reglone), fluazifop-p (Fusilade), and MSMA; non-bearing vines only.
- Carfentrazone-ethyl (Shark).
- Pyraflufen-ethyl (Venue).
- Organic products (e.g., soap-based (Scythe), acetic acid formulations, clove (e.g., Matram2) and other essential oils, and corn gluten); not very efficacious, rarely used.

Cultural control

- Cultivation.
- Mowing.
- Propane flaming; risky due to fire hazard.

- Steam and/or hot water; high cost associated with large volume of water needed but may be viable for organic growers.
- Mulches.
- Cover crops.

Biological control

- Domesticated animals (sheep, geese, chickens, goats, etc.).
- Puncture vine weevil; releases and preservation of established populations.

Needs for Weed Management during Dormancy:

Research:

- Develop more environmentally friendly, cost-effective control measures.
- Need more basic work on economic thresholds.
- Improve application techniques to ensure soil coverage for low-rate pre-emergent products; current techniques occasionally provide inconsistent efficacy especially on raised berms.

Regulatory:

- Expedite registration of environmentally friendly, cost-effective herbicides.
- Ease standards for obtaining Special Local Needs and Section 18 exemptions, e.g., permit greater flexibility in allowing multiple uses for resistance management.

Education:

- Continue grower and pest control advisor education on weed management options.
- Enhance grower and pest control advisor education about strategies for resistance management and examples of resistance already developed.
- Continue grower and pest control advisor education on means to prevent off-site movement of herbicides.
- Continue education on drift mitigation and management, and associated complaints.
- Educate growers and pesticide applicators about sprayer technologies (including electrostatic) and their effective operation (proper calibration and application use rates, timing, coverage, and placement).

VERTEBRATES

Many vertebrates provide important services in vineyards. For example, birds such as owls, hawks, eagles, kestrels, and other raptors prey on pests; and studies show that some song birds may help control insect pests. Other vertebrates, such as bobcats, raccoons, foxes, opossums, and other wildlife species, have a neutral role but contribute to a healthy ecosystem. Many winegrape growers have taken steps to protect and enhance wildlife on their properties. On the other hand, certain vertebrates can cause problems to vineyards throughout the year. Problems occur when vertebrate pests move into or live near vineyards and seek vineyards for food and cover. Direct feeding damage by rodents is greatest to young vines. During dormancy, management tactics may be implemented for ground squirrels, meadow voles (field mice), pocket gophers, deer, coyotes, wild pigs, and wild turkeys.

Ground squirrel

Ground squirrels at dense populations can cause significant injury by gnawing on vine trunks,

removing bark and potentially girdling vines. They also may feed directly on shoots and fruit and gnaw and damage polyethylene irrigation hoses. Moreover, ground squirrels can create large burrows that can endanger workers, disrupt equipment operation, and cause erosion.

Chemical control

- Aluminum and magnesium phosphide (Phostoxin and Magtoxin); fumigants introduced into burrows, work best applied in spring with high soil moisture.
- Anticoagulant baits (e.g., diphacinone); require multiple feedings often via bait station.

Cultural control

- Trapping; often baited, works best for small areas with few squirrels.
- Sanitation; remove cover such as brush piles and debris in or near vineyards.
- Shooting.
- Rodex (propane gun).

Biological control

- Enhancing predation by raptors (hawks and eagles); via raptor perches, kestrel boxes, etc.
- Hunting dogs.

Meadow vole (field mouse)

Populations fluctuate greatly based on environmental conditions and typically thrive in areas where grass, brush, and trash accumulate. Voles injure and can kill vines by gnawing bark and partially or completely girdling the trunk at or slightly above soil level, and also by chewing the vine inside the grow tube.

Chemical control

- Anticoagulant baits (e.g. diphacinone); require multiple feedings.

Cultural control

- Sanitation; minimize weeds (particularly around base of vines), heavy mulch, and dense vegetation near vines.
- Removing cartons from transplanted vines.
- Under-the-vine cultivation.

Biological control

- Enhancing predation by raptors (hawks and eagles) and owls; via raptor perches and kestrel and owl boxes, etc.
- Hunting dogs.

Pocket gopher

Pocket gophers are important pests, capable of significant injury by cutting roots or gnawing bark and rapidly girdling vines several inches below the soil line. Moreover, their extensive burrows divert water and contribute to soil erosion and produce an uneven vineyard floor, precluding efficient tractor operations.

Chemical control

- Aluminum and magnesium phosphide (Phostoxin and Magtoxin); fumigants introduced into burrows, work best applied in spring with high soil moisture.

- Strychnine bait; kills with single feeding, introduced into main burrows by hand or mechanically incorporated via artificial burrow builders.

Cultural control

- Trapping; placed in main burrows.
- Rodex (propane gun).

Biological control

- Enhancing predation by raptors (hawks and eagles) and especially owls; via raptor perches and kestrel and owl boxes, etc.
- Hunting dogs.

Deer

Deer can feed on vines and berries and are predominantly a problem near woodlands in coastal areas and the foothills.

Chemical control

- None.

Cultural control

- Fencing; provides excellent year-round control.
- Shooting; requires depredation permit, not long-term solution.

Biological control

- None.

Coyote

Coyotes can damage drip irrigation hoses.

Chemical control

- None.

Cultural control

- Shooting; requires depredation permit.
- Trapping.

Biological control

- Guard dogs; can help ward off coyotes.

Wild Pig

Wild pigs can eat grapes, root up the vine, etc.

Chemical control

- None.

Cultural control

- Hunting/shooting; requires depredation permit.
- Electric fencing.

Biological control

- None.

Wild Turkey

Wild turkeys can eat young vines and the grapes.

Chemical control

- None.

Cultural control

- Hunting/shooting; requires depredation permit.

Biological control

- None.

Needs for Vertebrate Management during Dormancy:

Research:

- Need additional work on deer exclusion alternatives.
- Determine the most effective ratio of predator-prey populations.
- Develop economic thresholds for rodents.
- Determine the effectiveness of different raptors for control of small vertebrate pests.
- Determine if higher densities of small vertebrate pests resulting from cover cropping increase damage to vines or just to cover crops.
- Determine if the peripheral planting or conservation of native plants surrounding vineyards deters deer from entering vineyards.

Regulatory:

- None specified.

Education:

- Educate growers about efficacious, neighbor-friendly practices.
- Enlighten the general public to health risks associated with vertebrates, as well as the ecosystem services provided by wildlife.
- Educate growers and pest control advisors about the ground squirrel life cycle, feeding behavior, etc.
- Educate growers and pest control advisors about proper bait placement including caution with respect to endangered/threatened species habitat.

BUD BREAK TO START OF BLOOM (mid March – early June)

FARMING ACTIVITIES

- Trunk and shoot suckering (some via chemical).
- Mowing and/or disking.
- Vine tying.

- Canopy management by hand.
- Collection of viticultural data.
- Tissue sampling.
- Soil moisture monitoring.
- Irrigation.
- Frost protection via sprays, mowing, etc.
- Fertilization.
- Marketing (winemaker and broker field visits).
- Berm sweeping.
- Weed hoeing and/or plowing.
- Planting and/or replanting.
- Vine grafting.
- Positioning pheromone traps.
- Pest and disease monitoring.
- Releasing predators.
- Pesticide applications and/or other pest controls.
- Secondary pruning at bud break.
- Tipping (improves set).

INSECTS AND MITES

A number of insect and mite pests may be controlled with pesticides during bud break to start of bloom. These include cutworms, grape bud beetle, false chinch bug, thrips, spider mites, branch and twig borer, sharpshooters, mealybugs, European fruit lecanium, grape phylloxera, omnivorous leafroller, orange tortrix, grape leaf folder, and western grapeleaf skeletonizer. Although neither an insect nor mite, snails occasionally require control during this interval and are discussed here.

Cutworms and grape bud beetle

Cutworms are infrequent pests occurring in small pockets of vineyards and damage vines by feeding on buds and young shoots. Most vines compensate for this injury by developing shoots from secondary buds and/or increasing berry size. Spot treatment with insecticides may be necessary around bud break. Grape bud beetle occurs in localized areas of the San Joaquin Valley where emerging adults aggregate and feed on opening buds, requiring occasional spot treatments.

Chemical control

- Carbaryl (Sevin) baits/sprays for cutworms; baits preferred (especially for spot treatments) since control occurs before cutworms climb vines, but degraded by rain and overhead irrigation and very toxic to honeybees.
- Methomyl (Lannate) and diazinon for cutworms; fair to good control, but disruptive to natural enemies and concerns with worker safety.
- *Bacillus thuringiensis* sprays for cutworms; ineffective against damaging stages.
- Dimethoate (Cygon) and phosmet (Imidan) for grape bud beetle; fair control, but disruptive to natural enemies and dimethoate has relatively high VOC emissions.
- Spinetoram (Delegate).
- Indoxycarb (Avaunt).
- Cyfluthrin (Renounce) and other pyrethroids; not used during this interval due to mite flare-ups, pyrethroids in irrigation and storm water runoff are of increasing regulatory interest by DPR and State and Regional Water Boards.

Cultural control

- Cultivation of weed hosts to control cutworms; done later during late summer or fall.
- Furrow or flood irrigation; exposes cutworms to natural mortality factors at soil surface.

Biological control

- Avoiding pesticides disruptive to the many naturally occurring enemies of cutworms.
- Chickens; feed on cutworms.

False chinch bug

The false chinch bug occurs sporadically but can significantly damage young vines on vineyard borders, as bugs mass migrate from desiccating weed hosts. Feeding by nymphs and adults causes vines to wilt and turn brown. Monitoring and cultural management generally prevent problems.

Chemical control

- Diazinon, malathion, methomyl (Lannate), and carbaryl (Sevin); fair to good control via spot treatment, but disruptive to natural enemies and concerns with worker safety.

Cultural control

- Disking weed hosts in surrounding areas before vines produce leaves; can prevent migration.

Biological control

- None.

Thrips

Thrips are a minor problem but may require insecticide treatment soon after bud break and possibly later, as needed. Shoot feeding shortly after bud break can cause stunting of certain varieties during cool springs.

Chemical control

- Dinotefuran (Venom); excellent control via soil and foliar applications, but trade issues (no CODEX MRL as of 4/23/09) and concern about potential resistance to this widely used neonicotinoid class of chemistry.

- Dimethoate (Cygon); good control at low rates, but relatively high VOC emissions and can cause secondary pest outbreaks.
- Carbaryl (Sevin) and methomyl (Lannate); good control, but avoided because of secondary pest outbreaks.
- Spinosad (Success, Entrust); expensive products; Entrust approved for organic production.
- Acetamiprid (Assail); neonicotinoid like dinotefuran thus resistance concerns, efficacy not fully determined.
- Pyrethroids; generally not used during this interval.

Cultural control

- Clean cultivation.
- Avoiding mowing thrips-infested cover crops from bud break to bloom.

Biological control

- Avoiding pesticides disruptive to natural enemies.

Spider mites

Mites can first become pests during bud break in certain regions, although damaging populations generally are found from shoot elongation to harvest. Injury results from leaf feeding by Willamette or Pacific mites, which causes leaf discoloration and decreased functionality. No organophosphates or carbamates are used for mite control. Some materials listed below can be quite disruptive to natural enemies. Cultural manipulations and/or natural enemies often maintain mite populations at tolerable levels in winegrapes.

Chemical control

- Dicofol (Kelthane); infrequently used because of resistance and disruption to natural enemies.
- Fenbutatin-oxide (Vendex); inadequate knockdown.
- Narrow range oil (e.g., JMS Stylet Oil, Saf-T-Side); fair control and relatively safe to natural enemies, but not used in close proximity to sulfur or during hot temperatures.
- Propargite (Omite); used as last resort because of resistance, worker safety issues, and relatively long restricted entry interval.
- Fenpropathrin (Danitol); fair control, but disruptive to natural enemies.
- Abamectin (AgriMek); good control, but relatively high VOC emissions.
- Insecticidal soap (M-Pede); fair to good control.
- Pyridaben (Nexter); efficacious product, best on Willamette mite.
- Fenpyroximate (FujiMite); efficacious product.
- Bifenazate (Acramite); efficacious product.
- Hexythiazox (Onager); good early season ovicide, but expensive.
- Clofentezine (Apollo); works well if applied early.
- Etoxazole (Zeal); works well if applied early.
- Spirodichlorem (Envidor); must apply when spider mite densities are low.
- Peppermint, spearmint, and rosemary (Ecotrol) oils; must use with extreme caution to preclude off-flavoring of wine.

Cultural control

- Cover crops; reduce dust associated with outbreaks and provide habitat for natural enemies,

delaying some treatments or making them unnecessary.

- Dust minimization; on roads in and surrounding vineyards can limit population buildup.
- Irrigation management; avoiding water-stressed vines reduces population buildup.
- Avoiding excessive use of sulfur dust; can exacerbate mite outbreaks.

Biological control

- Releases of predatory mites; species released and efficacy depend on temperature.
- Avoiding applications of sulfur dust prior to flowering; disrupts predator-prey balance.
- Avoiding pesticides disruptive to natural enemies.

Branch and twig borer

The branch and twig borer is a minor pest and generally is suppressed sufficiently by decreasing the availability of dead or dying vines or other wood used for establishment sites. Insecticides rarely are applied for this pest alone.

Chemical control

- Carbaryl (Sevin); limited suppression since difficult to contact concealed adults and disruptive to natural enemies, can induce spider mite outbreaks.
- Endosulfan (Thiodan); unreliable efficacy and associated with contamination of surface and ground water.

Cultural control

- Brush removal and destruction (e.g., chopping and shredding); prior to adult emergence in March.
- Removal and destruction of dying portions of vines.
- Physical removal; via wire during suckering.
- Maintaining healthy vines; minimizes establishment sites.

Biological control

- None.

Sharpshooters

Sharpshooters (blue-green, red-headed, green, and glassy-winged) may be controlled with insecticides beginning at shoot elongation. Shoot feeding can result in the transmission of the bacterium *Xylella fastidiosa*, which causes Pierce's Disease for which there is no cure. The glassy-winged sharpshooter, a relatively new pest established in the South Coast and Central Valley, is an extremely effective vector of this disease. Disease transmission by blue-green sharpshooters generally is associated with coastal vineyards adjacent to riparian areas, where alternative hosts are found. Red-headed and green sharpshooters are the primary vectors in the Central Valley, but cause only occasional problems.

Chemical control

- Imidacloprid (Provado/Admire); preferred and efficacious material, but trade issues and concerns about potential resistance.
- Acetamiprid (Assail); a neonicotinoid like imidacloprid thus resistance concerns.
- Dimethoate (Cygon); only material for use near riparian environments, but unreliable efficacy against adults, disruptive to natural enemies, and relatively high VOC emissions.
- Clay (Surround); suppresses feeding.

- Malathion and naled (Dibrom); fair control, but short residuals and disruptive to natural enemies.
- Fenpropathrin (Danitol); disruptive to natural enemies.

Cultural control

- Vegetation management of riparian areas for blue-green sharpshooter; plant replacement in these ecologically sensitive areas must be approved by regulatory authorities.
- Large buffers between vineyards and adjacent host habitat.
- Trapping with yellow-sticky traps; predominantly used for monitoring.
- Sharpshooter management in surrounding crops and landscapes.

Biological control

- None.

Mealybugs

Pseudococcus species (grape, obscure, and long-tailed mealybugs) and vine mealybugs cause problems. Vine mealybug (a species from the genus *Planococcus*) is a serious new pest, occurring in winegrowing areas of the San Joaquin Valley, Central and North coasts, and Sierra Foothills. Intensive efforts are being devoted to limit the spread of vine mealybug and improve IPM programs. Mealybugs can transmit grape viruses, reduce vine growth, and render grapes unmarketable by contaminating clusters with their life stages, honeydew, and sooty mold (honeydew is the substrate). Vine mealybug is of key concern because it has a large rate of population increase, an ability to excrete excessive honeydew, a portion of the population is always secluded under bark or on roots, few natural enemies, and multiple hosts. Vine mealybug can be found living on roots of grapes in soil as deep as two feet, especially when tended by ants or in sandy soils. Insecticides may be applied during delayed dormancy, spring, summer, and post harvest. Optimal timing of treatment(s) depends on the species and should be made when more susceptible life stages (crawlers and young nymphs) are exposed on plant surfaces. Natural enemies suppress mealybugs, so tactics used to control honeydew-seeking ants (e.g., tillage, contact insecticides, bait stations) can enhance natural control.

Chemical control (near bloom)

- Imidacloprid (Admire); good control with single/split applications, but trade issues and concern about potential resistance.
- Buprofezin (Applaud); foliar applied.
- Dinotefuran (Venom); soil and foliar applied, neonicotinoid like imidacloprid thus resistance concerns.
- Thiamethoxam (Platinum); soil applied, neonicotinoid like imidacloprid thus resistance concerns.
- Bait stations for control of Argentine ants; can be effective, but currently expensive.
- Acetamiprid (Assail); works well, but neonicotinoid like imidacloprid thus resistance concerns.
- Clothianidin (Clutch); newly registered, but trade issues and neonicotinoid like imidacloprid thus resistance concerns.
- Spirotetramat (Movento); newly registered lipid biosynthesis inhibitor, but trade issues (incomplete international MRLs).

Cultural control

- Tillage; enhances natural control by destroying ant mounds.

- Equipment and general vineyard sanitation; prevents spread to non-infested areas.

Biological control

- Avoiding pesticides disruptive to natural enemies of *Pseudococcus* mealybugs.

European fruit lecanium

The European fruit lecanium (i.e., brown apricot scale) produces honeydew that can result in excess sooty mold on berries and leaves. At high densities, lecanium feeding can stunt vine growth. Indigenous parasitoids and predators generally suppress lecanium to sub-economic levels. Management includes monitoring, preserving natural enemies, and insecticide applications as necessary. Parasitism of nymphs should be monitored during late dormancy and necessary insecticides should target crawlers (first instars), present May through June.

Chemical control

- Narrow range oil (e.g., JMS Stylet Oil, Saf-T-Side); best efficacy from split applications.
- Imidacloprid (Admire); good control, but trade issues and concern about potential resistance.

Cultural control

- Controlling honeydew-seeking ants via ant bait stations or chlorpyrifos (Lorsban); enables optimal impact by natural enemies.

Biological control

- Avoiding pesticides that disrupt natural biological control.

Grape phylloxera

Grape phylloxera feed on grape roots, stunting or killing vines. Phylloxera cause greater injury in areas with heavier clay soils, although problems occur in all winegrowing regions. Phylloxera can be managed culturally and/or chemically, but the only reliable means for control is the planting of resistant rootstocks. Pre-plant applications of fumigants targeting nematodes or oak root fungus may provide limited suppression of existing phylloxera in replanting situations. Post-plant insecticides provide suppression only, due to the difficulty in penetrating the heavy clay soils that the pest prefers and because populations rebound quickly. Although insecticides may be applied throughout the year, best timing generally is associated with rapid root growth during the spring and/or fall (early post harvest).

Chemical control

- Imidacloprid (Admire) and thiamethoxam (Platinum); provide suppression especially when applied in a single or split application over several consecutive years, but trade issues and concern about potential resistance to this widely used neonicotinoid class of chemistry.
- Sodium tetrathiocarbonate (Enzone); avoided because of inconsistent efficacy.
- Fenamiphos (Nemacur); fair suppression, but not for purchase since May 31, 2008 under terms of phase-out agreement.
- Spirotetramat (Movento); newly registered, but trade issues (incomplete international MRLs).

Cultural control

- Irrigation and fertilization; reduces vine stress, especially in the hot Central Valley.

- Sanitation; remove soil from equipment before moving among vineyards.
- Addition of organic matter to soil; may mitigate vine stress.

Biological control

- None.

Lepidoptera

The omnivorous leafroller, orange tortrix, grape leaffolder, and/or western grapeleaf skeletonizer feed on various shoot tissues and are capable of causing extensive defoliation (western grapeleaf skeletonizer and grape leaffolder) or fruit damage (predominantly omnivorous leafroller and orange tortrix) via direct feeding and, more importantly, the subsequent entry by botrytis and other fungi and bacteria capable of causing bunch rots. Necessary insecticide applications may first be made during shoot elongation, but generally are not made until after bloom. Light brown apple moth is a newly introduced pest to California (detected in Central and North Coasts), for which quarantine restrictions and eradication procedures are underway.

Chemical control

- Phosmet (Imidan) and diazinon; fair to excellent control, but generally not used because of ecological disruption and worker safety concerns.
- Carbaryl (Sevin) and methomyl (Lannate); fair to good control, but disruptive to natural enemies and IPM programs.
- Cryolite (Kryocide); effective, but must be applied before full bloom, can cause secondary pest outbreaks, and has trade issues (fluoride residues) causing wineries with export markets to prohibit its use.
- *Bacillus thuringiensis* sprays; effective on small larvae, but short residuals.
- Methoxyfenozide (Intrepid); excellent efficacy except for western grapeleaf skeletonizer.
- Fenpropathrin (Danitol); poor control of western grapeleaf skeletonizer.
- Clay (Surround); feeding barrier providing suppression.
- Pheromone confusion; used for omnivorous leafroller.
- Spinosad (Success, Entrust); expensive products, Entrust approved for organic production.
- Spinetoram (Delegate).
- Indoxacarb (Avaunt).

Cultural control

- Vegetation management and destruction of old clusters; helps suppress/control omnivorous leafroller and orange tortrix.

Biological control

- Natural populations of numerous parasitoids and predators suppress these pests; avoid disruptive pesticides.
- Introduction of the granulosis virus for western grapeleaf skeletonizer.

Snails

Snails are infrequent pests that can be problematic during wet springs.

Chemical control

- Metaldehyde bait; spot treatment.

- Iron phosphite.
- Carbaryl (Sevin) bait; inconsistent efficacy.
- Copper.

Cultural control

- Physical removal.

Biological control

- Domesticated fowl (ducks, geese, or chickens).

Needs for Insect and Mite Management during Bud Break to Start of Bloom:

Research:

- Develop effective monitoring protocols and economic thresholds for thrips.
- Establish economic thresholds for mites, leafhoppers, and vine mealybug.
- Find new products for effectively managing phylloxera.
- Further evaluate mealybug natural controls.
- Better understand how to optimally manage ants.
- Improve sampling and management programs for “low density” mealybug populations as related to prevention of grape leafroll disease.
- Determine impacts of insect growth regulators on natural enemies.

Regulatory:

- Expedite registrations of new materials for phylloxera and vine mealybug.
- Expedite registration of orange tortrix pheromone for mating disruption.
- Seek expanded registration of ant baits for existing active ingredients (e.g., fipronil, abamectin, neonicotinoids).
- Ease standards for obtaining Special Local Needs and Section 18 exemptions.

Education:

- Educate growers on importance of monitoring and decision making, including development and use of thresholds and knowledge about pest life cycles and identification of natural enemies.
- Educate growers about properties and use of safer materials, especially strategies for use against multiple pests.
- Disseminate information on resistance management, i.e., rotating modes of action.
- Continue education on drift mitigation and management, and associated complaints.
- Educate growers and pesticide applicators about sprayer technologies (including electrostatic) and their effective operation (proper calibration and application use rates, timing, coverage, and placement).
- Increase grower education on systems approaches for pest management, including impacts of irrigation and moisture, fertilization, soil health, and other factors affecting pest and natural enemy populations.
- Teach growers, pest control advisors, and workers (English- and Spanish-speaking) to identify sharpshooters (especially glassy-winged sharpshooter), vine mealybug, light brown apple moth (ensuring its rapid eradication), and other newly introduced pests.

NEMATODES

Root feeding by plant-parasitic nematodes reduces water and nutrient uptake, which can decrease vine vigor and yield. The five most important species or groups are root knot nematode, ring nematode, dagger nematode, root lesion nematode, and citrus nematode. Although causing occasional yield reduction, the dagger nematode is the most destructive because it vectors grapevine fanleaf virus. Chemical (pre or post plant) and/or cultural tactics are used for control. Post-plant nematicides may be applied throughout the year, but, best timing generally is associated with rapid root growth during the spring and/or fall (early post harvest).

Chemical control

- Fenamiphos (Nemacur); fair control, but not for purchase since May 31, 2008 under terms of phase out agreement.
- Sodium tetrathiocarbonate (Enzone); fair control, but requires multiple applications.
- *Myrothecium verrucaria* toxins (DiTera); use regime and efficacy poorly understood.

Cultural control

- Soil fertility and irrigation management; improves vine vigor.
- Addition of organic matter to soil; may mitigate vine stress.

Biological control

- None.

Needs for Nematode Management during Bud Break to Start of Bloom:

Research:

- Determine efficacy of neonicotinoid products and spirotetramat (Movento).
- Determine if population shifts of virulent biotypes are developing on resistant rootstocks.
- Find effective post-plant substitutes for fenamiphos (Nemacur).
- Refine understanding of the antagonistic actions of cover crops.

Regulatory:

- Register an effective post-plant alternative to fenamiphos (Nemacur).
- Ease standards for obtaining Special Local Needs and Section 18 exemptions.

Education:

- Continue education on drift mitigation and management, and associated complaints.
- Educate growers and pesticide applicators about sprayer technologies (including electrostatic) and their effective operation (proper calibration and application use rates, timing, coverage, and placement).

DISEASES

During bud break to early bloom, fungicides may be applied to manage powdery mildew, Phomopsis, and Botrytis. Also, vines with shoots visibly infected with Eutypa dieback are marked for subsequent removal.

Powdery mildew

Powdery mildew is the most significant disease affecting winegrapes. It is estimated that powdery mildew is present in virtually all vineyards each year, the only variable being the severity of infection. Fungicides may be applied during dormancy to reduce over-wintering inoculum, but powdery mildew is predominantly treated from bud break to veraison. The use of the mildew index, determined via a temperature-driven disease forecasting model, helps optimally time fungicide applications for preventive treatment, often reducing applications. Field monitoring is essential for identifying symptoms of the disease to supplement decision making for preventive and curative treatments. Sulfur products are key tools for management. Sterol inhibitor chemistry remains an important alternative mode of action, despite evidence of resistance.

Chemical control

Sulfur and Related Compounds

- Dusting sulfur; widely used because of its organic classification, relatively low cost, and reliable efficacy, but issues with drift, worker safety, and phytotoxicity at high temperatures.
- Wettable, flowable, and micronized sulfur formulations; excellent control, but issues with phytotoxicity at high temperatures.
- Copper sprays with or without sulfur; good to excellent control, but can be phytotoxic.

Sterol Inhibitors

- Myclobutanil (Rally); often excellent control, but some resistance.
- Fenarimol (Rubigan); efficacious, but some resistance and can be phytotoxic to young shoots.
- Triflumizole (Procure); efficacious, but some resistance.
- Tebuconazole (Elite); efficacious product used interchangeably with myclobutanil and fenarimol.

Strobilurins

- Azoxystrobin (Abound); highly effective material, but costly.
- Trifloxystrobin (Flint); excellent control.
- Kresoxim-methyl (Sovran); excellent control.
- Pyraclostrobin + boscalid (Pristine); efficacious product.

Biologicals

- *Bacillus subtilis* (Serenade); efficacious at low disease pressure.
- *Bacillus pumilus* (Sonata).

Systemic Acquired Resistance Elicitors

- Harpin protein (Messenger); good control at low disease pressure on specific varieties.
- Chitosan (Elexa); good control at low disease pressure.
- Gaba/L-glutamic acid (AuxiGro); efficacy not fully understood.

Contacts

- Narrow range oil (e.g., JMS Stylet Oil, Saf-T-Side) and neem; good control, but can be phytotoxic at high temperatures or in close proximity to sulfur.
- Potassium bicarbonate (Kaligreen, Armicarb); good control.
- Insecticidal soap (M-Pede); fair to good control.

Other

- Quinoxifen (Quintec); excellent control.
- Boscalid (Endura).

Cultural control

- Canopy management (e.g., shoot removal and positioning); opens canopy, enabling complete fungicide coverage with lowest effective rates.
- Sanitation; removal of diseased shoots and old clusters.
- Integration of weather information via the mildew index; optimizes and often reduces treatments.

Biological control

- None.

Phomopsis cane and leafspot

Phomopsis is common in regions with spring rains occurring after bud break. The fungus overwinters as pycnidia and new infections begin when rain splashes spores onto developing green tissues. Leaves, clusters, and other shoot tissues can become infected. In-season fungicide treatments for controlling Phomopsis may be necessary during this interval if rains occur following bud break.

Chemical control

- Copper hydroxide + sulfur spray; preferred control, but can be phytotoxic.
- Mancozeb (Dithane) and maneb; good control, but used minimally because of trade constraints.
- Ziram; fair to good control, but used minimally because of trade constraints.
- Captan; good control, but not used extensively because of trade constraints and status as a Group B₂ carcinogen.
- Azoxystrobin (Abound); efficacious, but costly.
- Other strobilurins – trifloxystrobin (Flint), kresoxim-methyl (Sovran), and pyraclostrobin + boscalid (Pristine); fair to excellent control.

Cultural control

- Avoiding overhead irrigation (e.g., for frost protection).

Biological control

- None.

Botrytis – shoot blight

Succulent plant tissues (young shoots or flower parts) are susceptible to infection by Botrytis. Rainy, warm springs increase disease incidence and severity. A disease forecasting model to time necessary preventive treatments based on wetness duration and temperature has been developed but has not been widely adopted. By allowing sufficient air exchange that lowers the canopy humidity, canopy management, particularly leaf removal proximal to clusters, is a highly effective tactic to integrate into management programs and can reduce the need for fungicide treatments. Few fungicides used for other diseases control Botrytis. Unfortunately, no products enable practical, effective curative control.

Chemical control

- Captan, mancozeb (Dithane), and maneb; fair to good efficacy, but have trade issues and mancozeb and maneb cannot be applied after bloom.
- Iprodione (Rovral); good efficacy.
- Ziram; fair to good control, but used minimally because of trade constraints.
- *Bacillus subtilis* (Serenade); fair to good control.
- Pyraclostrobin + boscalid (Pristine); new efficacious product.
- Fenhexamid (Elevate); excellent control.
- Narrow range oil (e.g., JMS Stylet Oil, Saf-T-Side); good control, but can be phytotoxic during high temperatures or in close proximity to sulfur.
- Cyprodinil (Vanguard); excellent control.
- Copper + sulfur sprays; fair control, but can be phytotoxic.

Cultural control

- Sanitation; destruction/burial of old clusters on vines and soil surface.
- Canopy management; use of trellis systems and shoot-position wiring that open canopies.
- Irrigation management; reduced irrigation limits lush growth associated with larger berries and splitting.

Biological control

- *Trichoderma* spp. (Trichodex); may help with suppression.

Needs for Disease Management during Bud Break to Start of Bloom:

Research:

- Find new products (especially curative) and methods (including genetic resistance) for managing powdery mildew.
- Determine the relationship between Phomopsis infection and cankers.
- Refine use rates and timing of gibberellic acid to reduce berry splitting but not yield.
- Elucidate the relationship between sulfur use and SO₂ production during wine fermentation.

Regulatory:

- Maintain sulfur dust as viable option by complying with winegrape industry and Sulfur Task Force stewardship recommendations (sulfur dust has drift and possible PM-10 air quality concerns).
- Ease standards for obtaining Special Local Needs and Section 18 exemptions.

Education:

- Continue educating growers, applicators, and pest control advisors about label guidelines and stewardship recommendations for preventing sulfur and other pesticide drift, and associated complaints.
- Further educate growers and pest control advisors on using the powdery mildew index to optimally time and potentially reduce treatments.
- Disseminate information on the importance of monitoring and resistance management for various diseases, as well as alternative methods when available.
- Educate growers and pesticide applicators about sprayer technologies (including electrostatic) and their effective operation (proper calibration and application use rates, timing, coverage, and placement).

WEEDS

Weeds may be managed with post-emergent and/or non-chemical tactics during bud break to early bloom. Herbicides often are a significant portion of the pest control budget. Glyphosate (e.g. Roundup), glufosinate-ammonium (Rely), and paraquat (Gramoxone) are important post-emergent herbicides that control a wide-spectrum of grassy and broadleaf weeds. Post-emergent herbicides are applied under the vine in bands or spot sprayed, often via precision technology. Hooded spray booms are available for minimizing drift. A number of post-emergent herbicides are also available for non-bearing vines. Extra care must be taken to ensure that green shoots are not contacted by non-selective, post-emergent materials.

Besides herbicides, mechanical removal of under-the-vine weeds is used but its frequency is based on region, vineyard size, and soil type. Mechanical control often requires an investment in additional equipment, not always economically viable. However, organic winegrape growers rely mostly on mechanical cultivation, using under-the-vine tillage equipment. This approach has proven to be economical for them. Other non-chemical options include flaming, mulches, and cover crops (including under the vine).

Many growers maintain cover crops between rows primarily to manage soils but also to prevent weeds from invading vine rows. Factors limiting greater adoption of cover crops include concerns about decreased crop vigor, greater water and fertilizer requirements and overall costs, and increased problems with perennial weeds such as bermudagrass, bindweed, and johnsongrass. Moreover, cover crops may increase problems with vertebrate pests such as voles and gophers.

Chemical control (post-emergent)

- Glyphosate (Roundup); widely use, non-selective material.
- Paraquat (Gramoxone); non-selective material.
- Glufosinate-ammonium (Rely).
- Sethoxydim (Poast).
- Sulfosate (Touchdown); non-selective material.
- Clethodim (Prism), diquat (Reglone), fluazifop-p (Fusilade), and MSMA; non-bearing vines only.
- Carfentrazone-ethyl (Shark).
- Pyraflufen-ethyl (Venue).
- Organic products (e.g., soap-based (Scythe), acetic acid formulations, clove (e.g., Matram2) and other essential oils, and corn gluten); not very efficacious, rarely used.

Cultural control

- Cultivation (including hand hoeing).
- Mowing.
- Propane flaming; risky due to fire hazard.
- Steam and/or hot water; high cost associated with large volume of water needed but may be viable for organic growers.
- Mulches.
- Cover crops.

Biological control

- Domesticated animals (sheep, geese, goats, chickens, etc.).
- Puncture vine weevil; releases and preservation of established populations.

Needs for Weed Management during Bud Break to Start of Bloom:

Research:

- Develop post-emergent herbicides that are environmentally friendly and cost effective.
- Need more basic work on economic thresholds.

Regulatory:

- Expedite registration of environmentally friendly, cost-effective herbicides.
- Ease standards for obtaining Special Local Needs and Section 18 exemptions.

Education:

- Continue grower and pest control advisor education on weed identification and monitoring and alternative management strategies and tactics (including comparative economics).
- Enhance grower and pest control advisor education about strategies for resistance management and examples of resistance already developed.
- Continue grower and pest control advisor education on means to prevent off-site movement of herbicides.
- Continue education on drift mitigation and management, and associated complaints.
- Educate growers and pesticide applicators about sprayer technologies (including electrostatic) and their effective operation (proper calibration and application use rates, timing, coverage, and placement).

VERTEBRATES

Certain vertebrates can cause problems to vineyards throughout the year. Problems occur when vertebrate pests move into or live near vineyards and seek vineyards for food and cover. Direct feeding damage by rodents is greatest to young vines. Vertebrates managed during bud break to the start of bloom are ground squirrels, meadow voles (field mice), pocket gophers, deer, coyotes, wild pigs, and wild turkeys.

Ground squirrel

Ground squirrels, at dense populations, can cause significant injury by gnawing on vine trunks, removing bark and potentially girdling vines. They also may feed directly on shoots and fruit and gnaw and damage polyethylene irrigation hoses. Moreover, ground squirrels can create large burrows that can endanger workers, disrupt equipment operation, and cause erosion.

Chemical control

- Aluminum and magnesium phosphide (Phostoxin and Magtoxin); fumigants introduced into burrows, work best applied in spring with high soil moisture.
- Anticoagulant baits (e.g., diphacinone); require multiple feedings often via bait station.

Cultural control

- Trapping; often baited, works best for small areas with few squirrels.
- Sanitation; remove cover such as brush piles and debris in or near vineyards.
- Shooting.
- Rodex (propane gun).

Biological control

- Enhancing predation by raptors (hawks and eagles); via raptor perches, kestrel boxes, etc.

Meadow vole (field mouse)

Populations fluctuate greatly based on environmental conditions and typically thrive in areas where grass, brush, and trash accumulate. Voles injure and can kill vines by gnawing bark and partially or completely girdling the trunk at or slightly above soil level, and also by chewing the vine inside the grow tube.

Chemical control

- Anticoagulant baits (e.g., diphacinone); require multiple feedings.

Cultural control

- Sanitation; minimize weeds (particularly around base of vines), heavy mulch, and dense vegetation near vines.
- Removing cartons from transplanted vines.
- Under-the-vine cultivation.

Biological control

- Enhancing predation by raptors (hawks and eagles) and owls; via raptor perches and kestrel and owl boxes, etc.

Pocket gopher

Pocket gophers are important pests, capable of significant injury by cutting roots or gnawing bark and rapidly girdling vines several inches below the soil line. Moreover, their extensive burrows divert water and contribute to soil erosion and produce an uneven vineyard floor, precluding efficient tractor operations.

Chemical control

- Aluminum and magnesium phosphide (Phostoxin and Magtoxin); fumigants introduced into burrows, work best applied in spring with high soil moisture.
- Strychnine bait; kills with single feeding, introduced into main burrows by hand or mechanically incorporated via artificial burrow builders.

Cultural control

- Trapping; placed in main burrows.

- Rodex (propane gun).

Biological control

- Enhancing predation by raptors (hawks and eagles) and especially barn owls; via raptor perches and kestrel and owl boxes, etc.

Deer

Deer can feed on vines and berries and are predominantly a problem near woodlands in coastal areas and the foothills.

Chemical control

- Clay (Surround); somewhat effective at deterring feeding.
- Odor repellents; not very effective as deer acclimate to them.

Cultural control

- Fencing; provides excellent year-round control.
- Shooting; requires depredation permit, not long-term solution.
- Sound repellents; not very effective as deer acclimate to them.

Biological control

- None.

Coyote

Coyotes can damage drip irrigation hoses.

Chemical control

- None.

Cultural control

- Shooting; requires depredation permit.
- Trapping.

Biological control

- None.

Wild Pig

Wild pigs can eat the grapes, root up the vine, etc.

Chemical control

- None.

Cultural control

- Hunting/shooting; requires depredation permit.
- Electric fencing.

Biological control

- None.

Wild Turkey

Wild turkeys eat the young vines and the grapes.

Chemical control

- None.

Cultural control

- Hunting/shooting; requires depredation permit.

Biological control

- None.

Needs for Vertebrate Management during Bud Break to Start of Bloom:

Research:

- Need additional work on deer exclusion alternatives.
- Determine the most effective ratio of predator-prey populations.
- Develop economic thresholds for rodents.

Regulatory:

- None specified.

Education:

- Educate growers about efficacious, neighbor-friendly practices
- Enlighten the general public to health risks associated with vertebrates, as well as the ecosystem services provided by wildlife.
- Educate growers and pest control advisors about the ground squirrel life cycle, feeding behavior, etc.
- Educate growers and pest control advisors about proper bait placement including caution with respect to endangered/threatened species habitat.

BLOOM TO VERAISON (early May – early August)

FARMING ACTIVITIES

- Trunk and shoot suckering.
- Mowing and/or disking.
- Canopy management by hand or mechanical.
- Collection of viticultural data.
- Tissue sampling.
- Soil moisture monitoring.
- Irrigation.
- Fertilization.
- Marketing (winemaker and broker field visits).
- Weed hoeing.
- Pest monitoring.
- Releasing predators.

- Pesticide sprays.
- Fruit thinning.
- Marking vines with symptoms of Pierce's Disease for later removal.

INSECTS AND MITES

During the interval bloom to veraison, management tactics may be implemented for leafhoppers, sharpshooters, spider mites, mealybugs, European fruit lecanium, phylloxera, omnivorous leafroller, orange tortrix, western grapeleaf skeletonizer, and grape leaf folder.

Leafhoppers

Grape and variegated leafhoppers are important pests that may be controlled during this interval. The grape leafhopper is a pest of grapes in the Central Valley, North Coast, and occasionally the Central Coast. The variegated leafhopper is a pest in Southern California and the Central Valley. Adults and nymphs injure grapes by puncturing and feeding from leaf cells, causing yellowing (stippling) and decreased photosynthetic efficiency. Vines tolerate much injury but dense populations can delay fruit maturity and reduce yield and quality. First generations generally are not treated with insecticides to enable suppression via natural enemies and basal leaf removal.

Chemical control

- Imidacloprid (Provado/Admire); preferred and efficacious material, but trade issues and concern about potential resistance.
- Acetamiprid (Assail); neonicotinoid like imidacloprid thus resistance concerns.
- Dimethoate (Cygon), naled (Dibrom), methomyl (Lannate), endosulfan (Thiodan), and carbaryl (Sevin); fair to good control, but resistance issues, disruptive to natural enemies, and dimethoate has relatively high VOC emissions.
- Fenpropathrin (Danitol); good control, but disruptive to natural enemies.
- Clay (Surround); suppresses feeding.
- Buprofezin (Applaud); good control if sufficient coverage.
- Narrow range oil (e.g., JMS Stylet Oil, Saf-T-Side) and neem (e.g., Trilogy); partially effective against young nymphs at low pressures, but not used in close proximity to sulfur or during hot temperatures.
- Insecticidal soap (M-Pede); partially effective against young nymphs at low pressures.
- Pyrethrins (e.g., Pyganic); fair control.
- Pyridaben (Nexter); efficacious product.
- Dinotefuran (Venom); soil and foliar applied, neonicotinoid like imidacloprid thus resistance concerns.
- Thiamethoxam (Platinum); soil applied, neonicotinoid like imidacloprid thus resistance concerns.

Cultural control

- Basal leaf removal; decreases first generation nymphs, limiting subsequent generations.
- Flail mowing; if done prior to bud break can reduce overwintering adults.
- Yellow sticky tape; traps some overwintering adults.
- Suppressing overly vigorous growth; via irrigation, fertilization, and/or competition from cover crops.
- Encouraging growth in low-vigor areas; provides damage tolerance.

Biological control

- Avoiding pesticides disruptive to natural enemies (e.g., *Anagrus* spp).
- Planted cover crop insectaries; may enhance natural enemy activity.

Sharpshooters

Sharpshooters (blue-green, red-headed, green, and glassy-winged) may be controlled with insecticides beginning at shoot elongation. The direct injury caused by sharpshooter shoot feeding is not a problem. However, this feeding can result in the transmission of the bacterium *Xylella fastidiosa*, which causes Pierce's Disease for which there is no cure. The glassy-winged sharpshooter, a relatively new pest established in the South Coast and Central Valley, is an extremely effective vector of this disease. Disease transmission by blue-green sharpshooters generally is associated with coastal vineyards adjacent to riparian areas, where alternative hosts are found. Red-headed and green sharpshooters are the primary vectors in the Central Valley, but cause only occasional problems. To prevent disease transmission, it is important to manage surrounding landscapes to keep sharpshooters from entering vineyards and feeding on vines. Landscape management includes controlling glassy-winged sharpshooter in citrus (southern California) or minimizing host plants for blue-green sharpshooter in riparian areas.

Chemical control

- Imidacloprid (Provado/Admire); preferred and efficacious material, but trade issues and concern about potential resistance.
- Acetamiprid (Assail); neonicotinoid like imidacloprid thus resistance concerns.
- Dimethoate (Cygon); only material for use near riparian environments, but unreliable efficacy against adults, disruptive to natural enemies, and relatively high VOC emissions.
- Clay (Surround); suppresses feeding.
- Malathion and naled (Dibrom); fair control, but short residuals and disruptive to natural enemies.
- Fenpropathrin (Danitol); disruptive to natural enemies.

Cultural control

- Vegetation management of riparian areas for blue-green sharpshooter; plant removal in these ecologically sensitive areas must be approved by regulatory authorities.
- Large buffers between vineyards and adjacent host habitat.
- Trapping with yellow-sticky traps; predominantly used for monitoring.
- Sharpshooter management in surrounding crops and landscapes.

Biological control

- Releases of Mymarid egg parasitoids; help suppress glassy-winged sharpshooter.

Spider mites

Mites can first become pests during bud break in certain regions, although damaging populations generally are found from shoot elongation to harvest. Injury results from leaf feeding by Willamette or Pacific mites, which causes leaf discoloration and decreased functionality. No organophosphates or carbamates are used for mite control. Some materials listed below can be quite disruptive to natural enemies. Cultural manipulations and/or natural enemies often maintain mite populations at tolerable levels in winegrapes.

Chemical control

- Dicofol (Kelthane); infrequently used because of resistance and disruption to natural enemies.
- Fenbutatin-oxide (Vendex); inadequate knockdown.
- Narrow range oil (e.g., JMS Stylet Oil, Saf-T-Side); fair control and relatively safe to natural enemies, but not used in close proximity to sulfur or during hot temperatures.
- Propargite (Omite); used as last resort because of resistance, worker safety issues, and relatively long restricted entry interval.
- Fenpropathrin (Danitol); fair control, but disruptive to natural enemies.
- Abamectin (AgriMek); good control, but relatively high VOC emissions.
- Insecticidal soap (M-Pede); fair to good control.
- Pyridaben (Nexter); efficacious product, best on Willamette mite.
- Fenpyroximate (FujiMite); efficacious product.
- Bifenazate (Acramite); efficacious product.

Cultural control

- Cover crops; reduce dust associated with outbreaks and provide habitat for natural enemies, delaying some treatments or making them unnecessary.
- Dust minimization; on roads in and surrounding vineyards can limit population buildup.
- Irrigation management; avoiding water-stressed vines reduces population buildup.

Biological control

- Releases of predatory mites; species released and efficacy depend on temperature.
- Avoiding pesticides disruptive to natural enemies.

Mealybugs

Pseudococcus species (grape, obscure, and long-tailed mealybugs) and vine mealybugs cause problems. Vine mealybug (a species from the genus *Planococcus*) is a serious new pest, occurring in winegrowing areas of the San Joaquin Valley, Central and North coasts, and Sierra Foothills. Intensive efforts are being devoted to limit the spread of vine mealybug and improve IPM programs. Mealybugs can transmit grape viruses, reduce vine growth, and render grapes unmarketable by contaminating clusters with their life stages, honeydew, and sooty mold (honeydew is the substrate). Vine mealybug is of key concern because it has a large rate of population increase, an ability to excrete excessive honeydew, a portion of the population is always secluded under bark or on roots, few natural enemies, and multiple hosts. Vine mealybug can be found living on roots of grapes in soil as deep as two feet, especially when tended by ants or in sandy soils. Insecticides may be applied during delayed dormancy, spring, summer, and post harvest. Optimal timing of treatment(s) depends on the species and should be made when more susceptible life stages (crawlers and young nymphs) are exposed on plant surfaces. Natural enemies suppress mealybugs, so tactics used to control honeydew-seeking ants (e.g., tillage, contact insecticides, bait stations) can enhance natural control.

Chemical control

- Imidacloprid (Admire); good control with single/split applications, but trade issues and concern about potential resistance.
- Buprofezin (Applaud); effective, but not used if vine mealybug eradication is objective.
- Acetamiprid (Assail); works well, but neonicotinoid like imidacloprid thus resistance concerns.

- Clothianidin (Clutch); newly registered, but trade issues and neonicotinoid like imidacloprid thus resistance concerns.
- Spirotetramat (Movento); newly registered lipid biosynthesis inhibitor, but trade issues (incomplete international MRLs).
- Malathion and naled (Dibrom); fair control, but short residuals and disruptive to natural enemies.
- Fenpropathrin (Danitol); disruptive to natural enemies and not efficacious.
- Dinotefuran (Venom); soil and foliar applied, neonicotinoid like imidacloprid thus resistance concerns.
- Thiamethoxam (Platinum); soil applied, neonicotinoid like imidacloprid thus resistance concerns.

Cultural control

Equipment and general vineyard sanitation; prevents spread to non-infested areas.

Biological control

- Avoiding pesticides disruptive to natural enemies of *Pseudococcus* mealybugs.

European fruit lecanium

The European fruit lecanium (i.e., brown apricot scale) produces honeydew that can result in excess sooty mold on berries and leaves. At high densities, lecanium feeding can stunt vine growth. Indigenous parasitoids and predators generally suppress lecanium to sub-economic levels. Management includes monitoring, preserving natural enemies, and insecticide applications as necessary. Parasitism of nymphs should be monitored during late dormancy and necessary insecticides should target crawlers (first instars), present May through June.

Chemical control

- Narrow range oil (e.g., JMS Stylet Oil, Saf-T-Side); best efficacy from split applications.
- Imidacloprid (Admire); good control, but trade issues and concern about potential resistance.

Cultural control

- Controlling honeydew-seeking ants via tillage or chlorpyrifos (Lorsban); enables optimal impact by natural enemies.

Biological control

- Avoiding pesticides that disrupt natural biological control.

Grape phylloxera

Grape phylloxera feed on grape roots, stunting or killing vines. Phylloxera cause greater injury in areas with heavier clay soils, although problems occur in all winegrowing regions. Phylloxera can be managed culturally and/or chemically, but the only reliable means for control is the planting of resistant rootstocks. Pre-plant applications of fumigants targeting nematodes or oak root fungus may provide limited suppression of existing phylloxera in replanting situations. Post-plant insecticides provide suppression only, due to the difficulty in penetrating the heavy clay soils that the pest prefers and because populations rebound quickly. Although insecticides may be applied throughout the year, best timing generally is associated with rapid root growth during the spring and/or fall (early post harvest).

Chemical control

- Imidacloprid (Admire) and thiamethoxam (Platinum); provide suppression especially when applied in a single or split application over several consecutive years, but trade issues and concern about potential resistance to this widely used neonicotinoid class of chemistry.
- Sodium tetrathiocarbonate (Enzone); avoided because of inconsistent efficacy.
- Fenamiphos (Nemacur); fair suppression, but not for purchase after May 31, 2008 under terms of phase out agreement.
- Spirotetramat (Movento); newly registered, but trade issues (incomplete international MRLs).

Cultural control

- Irrigation and fertilization; reduces vine stress, especially in the hot Central Valley.
- Sanitation; remove soil from equipment before moving among vineyards.
- Addition of organic matter to soil; may mitigate vine stress.

Biological control

- None.

Lepidoptera

This is an active period for managing omnivorous leafroller, orange tortrix, grape leaffolder, and western grapeleaf skeletonizer. These pests feed on various shoot tissues and are capable of causing extensive defoliation (western grapeleaf skeletonizer and grape leaffolder) or fruit damage (predominantly omnivorous leafroller and orange tortrix) via direct feeding and, more importantly, the subsequent entry by botrytis and other fungi and bacteria capable of causing bunch rots. Necessary insecticide applications may first be made during shoot elongation, but generally are not made until after bloom. Light brown apple moth is a newly introduced pest to California (detected in Central and North Coasts), for which quarantine restrictions and eradication procedures are underway.

Chemical control

- Phosmet (Imidan) and diazinon; fair to excellent control, but generally not used because of ecological disruption and worker safety concerns.
- Carbaryl (Sevin) and methomyl (Lannate); fair to good control, but disruptive to natural enemies and IPM programs.
- Cryolite (Kryocide); effective, but must be applied before full bloom, can cause secondary pest outbreaks, and has trade issues (fluoride residues) causing wineries with export markets to prohibit its use.
- *Bacillus thuringiensis* sprays; effective on small larvae, but short residuals.
- Methoxyfenozide (Intrepid); excellent efficacy except for western grapeleaf skeletonizer.
- Fenpropathrin (Danitol); poor control of western grapeleaf skeletonizer.
- Clay (Surround); feeding barrier providing suppression.
- Pheromone confusion; used for omnivorous leafroller.
- Spinosad (Success, Entrust); expensive products, Entrust approved for organic production.
- Spinetoram (Delegate).
- Indoxacarb (Avaunt).
- Chlorantraniliprole (Altacor); newly registered May 28, 2008.

Cultural control

- Basal leaf removal; improves coverage with pesticides.

Biological control

- Natural populations of numerous parasitoids and predators suppress these pests; avoid disruptive pesticides.
- Introduction of the granulosis virus for western grapeleaf skeletonizer.

Needs for Insect and Mite Management during Bloom to Veraison:

Research:

- Continue allocating funds toward understandings and management strategies for glassy-winged sharpshooter and Pierce's Disease (the state PD/GWSS Board is funding extensive research).
- Evaluate impacts of newer pest control products, including growth regulators, on non-target organisms.
- Establish economic thresholds for mites and leafhoppers.
- Develop new control tactics for vine mealybug, including use of parasitoids and pheromone-based mating disruption.
- Develop effective tactics for controlling phylloxera.
- Improve understanding of the effects of narrow range oils, including application timing, on fermentation and wine quality.

Regulatory:

- Expedite registrations of new materials for sharpshooters, vine mealybug, and phylloxera.
- Enable large-scale field testing of pheromones without the expensive requirement of crop destruction.
- Ease standards for obtaining Special Local Needs and Section 18 exemptions.

Education:

- Teach growers, pest control advisors, and workers (English- and Spanish-speaking) to identify sharpshooters (especially glassy-winged sharpshooter), vine mealybug, light brown apple moth (ensuring its rapid eradication), and other newly introduced pests.
- Educate growers and pest control advisors about cultural, chemical, and other management options, resistance management strategies, and monitoring procedures and thresholds.
- Ensure growers and pest control advisors are familiar with use of available development models (biofix determinations) for lepidopterous pests.
- Inform growers and pest control advisors about newly developed pest management practices.
- Continue education on drift mitigation and management, and associated complaints.
- Educate growers and pesticide applicators about sprayer technologies (including electrostatic) and their effective operation (proper calibration and application use rates, timing, coverage, and placement).

DISEASES

Powdery mildew and Botrytis often are actively managed during bloom to veraison.

Powdery mildew

Powdery mildew is the most significant disease affecting winegrapes. It is estimated that powdery mildew is present in virtually all vineyards each year, the only variable being the severity of infection. Fungicides may be applied during dormancy to reduce over-wintering inoculum, but powdery mildew is predominantly treated from bud break to veraison. The use of the mildew index, determined via a temperature-driven disease forecasting model, helps optimally time fungicide applications for preventive treatment, often reducing applications. Field monitoring is essential for identifying symptoms of the disease to supplement decision making for preventive and curative treatments. Sulfur products are key tools for management. Sterol inhibitor chemistry remains an important alternative mode of action, despite evidence of resistance.

Chemical control

Sulfur and Related Compounds

- Dusting sulfur; widely used because of its organic classification, relatively low cost, and reliable efficacy, but issues with drift, worker safety, and phytotoxicity at high temperatures.
- Wettable, flowable, and micronized sulfur formulations; excellent control, but issues with phytotoxicity at high temperatures.
- Copper sprays with or without sulfur; good to excellent control, but can be phytotoxic.

Sterol Inhibitors

- Myclobutanil (Rally); often excellent control, but some resistance.
- Fenarimol (Rubigan); efficacious, but some resistance and can be phytotoxic to young shoots.
- Triflumizole (Procure); efficacious, but some resistance.
- Tebuconazole (Elite); efficacious product used interchangeably with myclobutanil and fenarimol.

Strobilurins

- Azoxystrobin (Abound); highly effective material, but costly.
- Trifloxystrobin (Flint); excellent control.
- Kresoxim-methyl (Sovran); excellent control.
- Pyraclostrobin + boscalid (Pristine); efficacious product.

Biologicals

- *Bacillus subtilis* (Serenade); efficacious at low disease pressure.
- *Bacillus pumilus* (Sonata).

Systemic Acquired Resistance Elicitors

- Harpin protein (Messenger); good control at low disease pressure on specific varieties.
- Chitosan (Elexa); good control at low disease pressure.
- Gaba/L-glutamic acid (AuxiGro); efficacy not fully understood.

Contacts

- Narrow range oil (e.g., JMS Stylet Oil, Saf-T-Side) and neem; good control, but can be phytotoxic at high temperatures or in close proximity to sulfur.
- Potassium bicarbonate (Kaligreen, Armicarb); good control.
- Insecticidal soap (M-Pede); fair to good control.

Other

- Quinoxifen (Quintec); excellent control.
- Boscalid (Endura).

Cultural control

- Canopy management (e.g., leaf and shoot removal and positioning); opens canopy, enabling complete fungicide coverage at lowest effective rates.
- Sanitation; removal of diseased shoots and old clusters.
- Integration of weather information via the mildew index; optimizes and often reduces treatments.

Biological control

- None.

Botrytis – bunch rot

Succulent plant tissues (young shoots or flower parts) are susceptible to infection by Botrytis. Rainy, warm springs increase disease incidence and severity. A disease forecasting model to time necessary preventive treatments based on wetness duration and temperature has been developed but has not been widely adopted. By allowing sufficient air exchange that lowers the canopy humidity, canopy management, particularly leaf removal proximal to clusters, is a highly effective tactic to integrate into management programs and can reduce the need for fungicide treatments. Few fungicides used for other diseases control Botrytis. Unfortunately, no products enable practical, effective curative control.

Chemical control

- Iprodione (Rovral); good efficacy.
- *Bacillus subtilis* (Serenade); fair to good control.
- Pyraclostrobin + boscalid (Pristine); new efficacious product.
- Fenhexamid (Elevate); excellent control.
- Narrow range oil (e.g., JMS Stylet Oil, Saf-T-Side); good control, but can be phytotoxic during high temperatures or in close proximity to sulfur.
- Cyprodinil (Vanguard); excellent control.
- Dichloran (Botran); fair control.
- Copper + sulfur sprays; fair control, but can be phytotoxic.

Cultural control

- Canopy management; especially leaf removal.
- Irrigation management; reduced irrigation limits lush growth associated with larger berries and splitting.
- Cluster sculpturing and/or removal on some varieties.

Biological control

- *Trichoderma* spp. (Trichodex); may help with suppression.

Esca (black measles)

Esca (black measles) typically occurs in older vines and is caused by a complex of fungal pathogens that propagate in old, rotted vascular tissue. Spores released from these tissues reinfect vines through pruning wounds. Symptoms are most prevalent during July and August. Leaves of infected vines often display chlorotic interveinal areas. Severely infected vines can experience leaf drop, cane dieback, and cracked and dried fruit. Young esca, also known as Petri disease or young vine decline, is a related disease in young vines that likely originates from infected nursery stock.

Chemical control

- None.

Cultural control

- Dropping crop prior to harvest.

Biological control

- None.

Needs for Disease Management during Bloom to Veraison:

Research:

- Find new products (especially curative) and methods (including genetic resistance) for managing powdery mildew.
- Continue to refine the powdery mildew model.
- Determine effects of vineyard sanitation practices on the fungal complex causing esca (black measles).

Regulatory:

- Maintain sulfur dust as a viable option by complying with winegrape industry and Sulfur Task Force stewardship recommendations (sulfur dust has drift and possible PM-10 air quality concerns).
- Ease standards for obtaining Special Local Needs and Section 18 exemptions.

Education:

- Continue educating growers, applicators, and pest control advisors about label guidelines and stewardship recommendations for preventing sulfur and other pesticide drift, and associated complaints.
- Further educate growers and pest control advisors on using the powdery mildew index to optimally time and potentially reduce treatments.
- Disseminate information on the importance of monitoring and resistance management for various diseases, as well as alternative methods when available.
- Educate growers about irrigation management and canopy management for preventing bunch rots.
- Educate growers and pesticide applicators about sprayer technologies (including electrostatic) and their effective operation (proper calibration and application use rates, timing, coverage, and placement).

- Ensure understanding about diagnosing symptoms of Pierce's Disease.

WEEDS

Weeds may be managed with post-emergent herbicides and/or non-chemical tactics during bloom to veraison. Herbicides often are a significant portion of the pest control budget. Glyphosate (e.g. Roundup), glufosinate-ammonium (Rely), and paraquat (Gramoxone) are important post-emergent herbicides that control a wide-spectrum of grassy and broadleaf weeds. Post-emergent herbicides are applied under the vine in bands or spot sprayed, often via precision technology. Hooded spray booms are available for minimizing drift. A number of post-emergent herbicides are available for non-bearing vines only. Extra care must be taken to ensure that green shoots are not contacted by non-selective, post-emergent materials.

Besides herbicides, mechanical removal of under-the-vine weeds is used but its frequency is based on region, vineyard size, and soil type. Mechanical control often requires an investment in additional equipment, not always economically viable. However, organic winegrape growers rely mostly on mechanical cultivation, using under-the-vine tillage equipment. This approach has proven to be economical for them. Other non-chemical options include flaming, mulches, and cover crops (including under the vine).

Many growers maintain cover crops between rows primarily to manage soils but also to prevent weeds from invading vine rows. Factors limiting greater adoption of cover crops include concerns about decreased crop vigor, greater water and fertilizer requirements and overall costs, and increased problems with perennial weeds such as bermudagrass, bindweed, and johnsongrass. Moreover, cover crops may increase problems with vertebrate pests such as voles and gophers.

Chemical control (post-emergent)

- Glyphosate (Roundup); widely used, non-selective material.
- Paraquat (Gramoxone); non-selective material.
- Glufosinate-ammonium (Rely).
- Sethoxydim (Poast).
- Sulfosate (Touchdown); non-selective material.
- Clethodim (Prism), diquat (Reglone), fluazifop-p (Fusilade), and MSMA; non-bearing vines only.
- Organic products (e.g., soap-based (Scythe), acetic acid formulations, clove (e.g., Matram2) and other essential oils, and corn gluten); not very efficacious, rarely used.

Cultural control

- Cultivation (including hand hoeing).
- Mowing.
- Propane flaming; risky due to fire hazard.
- Steam and/or hot water; high cost due to large volume of water needed but may be viable for organic growers.
- Mulches.
- Cover crops.

Biological control

- Domesticated animals (sheep, geese, goats, chickens, etc.).

- Puncture vine weevil; releases and preservation of established populations.

Needs for Weed Management during Bloom to Veraison:

Research:

- Develop post-emergent herbicides that are environmentally friendly and cost effective.
- Need more basic work on economic thresholds.

Regulatory:

- Expedite registration of environmentally friendly, cost-effective herbicides.
- Ease standards for obtaining Special Local Needs and Section 18 exemptions.

Education:

- Continue grower and pest control advisor education on weed identification and monitoring and alternative management strategies and tactics (including comparative economics).
- Enhance grower and pest control advisor education about strategies for resistance management and examples of resistance already developed.
- Continue grower and pest control advisor education on means to prevent off-site movement of herbicides.
- Continue education on drift mitigation and management, and associated complaints.
- Educate growers and pesticide applicators about sprayer technologies (including electrostatic) and their effective operation (proper calibration and application use rates, timing, coverage, and placement).

VERTEBRATES

Certain vertebrates can cause problems to vineyards throughout the year. Problems occur when vertebrates move into or live near vineyards and seek vineyards for food and cover. Direct feeding damage by rodents is greatest to young vines. During bloom to veraison, management tactics may be implemented for ground squirrels, meadow voles (field mice), pocket gophers, deer, coyotes, and birds.

Ground squirrel

Ground squirrels at dense populations can cause significant injury by gnawing on vine trunks, removing bark and potentially girdling vines. They also may feed directly on shoots and fruit and gnaw and damage polyethylene irrigation hoses. Moreover, ground squirrels can create large burrows that can endanger workers, disrupt equipment operation, and cause erosion.

Chemical control

- Aluminum and magnesium phosphide (Phostoxin and Magtoxin); fumigants introduced into burrows, work best applied in spring with high soil moisture.
- Anticoagulant baits (e.g., diphacinone); require multiple feedings often via bait station.

Cultural control

- Trapping; often baited, works best for small areas with few squirrels.
- Sanitation; remove cover such as brush piles and debris in or near vineyards.
- Shooting.
- Rodex (propane gun).

Biological control

- Enhancing predation by raptors (hawks and eagles); via raptor perches, kestrel boxes, etc.

Meadow vole (field mouse)

Populations fluctuate greatly based on environmental conditions and typically thrive in areas where grass, brush, and trash accumulate. Voles injure and can kill vines by gnawing bark and partially or completely girdling the trunk at or slightly above soil level, and also by chewing the vine inside the grow tube.

Chemical control

- Anticoagulant baits (e.g., diphacinone); require multiple feedings.

Cultural control

- Sanitation; minimize weeds (particularly around base of vines), heavy mulch, and dense vegetation near vines.
- Removing cartons from transplanted vines.
- Under-the-vine cultivation.

Biological control

- Enhancing predation by raptors (hawks and eagles) and owls; via raptor perches and kestrel and owl boxes, etc.

Pocket gopher

Pocket gophers are important pests, capable of significant injury by cutting roots or gnawing bark and rapidly girdling vines several inches below the soil line. Moreover, their extensive burrows divert water and contribute to soil erosion and produce an uneven vineyard floor, precluding efficient tractor operations.

Chemical control

- Aluminum and magnesium phosphide (Phostoxin and Magtoxin); fumigants introduced into burrows, work best applied in spring with high soil moisture.
- Strychnine bait; kills with single feeding, introduced into main burrows by hand or mechanically incorporated via artificial burrow builders.

Cultural control

- Trapping; placed in main burrows.
- Rodex (propane gun).

Biological control

- Enhancing predation by raptors (hawks and eagles) and especially owls; via raptor perches and kestrel and owl boxes, etc.

Deer

Deer can feed on vines and berries and are predominantly a problem near woodlands in coastal areas and the foothills.

Chemical control

- Clay (Surround); somewhat effective at deterring feeding.
- Odor repellents; not very effective as deer acclimate to them.

Cultural control

- Fencing; provides excellent year-round control.
- Shooting; requires depredation permit and not long-term solution.
- Sound repellents; not very effective as deer acclimate to them.

Biological control

- None.

Coyote

Coyotes can damage drip irrigation hoses.

Chemical control

- None.

Cultural control

- Shooting; requires depredation permit.
- Trapping.

Biological control

- None.

Birds

Several species of birds (e.g., house finch, starling, American robin) are capable of substantial damage by feeding on ripening berries, directly reducing yield and quality and predisposing fruit to bunch rots.

Chemical control

- Chemical repellents; sporadic efficacy.

Cultural control

- Habitat alteration; minimizes house finch nesting and loafing habitats (e.g., brush piles).
- Shooting; may require depredation permit and costly and time consuming.
- Sound repellents (e.g., gas cannons, shell crackers, electric noise makers); alter frequency and location to minimize acclimation, but may create nuisance complaints from neighbors.
- Visual repellents (e.g., Mylar tape, kites, balloons, flags, foil); often short-term solution as birds acclimate.
- Netting; relatively expensive, but cost-effective for small vineyards with high value fruit.
- Trapping; can be effective for resident house finches and starlings.

Biological control

- Falconry; expensive, but cost-effective for certain areas.

Needs for Vertebrate Management during Bloom to Veraison:

Research:

- None specified.

Regulatory:

- None specified.

Education:

- Educate growers about efficacious and neighbor-friendly practices.
- Enlighten the general public to health risks associated with vertebrates, as well as the ecosystem services provided by wildlife.
- Educate growers and pest control advisors about the ground squirrel life cycle, feeding behavior, etc.
- Educate growers and pest control advisors about proper bait placement including caution with respect to endangered/threatened species habitat.

VERAISON TO HARVEST (early July – early November)

FARMING ACTIVITIES

- Canopy management by hand or mechanical.
- Fruit maturity sampling.
- Soil moisture monitoring.
- Irrigation.
- Cultivation.
- Fruit thinning (green fruit drop).
- Pest monitoring.
- Pesticide applications.
- Extraction of vines with Pierce's Disease.
- Marketing (winemaker and broker field visits).
- Harvesting via hand and/or machine.

INSECTS AND MITES

The interval from veraison to harvest is important for managing leafhoppers, spider mites, mealybugs, omnivorous leafroller, orange tortrix, grape leafroller, and western grapeleaf skeletonizer. Although the current crop can tolerate higher populations of leafhoppers and mites during this interval, most growers do not account for this because of concerns about storage carbohydrates for the next season and the annoyance of these pests to field workers. Because of the proximity to harvest, growers must carefully consider pre-harvest intervals for pesticide applications and consult with contracted wineries about pesticide restrictions.

Leafhoppers

Grape and variegated leafhoppers are important pests that may be controlled during this interval. The grape leafhopper is a pest of grape in the Central Valley, North Coast, and occasionally the Central Coast. The variegated leafhopper is a pest in Southern California and the Central Valley. Adults and nymphs injure grapes by puncturing and feeding from leaf cells, causing yellowing (stippling) and decreased photosynthetic efficiency. Vines tolerate much injury but dense populations can delay fruit maturity and reduce yield and quality. Earlier occurring first generations generally are not treated with insecticides to enable suppression via natural enemies and basal leaf removal.

Chemical control

- Imidacloprid (Provado); preferred and efficacious material, but trade issues and concern about potential resistance.
- Dinotefuran (Venom); soil and foliar applied, neonicotinoid like imidacloprid thus resistance concerns.
- Acetamiprid (Assail); neonicotinoid like imidacloprid thus resistance concerns.
- Dimethoate (Cygon), naled (Dibrom), methomyl (Lannate), endosulfan (Thiodan), and carbaryl (Sevin); fair to good control, but resistance issues, disruptive to natural enemies, and dimethoate has relatively high VOC emissions.
- Fenpropathrin (Danitol); good control, but disruptive to natural enemies.
- Buprofezin (Applaud); good control if sufficient coverage.
- Narrow range oil (e.g., JMS Stylet Oil, Saf-T-Side) and neem (e.g., Trilogy); partially effective against young nymphs at low pressures, but not used in close proximity to sulfur or during hot temperatures.
- Insecticidal soap (M-Pede); partially effective against young nymphs at low pressures.
- Pyrethrins (e.g., Pyganic); fair control.

Cultural control

- Suppressing overly vigorous growth; via irrigation, fertilization, and/or competition from cover crops.

Biological control

- Avoiding pesticides disruptive to natural enemies (e.g., *Anagrus* spp).
- Planted cover crop insectaries; may enhance natural enemy activity.

Spider mites

Mites can first become pests during bud break in certain regions, although damaging populations generally are found from shoot elongation to harvest. Injury results from leaf feeding by Willamette or Pacific mites, which causes leaf discoloration and decreased functionality. No organophosphates or carbamates are used for mite control. Some materials listed below can be quite disruptive to natural enemies. Cultural manipulations and/or natural enemies often maintain mite populations at tolerable levels in winegrapes.

Chemical control

- Dicofol (Kelthane); infrequently used because of resistance and disruption to natural enemies.
- Fenbutatin-oxide (Vendex); inadequate knockdown.
- Narrow range oil (e.g., JMS Stylet Oil, Saf-T-Side); fair control and relatively safe to

natural enemies, but not used in close proximity to sulfur or during hot temperatures.

- Propargite (Omite); used as last resort because of resistance, worker safety issues, and relatively long restricted entry interval.
- Fenprothrin (Danitol); fair control, but disruptive to natural enemies.
- Abamectin (AgriMek); good control, but relatively high VOC emissions.
- Insecticidal soap (M-Pede); fair to good control.
- Pyridaben (Nexter); efficacious product, best on Willamette mite.
- Fenpyroximate (FujiMite); efficacious product.
- Bifenazate (Acramite); efficacious product.

Cultural control

- Cover crops; reduce dust associated with outbreaks and provide habitat for natural enemies, delaying some treatments or making them unnecessary.
- Dust minimization; on roads in and surrounding vineyards can limit population buildup.
- Irrigation management; avoiding water-stressed vines reduces population buildup.

Biological control

- Releases of predatory mites; species released and efficacy depend on temperature.
- Avoiding pesticides disruptive to natural enemies.

Mealybugs

Pseudococcus species (grape, obscure, and long-tailed mealybugs) and vine mealybugs cause problems. Vine mealybug (a species from the genus *Planococcus*) is a serious new pest, occurring in winegrowing areas of the San Joaquin Valley, Central and North coasts, and Sierra Foothills. Intensive efforts are being devoted to limit the spread of vine mealybug and improve IPM programs. Mealybugs can transmit grape viruses, reduce vine growth, and render grapes unmarketable by contaminating clusters with their life stages, honeydew, and sooty mold (honeydew is the substrate). Vine mealybug is of key concern because it has a large rate of population increase, an ability to excrete excessive honeydew, a portion of the population is always secluded under bark or on roots, few natural enemies, and multiple hosts. Vine mealybug can be found living on roots of grapes in soil as deep as two feet, especially when tended by ants or in sandy soils. Insecticides may be applied during delayed dormancy, spring, summer, and post harvest. Optimal timing of treatment(s) depends on the species and should be made when more susceptible life stages (crawlers and young nymphs) are exposed on plant surfaces. Natural enemies suppress mealybugs, so tactics used to control honeydew-seeking ants (e.g., tillage, contact insecticides, bait stations) can enhance natural control. During the early part of the veraison to harvest interval, an insecticide may be used as a component of the management program. To prevent spread of vine mealybug, it is important to make an application if the pest is present and to prevent early leaf drop.

Chemical control

- Buprofezin (Applaud); effective, but not used if vine mealybug eradication is objective.
- Methomyl (Lannate); disruptive to natural enemies.
- Carbaryl (Sevin); disruptive to natural enemies.
- Dimethoate (Cygon); knockdown, but not great control, disruptive to natural enemies, and relatively high VOC emissions.
- Acetamiprid (Assail); works well, but neonicotinoid like imidacloprid thus resistance concerns.

- Clothianidin (Clutch); newly registered, but trade issues and neonicotinoid like imidacloprid thus resistance concerns.

Cultural control

- Equipment and general vineyard sanitation; prevents spread to non-infested areas.

Biological control

- Avoiding pesticides disruptive to natural enemies of *Pseudococcus* mealybugs.

Lepidoptera

During this interval, it is important to continue monitoring for and potentially controlling problematic lepidopterous pests, including omnivorous leafroller, orange tortrix, grape leaffolder, and western grapeleaf skeletonizer. These pests feed on various shoot tissues and are capable of causing extensive defoliation (western grapeleaf skeletonizer and grape leaffolder) or fruit damage (predominantly omnivorous leafroller and orange tortrix) via direct feeding and, more importantly, the subsequent entry by botrytis and other fungi and bacteria capable of causing bunch rots. Necessary insecticide applications may first be made during shoot elongation, but generally are not made until after bloom. Light brown apple moth is a newly introduced pest to California (detected in Central and North Coasts), for which quarantine restrictions and eradication procedures are underway.

Chemical control

- Phosmet (Imidan) and diazinon; fair to excellent control, but generally not used because of ecological disruption and worker safety concerns.
- Carbaryl (Sevin) and methomyl (Lannate); fair to good control, but disruptive to natural enemies and IPM programs.
- *Bacillus thuringiensis* sprays; effective on small larvae, but short residuals.
- Methoxyfenozide (Intrepid); excellent efficacy, except for western grapeleaf skeletonizer.
- Fenpropathrin (Danitol); poor control of western grapeleaf skeletonizer.
- Clay (Surround); feeding barrier providing suppression.
- Pheromone confusion; used for omnivorous leafroller.
- Spinosad (Success, Entrust); expensive products, Entrust approved for organic production.
- Spinetoram (Delegate).
- Indoxacarb (Avaunt).
- Chlorantraniliprole (Altacor); newly registered May 28, 2008.

Cultural control

- Early harvest can limit late-season damage to grape bunches.

Biological control

- Natural populations of numerous parasitoids and predators suppress these pests; avoid disruptive pesticides.
- Introduction of the granulosis virus for western grapeleaf skeletonizer.

Needs for Insect and Mite Management during Veraison to Harvest:

Research:

- Evaluate impacts of newer pest control products, including growth regulators, on non-target organisms.
- Develop new control tactics for vine mealybug, including use of parasitoids and pheromone-based mating disruption.
- Establish economic thresholds for mites.

Regulatory:

- Expedite registrations of new materials for vine mealybug.
- Enable large-scale field testing of pheromones without the expensive requirement of crop destruction.
- Ease standards for obtaining Special Local Needs and Section 18 exemptions.

Education:

- Teach growers, pest control advisors, and workers (English- and Spanish-speaking) to identify vine mealybug, light brown apple moth (ensuring its rapid eradication), and other newly introduced pests.
- Educate growers and pest control advisors about cultural, chemical, and other management options, resistance management strategies, and monitoring procedures and thresholds.
- Inform growers and pest control advisors about newly developed pest management practices.
- Continue education on drift mitigation and management, and associated complaints.
- Educate growers and pesticide applicators about sprayer technologies (including electrostatic) and their effective operation (proper calibration and application use rates, timing, coverage, and placement).

DISEASES

During veraison to harvest, fungicides may be applied to control powdery mildew, Botrytis bunch rot, and summer bunch rot (sour rot). Symptoms of esca are more evident during this time. Also, vines infected with Pierce's Disease may be removed.

Powdery mildew

Powdery mildew is the most significant disease affecting winegrapes. It is estimated that powdery mildew is present in virtually all vineyards each year, the only variable being the severity of infection. Fungicides may be applied during dormancy to reduce over-wintering inoculum, but powdery mildew is predominantly treated from bud break to veraison. The use of the mildew index, determined via a temperature-driven disease forecasting model, helps optimally time fungicide applications for preventive treatment, often reducing applications. Field monitoring is essential for identifying symptoms of the disease to supplement decision making for preventive and curative treatments. Sulfur products are key tools for management. Sterol inhibitor chemistry remains an important alternative mode of action, despite evidence of resistance. Post-veraison berries are immune to new infections. Contact fungicides, however, may be applied to eradicate existing infections, verified by monitoring.

Chemical control (contact materials)

- Potassium bicarbonate (Kaligreen, Armicarb).
- Water + wetting agent; tank mix may also include potassium bicarbonate (Kaligreen, Armicarb).
- Narrow range oil (e.g., JMS Stylet Oil, Saf-T-Side) and neem; good control, but can be phytotoxic at high temperatures and must be allowed by winemakers.

Cultural control

- None.

Biological control

- None.

Botrytis – bunch rot

Succulent plant tissues (young shoots or flower parts) are susceptible to infection by Botrytis during spring. Rainy, warm springs increase disease incidence and severity. A disease forecasting model to time necessary preventive treatments based on wetness duration and temperature has been developed but has not been widely adopted. During the veraison to harvest interval, fungicides may be applied to prevent late-season Botrytis problems, especially before rainfall. Appropriate canopy management done earlier, particularly leaf removal proximal to clusters, can reduce the need for fungicide treatments by producing a canopy microclimate less conducive to disease development. Few fungicides used for other diseases control Botrytis. Unfortunately, no products enable practical, effective curative control.

Chemical control

- Iprodione (Rovral); good efficacy.
- *Bacillus subtilis* (Serenade); fair to good control.
- Pyraclostrobin + boscalid (Pristine); efficacious product.
- Fenhexamid (Elevate); excellent control.
- Narrow range oil (e.g., JMS Stylet Oil, Saf-T-Side); good control, but can be phytotoxic during high temperatures or in close proximity to sulfur.
- Cyprodinil (Vangard); excellent control.
- Dichloran (Botran); fair control.
- Copper + sulfur sprays; fair control, but can be phytotoxic.

Cultural control

- Irrigation management; reduced irrigation limits lush growth associated with larger berries and splitting.
- Cluster sculpturing and/or removal on some varieties.

Biological control

- *Trichoderma* spp. (Trichodex); may help with suppression.

Sour rot (summer bunch rot)

Sour rot, also known as summer bunch rot, can be a problem in the San Joaquin Valley. The disease is associated with a complex of fungi and bacteria that invade berries previously damaged by insects or birds, mechanical means or growth cracks, or lesions resulting from other diseases. Fungicides are available, but treatments generally are not fully effective.

Chemical control

- Copper/sulfur dust (COCS); fair control.
- Hydrated lime/sulfur dust; limited use based on quality issues.
- Dichloran (Botran); somewhat effective.
- Pyraclostrobin + boscalid (Pristine); new product.
- *Bacillus subtilis* (Serenade); fair control.
- Boscalid (Endura).
- Pyraclostrobin + boscalid (Pristine).

Cultural control

- Pruning (during dormancy); decreases berry size and, therefore, problems with splitting.
- Irrigation and nutrient management (done earlier); can decrease berry size and splitting.

Biological control

- *Pseudomonas fluorescens* (BlightBan); may help with suppression.

Esca (black measles)

Esca typically occurs in older vines and is caused by a complex of fungal pathogens that propagate in old, rotted vascular tissue. Spores released from these tissues reinfect vines through pruning wounds. Symptoms are most prevalent during July and August. Leaves of infected vines often display chlorotic interveinal areas. Severely infected vines can experience leaf drop, cane dieback, and cracked and dried fruit. Young esca, also known as Petri disease or young vine decline, is a related disease in young vines that likely originates from infected nursery stock.

Chemical control

- None.

Cultural control

- Dropping crop prior to harvest.

Biological control

- None.

Needs for Disease Management during Veraison to Harvest:

Research:

- Characterize the epidemiology of esca and develop effective management strategies and tactics.
- Elucidate biological impacts of fungicides on arthropod predators and parasitoids.
- Determine the interaction between Botrytis infection and the development of sour rot.

Regulatory:

- Expand list of justifications for obtaining Special Local Needs and Section 18 exemptions to include resistance management.

Education:

- Ensure growers and pest control advisors can distinguish sour rot from Botrytis bunch rot

and understand the importance of preventing damage from lepidopterous pests as key to reducing sour rot incidence.

- Educate growers about irrigation management and canopy management (done earlier) for preventing bunch rots.
- Disseminate information on the importance of monitoring and resistance management for various diseases, as well as alternative methods when available.
- Educate growers and pesticide applicators about sprayer technologies (including electrostatic) and their effective operation (proper calibration and application use rates, timing, coverage, and placement).
- Continue education on drift mitigation and management, and associated complaints.

WEEDS

Minimal weed management occurs during veraison to harvest. However, chemical (post-emergent herbicides) and other tactics are used occasionally. Herbicides often are a significant portion of the pest control budget. Glyphosate (e.g. Roundup), glufosinate-ammonium (Rely), and paraquat (Gramoxone) are important post-emergent herbicides that control a wide-spectrum of grassy and broadleaf weeds. Post-emergent herbicides are applied under the vine in bands or spot sprayed, often via precision technology. Hooded spray booms are available for minimizing drift. A number of post-emergent herbicides are available for non-bearing vines only. Extra care must be taken to ensure that green shoots are not contacted by non-selective, post-emergent materials. Pre-harvest restrictions for herbicides must be carefully followed.

Besides herbicides, mechanical removal of under-the-vine weeds is used but its frequency is based on region, vineyard size, and soil type. Mechanical control often requires an investment in additional equipment, not always economically viable. However, organic winegrape growers rely mostly on mechanical cultivation, using under-the-vine tillage equipment. This approach has proven to be economical for them. Other non-chemical options include flaming, mulches, and cover crops (including under the vine).

Many growers maintain cover crops between rows primarily to manage soils but also to prevent weeds from invading vine rows. Factors limiting greater adoption of cover crops include concerns about decreased crop vigor, greater water and fertilizer requirements and overall costs, and increased problems with perennial weeds such as bermudagrass, bindweed, and johnsongrass. Moreover, cover crops may increase problems with vertebrate pests such as voles and gophers.

Chemical control (post-emergent)

- Glyphosate (Roundup); widely used, non-selective material.
- Paraquat (Gramoxone); non-selective material.
- Glufosinate-ammonium (Rely).
- Sethoxydim (Poast).
- Sulfosate (Touchdown); non-selective material
- Clethodim (Prism), diquat (Reglone), fluazifop-p (Fusilade), and MSMA; non-bearing vines only.
- Carfentrazone-ethyl (Shark).
- Organic products (e.g., soap-based (Scythe), acetic acid formulations, clove (e.g., Matram2) and other essential oils, and corn gluten); not very efficacious, rarely used.

Cultural control

- Cultivation (including hand hoeing).
- Mowing.
- Propane flaming; risky due to fire hazard.
- Steam and/or hot water; high cost associated with large volume of water needed but may be viable for organic growers.
- Mulches.
- Cover crops.

Biological control

- Domesticated animals (sheep, geese, goats, chickens, etc.).
- Puncture vine weevil; releases and preservation of established populations.

Needs for Weed Management during Veraison to Harvest:

Research:

- Develop post-emergent herbicides that are environmentally friendly and cost effective.
- Need more basic work on economic thresholds.

Regulatory:

- Expedite registration of environmentally friendly, cost-effective herbicides.
- Expand list of justifications for obtaining Special Local Needs and Section 18 exemptions to include resistance management.

Education:

- Continue grower and pest control advisor education on weed identification and monitoring and alternative management strategies and tactics (including comparative economics).
- Enhance grower and pest control advisor education about strategies for resistance management and examples of resistance already developed.
- Continue grower and pest control advisor education on means to prevent off-site movement of herbicides.
- Continue education on drift mitigation and management, and associated complaints.
- Educate growers and pesticide applicators about sprayer technologies (including electrostatic) and their effective operation (proper calibration and application use rates, timing, coverage, and placement).

VERTEBRATES

Vertebrates can cause problems to vineyards throughout the year. Problems occur when vertebrates move into or live near vineyards and seek vineyards for food and cover. Direct feeding damage by rodents is greatest to young vines. During veraison to harvest, management tactics may be implemented for ground squirrels, meadow voles (field mice), pocket gophers, deer, coyotes, and birds.

Ground squirrel

Ground squirrels at dense populations can cause significant injury by gnawing on vine trunks, removing bark and potentially girdling vines. They also may feed directly on shoots and fruit and gnaw and damage polyethylene irrigation hoses. Moreover, ground squirrels can create large

burrows that can endanger workers, disrupt equipment operation, and cause erosion.

Chemical control

- Aluminum and magnesium phosphide (Phostoxin and Magtoxin); fumigants introduced into burrows, works best applied in spring with high soil moisture.
- Anticoagulant baits (e.g. diphacinone); require multiple feedings often via bait station.

Cultural control

- Trapping; often baited, works best for small areas with few squirrels.
- Sanitation; remove cover such as brush piles and debris in or near vineyards.
- Shooting.
- Rodex (propane gun).

Biological control

- Enhancing predation by raptors (hawks and eagles); via raptor perches, kestrel boxes, etc.

Meadow vole (field mouse)

Populations fluctuate greatly based on environmental conditions and typically thrive in areas where grass, brush, and trash accumulate. Voles injure and can kill vines by gnawing bark and partially or completely girdling the trunk at or slightly above soil level, and also by chewing the vine inside the grow tube.

Chemical control

- Anticoagulant baits (e.g. diphacinone); require multiple feedings.

Cultural control

- Sanitation; minimize weeds (particularly around base of vines), heavy mulch, and dense vegetation near vines.
- Removing cartons from transplanted vines.
- Under-the-vine cultivation.

Biological control

- Enhancing predation by raptors (hawks and eagles) and owls; via raptor perches and kestrel and owl boxes, etc.

Pocket gopher

Pocket gophers are important pests, capable of significant injury by cutting roots or gnawing bark and rapidly girdling vines several inches below the soil line. Moreover, their extensive burrows divert water and contribute to soil erosion and produce an uneven vineyard floor, precluding efficient tractor operations.

Chemical control

- Aluminum and magnesium phosphide (Phostoxin and Magtoxin); fumigants introduced into burrows, work best applied in spring with high soil moisture.
- Strychnine bait; kills with single feeding, introduced into main burrows by hand or mechanically incorporated via artificial burrow builders.

Cultural control

- Trapping; placed in main burrows.
- Rodex (propane gun).

Biological control

- Enhancing predation by raptors (hawks and eagles) and especially barn owls; via raptor perches and kestrel and owl boxes, etc.

Deer

Deer can feed on vines and berries and are predominantly a problem near woodlands in coastal areas and the foothills.

Chemical control

- Clay (Surround); somewhat effective at deterring feeding.
- Odor repellents; not very effective as deer acclimate to them.

Cultural control

- Fencing; provides excellent year-round control.
- Shooting; requires depredation permit and not long-term solution.
- Sound repellents; not very effective as deer acclimate to them.

Biological control

- None.

Coyote

Coyotes can damage drip irrigation hoses.

Chemical control

- None.

Cultural control

- Shooting; requires depredation permit.
- Trapping.

Biological control

- None.

Birds

Several species of birds (e.g., house finch, startling, American robin) are capable of substantial damage by feeding on ripening berries, directly reducing yield and quality and predisposing fruit to bunch rots.

Chemical control

- Chemical repellents; sporadic efficacy.

Cultural control

- Habitat alteration; minimize house finch nesting and loafing habitats (e.g., brush piles).
- Shooting; may require depredation permit and costly and time consuming.
- Sound repellents (e.g., gas cannons, shell crackers, electric noise makers); alter frequency and location to minimize acclimation, but may create nuisance complaints from neighbors.
- Visual repellents (e.g., Mylar tape, kites, balloons, flags, foil); often short-term solution as birds acclimate.
- Netting; relatively expensive, but cost-effective for small vineyards with high value fruit.
- Trapping; can be effective for resident house finches and starlings.

Biological control

- Falconry; expensive, but cost-effective for certain areas.

Needs for Vertebrate Management during Veraison to Harvest:

Research:

- None specified.

Regulatory:

- None specified.

Education:

- Educate growers about efficacious and neighbor-friendly practices.
- Enlighten the general public to health risks associated with vertebrates, as well as the ecosystem services provided by wildlife.
- Educate growers and pest control advisors about the ground squirrel life cycle, feeding behavior, etc.
- Educate growers and pest control advisors about proper bait placement including caution with respect to endangered/threatened species habitat.

POST HARVEST (August – November)

FARMING ACTIVITIES

- Seeding cover crops.
- Cultivation.
- Irrigation.
- Fertilization.
- Pest monitoring.
- Pesticide treatments for vine mealybug, European fruit lecanium, phylloxera, nematodes, and weeds.
- Erosion control.
- Application of soil amendments, including composting of pomace.

INSECTS

Pest management during post harvest may include applications of pesticides for controlling vine mealybug, European fruit lecanium, and phylloxera.

Vine mealybug

Vine mealybug (a species from the genus *Planococcus*) is a serious new pest, occurring in winegrowing areas of the San Joaquin Valley, Central and North coasts, and Sierra Foothills. Intensive efforts are being devoted to limit its spread and to improve IPM programs. Like other mealybugs, vine mealybug can transmit grape viruses, reduce vine growth, and render grapes unmarketable by contaminating clusters with their life stages, honeydew, and sooty mold (honeydew is the substrate). Vine mealybug is of key concern because it has a large rate of population increase, an ability to excrete excessive honeydew, a portion of the population always secluded under bark or on roots, natural enemies, and multiple hosts. Vine mealybug can be found living on roots of grapes in soil as deep as two feet, especially when tended by ants or in sandy soils. Insecticides for this pest may be applied during delayed dormancy, spring, summer, and post harvest. Natural enemies suppress mealybugs so tactics used to control honeydew-seeking ants (e.g., tillage, contact insecticides, bait stations) can enhance natural control. During the first year that vine mealybug is detected, a postharvest insecticide may be applied as part of a multiple-treatment approach to eradication. This treatment prevents spread to non-infested areas at leaf drop and pruning.

Chemical control

- Chlorpyrifos (Lorsban); excellent control and, if target soil surface, can control ants, but application timing and frequency restricted, disruptive to natural enemies, associated with surface water contamination, could be Prop. 65 listed, and emulsifiable concentrate formulations have high VOC emissions (low VOC formulation granted a 24(c) registration in California).
- Methomyl (Lannate); disruptive to natural enemies.
- Carbaryl (Sevin); disruptive to natural enemies.
- Dimethoate (Cygon); knockdown, but not great control, disruptive to natural enemies, and relatively high VOC emissions.
- Spirotetramat (Movento); newly registered lipid biosynthesis inhibitor, but trade issues (incomplete international MRLs).

Cultural control

- Bark stripping and treatment; costly, but effective in improving efficacy of pesticide applications.
- Equipment and general vineyard sanitation; prevents spread to non-infested areas.

Biological control

- None.

European fruit lecanium

The European fruit lecanium (i.e., brown apricot scale) produces honeydew that can result in excess sooty mold on berries and leaves. At high densities, lecanium feeding can stunt vine growth. Indigenous parasitoids and predators generally suppress lecanium to sub-economic levels. Management includes monitoring, preserving natural enemies, and insecticide applications as

necessary. Parasitism of nymphs should be monitored during late dormancy. Dense infestations may be treated during early post harvest before nymphs move under bark for the winter.

Chemical control

- Narrow range oil (e.g., JMS Stylet Oil, Saf-T-Side); good efficacy if applied before mid October.

Cultural control

- Controlling honeydew-seeking ants via tillage or chlorpyrifos (Lorsban); enables optimal impact by natural enemies.

Biological control

- Avoiding pesticides that disrupt natural biological control.

Grape phylloxera

Grape phylloxera feed on grape roots, stunting or killing vines. Phylloxera cause greater injury in areas with heavier clay soils, although problems occur in all winegrowing regions. Phylloxera can be managed culturally and/or chemically, but the only reliable means for control is the planting of resistant rootstocks. Pre-plant applications of fumigants targeting nematodes or oak root fungus may provide limited suppression of existing phylloxera in replanting situations. Post-plant insecticides provide suppression only, due to the difficulty in penetrating the heavy clay soils that the pest prefers and phylloxera populations rebound quickly. Although insecticides may be applied throughout the year, best timing generally is associated with rapid root growth during the spring and/or fall (early post harvest).

Chemical control

- Imidacloprid (Admire) and thiamethoxam (Platinum); provide suppression especially when applied as a single or split application over several consecutive years, but trade issues and concerns about potential resistance to this widely used neonicotinoid class of chemistry.
- Sodium tetrathiocarbonate (Enzone); avoided because of inconsistent efficacy.
- Fenamiphos (Nemacur); fair suppression, but not for purchase after May 31, 2008 under terms of phase out agreement.
- Carbofuran (Furadan); fair suppression, Special Local Need registration only for non-bearing vines and for soil drench application on grapevines growing in containers in greenhouses, lath houses, shade houses, and screen houses.

Cultural control

- Irrigation and fertilization; reduces vine stress, especially in the hot Central Valley.
- Sanitation; remove soil from equipment before moving among vineyards.
- Addition of organic matter to soil; may mitigate vine stress.

Biological control

- None.

Needs for Insect Management during Post Harvest:

Research:

- Find new products for effectively managing phylloxera.

Regulatory:

- Expedite registrations of new materials for phylloxera.
- Expand list of justifications for obtaining Special Local Needs and Section 18 exemptions to include resistance management.

Education:

- Educate wineries about the importance of not recycling untreated winery bi-product for field use if grapes sourced from vineyards having vine mealybug.
- Continue education about mitigating drift and associated complaints.
- Educate growers and pesticide applicators about sprayer technologies (including electrostatic) and their effective operation (proper calibration and application use rates, timing, coverage, and placement).

NEMATODES

Root feeding by plant-parasitic nematodes reduces water and nutrient uptake, which can decrease vine vigor and yield. The five most important species or groups are root knot nematode, ring nematode, dagger nematode, root lesion nematode, and citrus nematode. Although causing occasional yield reduction, the dagger nematode is the most destructive because it vectors grapevine fanleaf virus. Chemical (pre or post plant) and/or cultural tactics are used for control. Post-plant nematicides may be applied throughout the year, but, best timing generally is associated with rapid root growth during the spring and/or fall (early post harvest).

Chemical control

- Fenamiphos (Nemacur); fair control, but not for purchase since May 31, 2008 under terms of phase out agreement.
- Sodium tetrathiocarbonate (Enzone); fair control, but requires multiple applications.
- Carbofuran (Furadan); fair control, Special Load Need registration only for non-bearing vines and for soil drench application on grapevines growing in containers in greenhouses, lath houses, shade houses, and screen houses.
- *Myrothecium verrucaria* toxins (DiTera); use regime and efficacy poorly understood.

Cultural control

- Cover crops; selective plantings can minimize buildup of problematic species.
- Soil fertility and irrigation management; improves vine vigor.
- Addition of organic matter to soil; may mitigate vine stress.

Biological control

- None.

Needs for Nematode Management during Post Harvest:

Research:

- Determine efficacy of neonicotinoid products and spirotetramat (Movento).
- Determine if population shifts of virulent biotypes are developing on resistant rootstocks.
- Find effective post-plant substitutes for fenamiphos (Nemacur).
- Refine understanding of the antagonistic actions of cover crops.

Regulatory:

- Register an effective post-plant alternative to fenamiphos (Nemacur).
- Expand list of justifications for obtaining Special Local Needs and Section 18 exemptions to include resistance management.

Education:

- Continue education on drift mitigation and management, and associated complaints.
- Educate growers and pesticide applicators about sprayer technologies (including electrostatic) and their effective operation (proper calibration and application use rates, timing, coverage, and placement).

DISEASES

No significant disease management activity during this interval.

WEEDS

Minimal under-the-vine weed management is done between harvest and dormancy, although some early applications of pre-emergent herbicides are made. Herbicides often are a significant portion of the pest control budget. Pre-emergent herbicides have limited windows of application to ensure incorporation by rain, and some pose environmental concerns, such as the contamination of ground and surface water. A number of pre-emergent herbicides are also available for non-bearing vines. Care must be taken to avoid exposing roots of newly planted vines to pre-emergent herbicides.

Following harvest, growers often plant cover crops between rows or apply mulches, helping prevent weed colonization under vines. Some growers seed cover crops directly within rows (under the vine) to compete with and exclude weeds. Factors limiting greater adoption of cover crops include concerns about decreased crop vigor, greater water and fertilizer requirements and overall costs, and increased problems with perennial weeds such as bermudagrass, bindweed, and johnsongrass. Moreover, cover crops may increase problems with vertebrate pests such as voles and gophers.

Chemical control (pre-emergent)

- Simazine (e.g., Princep); inexpensive, but ground water issues and associated restrictions.
- Oryzalin (e.g., Surflan).
- Diuron (e.g., Karmex); ground water issues and associated restrictions.
- Oxyfluorfen (Goal); relatively high VOC emission potential but concern minimized if applied outside May-October window (new formulation should be lower VOC).
- Dichlobenil (Casoron).
- Napropamide (Devrinol).

- Norflurazon (Solicam); ground water issues and associated restrictions.
- Pronamide (Kerb).
- Trifluralin (e.g., Treflan); relatively high VOC emission potential but concern minimized if applied outside May-October window.
- Pendamethalin (Prowl), non-bearing vines only, emulsifiable concentrate formulation has relatively high VOC emission potential but concern minimized if applied outside May-October window (Prowl H2O, new low VOC formulation now registered for bearing vines).
- Isoxaben (Gallery), and thiazopyr (Visor); non-bearing vines only.
- Flumioxazin (Chateau) and rimsulfuron (Matrix).

Cultural control

- Cover crops.
- Mulches.

Biological control

- Domesticated animals (sheep, geese, goats, chickens, etc.).

Needs for Weed Management during Post Harvest:

Research:

- Develop more environmentally friendly, cost-effective weed control measures.

Regulatory:

- Expedite registration of environmentally friendly, cost-effective herbicides.
- Expand list of justifications for obtaining Special Local Needs and Section 18 exemptions to include resistance management.

Education:

- Continue grower and pest control advisor education on weed identification and monitoring and alternative management options (including comparative economics).
- Enhance grower and pest control advisor education about strategies for resistance management and examples of resistance already developed.
- Continue grower and pest control advisor education on means to prevent off-site movement of herbicides.
- Educate growers and pesticide applicators about sprayer technologies (including electrostatic) and their effective operation (proper calibration and application use rates, timing, coverage, and placement).

VERTEBRATES

Vertebrates can cause problems to vineyards throughout the year. Problems occur when vertebrates move into or live near vineyards and seek vineyards for food and cover. Direct feeding damage by rodents is greatest to young vines. During post harvest, management tactics may be implemented for ground squirrels, meadow voles (field mice), pocket gophers, deer, coyotes, wild pigs, and wild turkeys.

Ground squirrel

Ground squirrels at dense populations can cause significant injury by gnawing on vine trunks,

removing bark and potentially girdling vines. They also may feed directly on shoots and fruit and gnaw and damage polyethylene irrigation hoses. Moreover, ground squirrels can create large burrows that can endanger workers, disrupt equipment operation, and cause erosion.

Chemical control

- Aluminum and magnesium phosphide (Phostoxin and Magtoxin); fumigants introduced into burrows, work best applied in spring with high soil moisture.
- Anticoagulant baits (e.g, diphacinone); require multiple feedings often via bait station.

Cultural control

- Trapping; often baited, works best for small areas with few squirrels.
- Sanitation; remove cover such as brush piles and debris in or near vineyards.
- Shooting.
- Rodex (propane gun).

Biological control

- Enhancing predation by raptors (hawks and eagles); via raptor perches, kestrel boxes, etc.

Meadow vole (field mouse)

Populations fluctuate greatly based on environmental conditions and typically thrive in areas where grass, brush, and trash accumulate. Voles injure and can kill vines by gnawing bark and partially or completely girdling the trunk at or slightly above soil level, and also by chewing the vine inside the grow tube.

Chemical control

- Anticoagulant baits (e.g., diphacinone); require multiple feedings.

Cultural control

- Sanitation; minimize weeds (particularly around base of vines), heavy mulch, and dense vegetation near vines.
- Removing cartons from transplanted vines.
- Under-the-vine cultivation.

Biological control

- Enhancing predation by raptors (hawks and eagles) and owls; via raptor perches and kestrel and owl boxes, etc.

Pocket gopher

Pocket gophers are important pests, capable of significant injury by cutting roots or gnawing bark and rapidly girdling vines several inches below the soil line. Moreover, their extensive burrows divert water and contribute to soil erosion and produce an uneven vineyard floor, precluding efficient tractor operations.

Chemical control

- Aluminum and magnesium phosphide (Phostoxin and Magtoxin); fumigants introduced into burrows, work best applied in spring with high soil moisture.
- Strychnine bait; kills with single feeding, introduced into main burrows by hand or mechanically incorporated via artificial burrow builders.

Cultural control

- Trapping; placed in main burrows.
- Rodex (propane gun).

Biological control

- Enhancing predation by raptors (hawks and eagles) and especially owls; via raptor perches and kestrel and owl boxes, etc.

Deer

Deer can feed on vines and berries and are predominantly a problem near woodlands in coastal areas and the foothills.

Chemical control

- None.

Cultural control

- Fencing; provides excellent year-round control.
- Shooting; requires depredation permit and not long-term solution.

Biological control

- None.

Coyote

Coyotes can damage drip irrigation hoses.

Chemical control

- None.

Cultural control

- Shooting; requires depredation permit.
- Trapping.

Biological control

- None.

Wild Pig

Wild pigs can eat the grapes, root up the vine, etc.

Chemical control

- None.

Cultural control

- Hunting/shooting; requires depredation permit.
- Electric fencing.

Biological control

- None.

Wild Turkey

Wild turkeys can eat the young vines and the grapes.

Chemical control

- None.

Cultural control

- Hunting/shooting; requires depredation permit.

Biological control

- None.

Needs for Vertebrate Management during Post Harvest:

Research:

- None specified.

Regulatory:

- None specified.

Education:

- Educate growers about efficacious and neighbor-friendly practices.
- Enlighten the general public to health risks associated with vertebrates, as well as the ecosystem services provided by wildlife.
- Educate growers and pest control advisors about the ground squirrel life cycle, feeding behavior, etc.
- Educate growers and pest control advisors about proper bait placement including caution with respect to endangered/threatened species habitat.

Table 1: Efficacy ratings for various insect and mite pest management tools in California winegrapes. E = excellent; G=good; F = fair; P = poor; ? = no data but suspected of being efficacious; blank = not used and not suspected of being efficacious.

MANAGEMENT TOOLS FOR INSECTS & MITES Registered chemistries	Leafhoppers	Spidermites	Phylloxera	Omnivorous Ifroller	Sharpshooters	Mealybugs	Thrips	Orange tortrix	W grapefif skeletonizer	Branch and twig borer	Cutworms	False chinch bug	Grape bud beetle	Grape leaffolder	E fruit lecanium	COMMENTS
abamectin (Agri-Mek)		G					F									
acetamiprid (Assail)	?	P			?	F	?				?	?				
azinphos methyl (Guthion)		P		F	?	P	P	F	G	?	?	?	F	F	?	
bifenazate (Acramite)		E														
Bt (<i>Bacillus thuringiensis</i>)				F				F	F		P			F		
buprofenzin (Applaud)	G-E				?	E										
carbaryl (Sevin)	F	P		G	?	G	G	G	F	G	G	F-G	F	G		resistance
cinnamaldehyde (Valero)	?	P-F														currently unavailable
chlorantraniliprole (Altacor)																
chlorpyrifos (Lorsban)		P				E				F	G	G				
clofentezine (Apollo)																
clothianidin (Clutch)																
cryolite (Prokil /Kryocide)		P		E	P			E	E		G			E		
cyfluthrin (Renounce)																
diazinon	P	P		F	G	F	G	F	E		F	G		F		
dicofol (Kelthane)		F-G			P						F					resistance
dimethoate (Cygon)	F-G	P		F	G	G	G	F				G	F	F		resistance
dinotefuran (Venom)																
endosulfan (Thiodan)	F-G				?	F			F	G						resistance
etoxazole (Zeal)																
fenamiphos (Nemacur)		P	F		P				P							
fenbutatin-oxide (Vendex)		F-G			P				P					G		
fenpropathrin (Danitol)	G	F		G	?	P	?	E	P			?		?		
fenpyroximate (FujiMite)	?	?				?										
hexythiazox (Onager)		G			P			P			F					
imidacloprid (Provado/Admire)	E	P	G		G	G	E								G?	
indoxycarb (Avaunt)																
kaolin clay (Surround)	?	P		?	?		?		?			F		?		
malathion	P-F	P		F	F	G	F	F	F		F	G		F		
methomyl (Lannate)	G	P		F-G	G	G	G	F-G	E		G	G		F-G		
methoxyfenozide (Intrepid)		P		E	P			E	P-F		G			E		
methyl parathion (PennCap-M)	?	P		P		G			P		G	G		P		
naled (Dibrom)	G	P		F	F	G	G	F	F		P			F		resistance
neem oil (Trilogy)	P	F-G		P	G	?	?		P		P					
petroleum oil - narrow range	P-F	F		P	G	F	?								G?	
pheromones				F-G		?		?								
phosmet (Imidan)	P	P	P	F	F	F	P	F	G	?	G	?	F	F		
propargite (Omite)	F-G	P-G														resistance

MANAGEMENT TOOLS INSECTS & MITES	Leafhoppers	Spidermites	Phylloxera	Omnivorous ifroller	Sharpshooters	Mealybugs	Thrips	Orange tortrix	W grapeelf skeletonizer	Branch and twig borer	Cutworms	False chinch bug	Grape bud beetle	Grape leafroller	E fruit lecanium	COMMENTS
Registered chemistries																
pyrethrins/PBO (Pyganic)	F						F									
pyridaben (Nexter)	G	E					G									
soap – insecticidal (M-Pede)	G	F-G										F			?	
sodium tetrathiocarbonate (Enzone)			F													
spinetoram (Delegate)																
spinosad (Success/Entrust)				?			E	G	?		?			?		
spirodichlorem (Envidor)																
spirotriamat (Movento)																
sulfur		P														
tebufenozide (Confirm)				G				G	?					G		
thiamethoxam (Platinum)																

Table 1 continued: Efficacy ratings for various insect and mite pest management tools in California winegrapes. E = excellent; G=good; F = fair; P = poor; ? = no data but suspected of being efficacious; blank = not used and not suspected of being efficacious. For non-chemical tactics, Y = used; blank = not used.

MANAGEMENT TOOLS INSECTS & MITES	Leafhoppers	Spidermites	Phylloxera	Omnivorous Ifroller	Sharpshooters	Mealybugs	Thrips	Orange tortrix	W grapeelf skeletonizer	Branch twig borer	Cutworms	False chinch bug	Grape bud beetle	Grape leaffolder	E fruit lecanium	COMMENTS
Unregistered/potential chemistries																
acequinocyl (Kanemite)		?														
bifenthrin (Capture/Brigade)	?	?			?		?	?	?		?	?		?		
clofentezine (Apollo)		F														
cyfluthrin (Baythroid)	?				?		?	?	?		?	?		?		
flufenzin (Flumite)	?	?														
lambda-cyhalothrin (Warrior)	?			?	?			?	?	?	?	?	?	?		
lufenuron	?			?				?	?					?		
pymetrozine (Fufill)																
pyriproxyfen (Knack)							?									
zeta-cypermethrin (Fury)	?			?	?			?	?	?	?	?	?	?		
Non-chemical (not stand alone)																
Mating disruption				Y		?		?								
Monitoring/action thresholds	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Natural enemies	Y	Y		Y	Y	Y	Y	Y	Y	?	Y?			Y	Y	
Soil and dust management		Y	Y													
Trellising/pruning	Y			Y		Y				Y						
Use of models				Y				Y								
Water management	Y	Y	?	Y							Y					
Weed control	?			?				?			Y	Y				
Leaf pulling	Y	?		Y				Y								
Cover crops	Y	Y?		?			Y	?								
Nutrition	Y?	Y?	Y	Y			?	?		Y						
Resistant Rootstock			Y													
Habitat Management	Y?	Y?		Y?	Y			Y?				Y				
Sanitation			Y	Y		Y		Y		Y	Y	Y			Y	
Sticky tape	Y															

Table 2: Efficacy ratings for nematode management tools in California winegrapes. E = excellent; G=good; F = fair; P = poor; ? = no data but suspected of being efficacious; blank = not used and not suspected of being efficacious. For non-chemical, Y = used, Blank = not used.

MANAGEMENT TOOLS – NEMATODES	NEMATODES (pre- or post-plant)										COMMENTS
	Root knot		Root lesion		Dagger		Ring		Citrus		
	pre	post	pre	post	pre	post	pre	post	pre	post	
Registered chemistries											
1,3-D (Telone)	E		E		E		E		E		
fenamiphos (Nemacur)		F		F		F		F		F	
metam sodium (Vapam)	F		F		F		F		F		
methyl bromide	E		E		E		E		E		
<i>Myrothecium verrucaria</i> toxins (DiTera)	?	?	?	?	?	?	?	?	?	?	
sodium tetrathiocarbonate (Enzone)		F		F		F		F		F	
Unregistered/potential chemistries											
fosthiazate	?	?	?	?	?	?	?	?	?	?	
Oxycom	?	?	?	?	?	?	?	?	?	?	
Non-chemical tactics											
Fallow	Y										
Monitoring - soil samples	Y	Y									
Cover crops	Y	Y									
Soil/water management	Y	Y									
Resistant rootstocks/varieties	Y		Y		Y		Y		Y		
UN32 + Fertilizer		Y		Y		Y		Y		Y	

Table 3: Efficacy ratings for various disease pest management tools in California winegrapes. E = excellent; G = good; F = fair; P = poor; ? = no data but suspected of being efficacious; blank = not used and not suspected of being efficacious.

MANAGEMENT TOOLS DISEASES Registered chemistries	Powdery mildew	Phomopsis	Downy mildew	Botrytis	Sour rot	Oak root fungus	Crown gall	Pierce's disease	Eutypa/Bot canker	Measles	COMMENTS
<i>Ampelomyces quisqualis</i> (AQ10)	F-G										@low-med pressure, currently unavailable
Azoxystrobin (Abound)	E	G	E	F							
<i>Bacillus pumilus</i> (Sonata)											
<i>Bacillus subtilis</i> (Serenade)	G			F-G	F						@low-med pressure
boric acid (B-Lock)											
boscalid (Endura)											
Captan		G	F	G	G						
chitosan (Elexa)	G										@low-med pressure
cinnamaldehyde (Valero)	G										currently unavailable
copper hydroxide	G	F	G	F	G						
copper sulfate	G	F	G	F	G						
copper/sulfur dust (COCS)	E		F	P-F	F-G						
cyprodinil (Vangard)				E	?						
dichloran (Botran)				F	G						
fenarimol (Rubigan)	E										resistance
fenhexamid (Elevate)				E	?						
GABA/L-glutamic acid (AuxiGro)	?										
harpin protein (Messenger)	F-G			?							@low-med pressure
hydrated lime/Sulfur dust					G						
iprodione (Rovral)				G							wineries dislike
kresoxim-methyl (Sovran)	E	E	E	?	?						
mancozeb (Dithane)		G	G	F-G							
maneb		G	G	F-G							
mefenoxam (Ridomil Gold)			E								
metam sodium (Vapam)						F					
methyl bromide						G					
myclobutanil (Rally)	E										resistance
neem oil (Trilogy)	?										
petroleum oil - narrow range	G			G							
potassium bicarbonate (Kaligreen/Armicarb)	G										
pyraclostrobin+boscalid (Pristine)	E	G	E	E	G						

MANAGEMENT TOOLS DISEASES												
Registered chemistries	Powdery mildew	Phomopsis	Downy mildew	Botrytis	Sour rot	Oak root fungus	Crown gall	Pierce's diseases	Eutypa/Bot canker	Measles	COMMENTS	
quinoxifen (Quintec)	E											
soap – insecticide (M-Pede)	F-G											
sodium tetrathiocarbonate (Enzone)						F						
sulfur – dust	E											
sulfur – sprays	E	G										
tebuconazole (Elite)	F-E			F	?							
thiophanate-methyl (Topsin)	?			?					?			
triadimefon (Bayleton)	P-G										resistance	
trifloxystrobin (Flint)	E	F-G	G-E	F-G								
triflumizole (Procure)	E										resistance	
Ziram		F-G		F-G								
2,4-xyleneol and meta cresol (Gallex)							F					

Table 3 continued: Efficacy ratings for various disease pest management tools in California winegrapes. E = excellent; G = good; F = fair; P = poor; ? = no data but suspected of being efficacious; blank = not used and not suspected of being efficacious. For non-chemical tactics, Y = used; blank = not used.

MANAGEMENT TOOLS DISEASES	Powdery mildew	Phomopsis	Downy mildew	Botrytis	Sour rot	Oak root fungus	Crown gall	Pierce's diseases	Eutypa/Bot canker	Measles	COMMENTS
Unregistered/potential chemistries											
acibenzolar (Actigard)	G		?								
<i>Bacillus pumilus</i> (Sonata)	?										
boscalid (Endura)	?			?	?						
cyamidazosulfamid (IKF-916)											
cymoxanil/famoxadone (Tanos)			?								
dimethomorph (Acrobat)	G		?								
ethaboxam (Guardian)			?								
fenamidone (RPA 407213)											
hydrogen peroxide (Oxidate)			F	F							
iprovalicarb (SZX 722)											
milsana bioprotectant	G-E										
propamocarb hydrochloride (Tattoo)			?								
pyrimethanil (Scala)				G-E							
spiroximine	?										
zoxamide (RH 7281)	E										
Non-chemical tactics											
Pruning		Y						Y	Y		
Leaf Removal	Y			Y	Y						
Varietal Selection	Y			Y	Y			Y	Y		
Canopy Management	Y			Y	Y						
Irrigation Management		Y		Y	Y						
<i>Trichoderma</i> (Trichodex)				Y							
<i>Pseudomonas fluorescens</i> (BlightBan)					Y?						
Insect Vector Control					Y			Y			
Weed Control					Y			Y			
Vine Removal						Y		Y	Y		
Disease Free Plants	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	

Table 4: Efficacy for registered herbicides against weeds in California winegrapes.

	Pre-emergence												Post-emergence									
	DIC	DIU	ISO-NB	NAP	NOR	ORY	OXY	PEN-NB	PRO	SIM	THI-NB	TRI	CLE-NB	DIQ-NB	FLU-NB	GLU	GLY	MSMA-NB	PAR	SET	SUL	2,4-D
Annual Broadleaves																						
Annual morningglories	C	C	C	P	C	P	C	N	-	C	-	C	N	P	N	C	C	P	P	N	C	P
Cheeseweed	C	P	C	P	P	P	C	P	P	P	C	N	N	C	N	C	P	N	C	N	P	P
Chickweeds	C	P	C	C	P	C	P	C	C	C	C	C	N	C	N	C	C	C	C	N	C	N
Clovers	P	P	P	P	N	N	P	N	N	C	-	N	N	P	N	P	P	N	P	N	P	N
Cockleburs	P	C	-	P	C	N	P	N	N	C	-	N	N	C	N	P	C	P	C	N	C	C
Cudweeds	C	C	C	C	C	N	N	N	N	C	C	N	N	C	N	P	C	N	C	N	P	P
Fiddlenecks	C	C	C	C	P	C	C	C	C	C	C	C	N	C	N	P	C	N	C	N	C	P
Filarees	P	C	C	C	P	P	C	N	N	C	C	P	N	C	N	C	P	N	P	N	C	C
Goosefoot, nettleleaf	C	C	C	C	P	C	C	C	C	C	C	C	N	C	N	P	C	N	C	N	C	C
Groundcherries	C	C	C	N	C	N	C	N	C	C	P	P	N	C	N	C	C	P	C	N	C	C
Groundsel, common	C	N	C	P	P	N	C	N	N	P	C	N	N	C	N	P	C	N	C	N	C	P
Hairy fleabane	P	P	C	N	P	N	P	N	N	C	P	N	N	P	N	C	C	N	P	N	C	C
Henbit	C	C	C	N	P	C	C	C	C	C	P	P	N	C	N	C	P	C	C	N	C	P
Horseweed	P	P	C	N	P	N	P	N	N	C	P	N	N	C	N	C	C	N	P	N	C	C
Knotweed, common	C	C	C	C	P	C	P	C	C	C	C	C	N	P	N	P	P	N	P	N	P	P
Lambsquarters, common	C	C	C	C	P	C	C	C	C	C	C	C	N	C	N	P	C	N	P	N	C	C
London rocket	C	C	C	C	P	N	C	P	C	C	P	N	N	C	N	C	C	N	C	N	C	C
Mullein, turkey	N	N	C	P	P	N	P	N	N	N	C	P	N	P	N	C	P	N	P	N	P	P
Mustards	C	C	C	P	P	N	C	P	C	C	P	N	N	C	N	C	C	N	C	N	C	P
Nettles	C	C	C	P	C	P	C	N	C	C	C	N	N	P	N	C	N	N	C	N	N	P
Nightshades	C	C	C	N	C	N	C	N	C	C	P	N	N	C	N	C	C	N	C	N	C	C
Pigweeds	P	C	C	C	P	C	C	C	C	C	C	C	N	C	N	C	C	N	C	N	C	P
Prickly lettuce	C	C	C	C	P	N	C	N	N	C	C	N	N	C	N	C	C	N	P	N	C	C
Primrose, cutleaf evening	-	P	C	P	N	P	P	P	P	C	C	P	N	C	N	C	C	N	C	N	C	-
Puncturevine	C	P	C	P	C	P	P	P	N	P	P	P	N	C	N	P	C	P	C	N	C	P
Purslanes	C	C	C	C	C	C	C	C	C	C	C	C	N	C	N	C	C	N	C	N	C	P
Russian thistle	C	P	C	P	C	P	P	P	P	C	P	P	N	P	N	C	C	N	P	N	P	P
Shepherd's-purse	C	C	C	P	P	N	C	P	C	C	C	N	N	C	N	C	C	N	C	N	C	C
Sowthistles	C	C	C	C	P	N	C	N	N	C	C	N	N	C	N	C	C	N	C	N	C	P
Spotted spurge	C	N	C	C	C	P	C	P	P	P	P	P	N	C	N	C	C	N	C	N	C	P
Wild radish	C	C	C	P	P	N	C	N	C	C	C	N	N	C	N	C	C	N	C	N	C	C
Willowherb, panicle	-	N	P	N	P	P	C	-	-	N	-	-	N	P	N	C	P	-	N	N	P	P

NB = Non-bearing vineyards only

DIC = dichlobenil (Casoron)
 DIU = diuron (Karmex, Direx)
 ISO = isoxaben (Gallery T&V)
 NAP = napropamide (Devrinol)
 NOR = norflurazon (Zorial)
 ORY = oryzalin (Surflan, etc.)

OXY = oxyfluorfen (Goal)
 PEN = pendimethalin (Prowl)
 PRO = pronamide (Kerb)
 SIM = simazine (Caliber 90, etc.)
 THI = thiazopyr (Visor)
 TRI = trifluralin (Treflan, etc.)

CLE = clethodim (Prism)
 DIQ = diquat (Reglone)
 FLU = fluazifop-p (Fusilade DX)
 GLU = glufosinate (Rely)
 GLY = glyphosate (Roundup, etc.)
 PAR = paraquat (Gramoxone Max, etc.)

MSMA = (MSMA, etc.)
 SET = sethoxydim (Poast)
 SUL = sulfosate (Touchdown 5)
 2,4-D = (Dri Clean, etc.)

Table 4 continued: Efficacy for registered herbicides against weeds in California winegrapes.

	Pre-emergence												Post-emergence									
	DIC	DIU	ISO-NB	NAP	NOR	ORY	OXY	PEN-NB	PRO	SIM	THI-NB	TRI	CLE-NB	DIQ-NB	FLU-NB	GLU	GLY	MSMA-NB	PAR	SET	SUL	2,4-D
C = Control P = Partial control N = No control -- = No information																						
Annual Grasses																						
Annual bluegrass	C	C	N	C	C	C	P	C	C	C	C	C	C	P	N	C	C	N	C	N	C	N
Barnyardgrass	P	C	N	C	P	C	P	C	C	P	C	C	C	P	C	C	C	P	P	C	C	N
Bromegrasses	C	C	N	C	C	C	P	C	C	-	C	C	P	-	P	C	C	-	C	P	C	N
Canarygrass	C	C	N	C	C	C	P	C	C	P	C	C	C	P	C	C	C	N	C	C	C	N
Crabgrass, large	P	C	N	C	P	C	N	C	C	N	C	C	C	C	C	C	C	C	C	C	C	N
Fescues	-	C	N	C	C	C	N	C	C	P	P	C	P	C	P	P	C	-	C	P	C	N
Foxtails	-	C	N	C	P	C	N	C	C	C	C	C	C	P	C	C	C	-	P	C	C	N
Junglerice	P	C	N	C	P	C	P	C	C	P	C	C	C	P	C	C	C	P	P	C	C	N
Lovegrass	P	C	N	C	P	C	C	C	C	P	P	C	C	P	C	C	C	-	C	C	C	N
Ryegrass, Italian	-	C	N	C	C	C	N	C	C	P	C	C	C	P	C	C	C	N	C	C	C	N
Sandbur	C	C	N	C	C	C	N	C	P	C	C	C	C	P	C	C	C	C	P	C	C	N
Sprangletops	-	P	N	C	P	P	N	P	C	N	C	C	C	N	C	C	C	N	P	C	C	N
Wild barley	C	C	N	C	C	C	P	C	C	P	C	C	C	P	C	C	C	N	C	C	C	N
Wild oat	C	P	N	C	C	P	P	P	C	C	P	P	P	P	C	C	C	N	C	C	C	N
witchgrass	P	C	N	C	P	C	P	C	C	P	P	C	C	P	P	P	C	N	C	P	C	N
Perennials (seedling)																						
Bermudagrass	P	C	N	C	C	C	P	C	C	P	C	C	C	P	C	C	C	N	C	C	C	N
Dallisgrass	C	C	N	C	C	C	P	C	C	C	C	C	C	P	C	C	C	C	C	C	C	N
Johnsongrass	N	C	N	C	C	C	P	C	C	C	C	C	C	P	C	C	C	C	C	C	C	N
Field bindweed	C	P	C	N	P	P	P	P	N	P	P	P	N	P	N	C	C	N	C	N	C	P
Perennials (established)																						
Bermudagrass	P	N	N	N	P	N	P	N	N	N	N	N	C	N	C	P	C	N	N	C	C	N
Dallisgrass	N	N	N	N	P	N	P	N	N	N	N	N	C	N	C	P	C	C	N	C	C	N
Johnsongrass	N	N	N	N	C	N	P	P	N	N	P	P	C	N	C	P	C	N	N	C	C	N
Field bindweed	P	N	N	N	N	N	N	P	N	N	P	P	N	P	N	P	P	N	P	N	P	N
Nutsedge, purple	C	N	N	N	P	N	N	N	N	N	P	N	N	P	N	P	C	P	C	N	C	N
Nutsedge, yellow	C	N	N	N	P	N	N	N	N	N	C	N	N	P	N	P	C	C	C	N	C	N

NB = Non-bearing vineyards only

DIC = dichlobenil (Casoron)
 DIU = diuron (Karmex, Direx)
 ISO = isoxaben (Gallery T&V)
 NAP = napropamide (Devrinol)
 NOR = norflurazon (Zorial)
 ORY = oryzalin (Surflan, etc.)

OXY = oxyfluorfen (Goal)
 PEN = pendimethalin (Prowl)
 PRO = pronamide (Kerb)
 SIM = simazine (Caliber 90, etc.)
 THI = thiazopyr (Visor)
 TRI = trifluralin (Treflan, etc.)

CLE = clethodim (Prism)
 DIQ = diquat (Reglone)
 FLU = fluazifop-p (Fusilade DX)
 GLU = glufosinate (Rely)
 GLY = glyphosate (Roundup, etc.)
 PAR = paraquat (Gramoxone Max, etc.)

MSMA = (MSMA, etc.)
 SET = sethoxydim (Poast)
 SUL = sulfosate (Touchdown 5)
 2,4-D = (Dri Clean, etc.)

Table 5: Relative toxicities of registered insecticides and miticides to natural enemies in California winegrapes. H = high, M = moderate; L = low; blank = unknown.

Registered Product	Selectivity (affected arthropods)	Predatory Mites	General Predators	Parasitoids	Duration of Impact
abamectin (Agri-Mek)	moderate (mites, leafminers)	H	L	M-H	Long
acetamiprid (Assail)					
azinphos methyl (Guthion)					
bifenazate (Acramite)	narrow (mites)	L	L	L	Short
Bt (<i>Bacillus thuringiensis</i>)	narrow (lepidoptera)	L	L	L	None
buprofezin (Applaud)					
carbaryl (Sevin)	broad (insects, mites)	L-H	H	H	Long
cinnamaldehyde (Valero)					
chlorpyrifos (Lorsban)	broad (insects, mites)	M	M	H	Moderate
clofentezine (Apollo)					
cryolite (Prokil /Kryocide)	narrow (foliage chewing insects)	L	L	L	short to none
cyfluthrin (Renounce)					
Diazinon	broad (insects, mites)	L	H	H	moderate to long
dicofol (Kelthane)	narrow (mites)	H	M	M	long to beneficial mites
dimethoate (Cygon)	broad (insects, mites)	H	H	H	Long
dinotefuran (Venom)					
endosulfan (Thiodan)	broad (insects, mites)	L	M	M	Short
etoxazole (Zeal)					
fenamiphos (Nemacur)					
fenbutatin-oxide (Vendex)	narrow (mites)	L	L	L	Short
fenpropathrin (Danitol)					
fenpyroximate (FujiMite)					
hexythiazox (Savey)	narrow (mites)	L	L	L	short to moderate
imidacloprid (Provado & Admire)	narrow (sucking insects)			L-H	short to moderate
indoxycarb (Avaunt)					
kaolin clay (Surround)					
malathion	broad (insects, mites)	H	H	H	Moderate
methomyl (Lannate)	broad (insects, mites)	H	H	H	Moderate
methoxyfenozide (Intrepid)					
methyl parathion (PennCap-M)					
naled (Dibrom)					
neem oil (Trilogy)	broad (soft-bodied insects)	L	L	L	Short
petroleum oil - narrow range	broad (exposed insects, mites)	L	L	L	short to none
pheromones					
phosmet (Imidan)	broad (insects, mites)	H	H	H	moderate to long
propargite (Omite)	narrow (mites)	M	L	L	Short
pyrethrins/PBO (Pyganic)	broad (insects)				Short
pyridaben (Nexter)	broad (insects, mites)				Short
soap – insecticidal (M-Pede)	broad (insects, mites)	M	M	M	short to none
sodium tetrathiocarbonate (Enzone)	broad (soil organisms)	L	L	L	None
spinetoram (Delegate)					
spinosad (Success)					
spirodichlorem (Envidor)					
sulfur	narrow (mites, citrus thrips)	L-H	L	H	Short
tebufenozide (Confirm)					
thiamethoxam (Platinum)					

Table 6: Farming activities for California winegrapes generalized over regions.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Crop Stages												
Dormancy	█	█	█									█
Bud break			█	█								
Rapid shoot growth				█	█	█						
Bloom					█	█						
Veraison							█	█				
Harvest									█	█		
Cultural Activities												
Pruning	█	█	█									█
Nitrogen Fertilization			█	█		█						
Shoot removal					█	█						
Leaf removal						█	█					
Spring cultivation (as needed)			█	█								
Plant cover crops								█	█	█		
Irrigation (as needed)			█	█	█	█	█	█	█			
Management Activities for Major Pests												
Monitor & treat leafhoppers (as needed)					█	█	█	█	█	█		
Monitor & treat spider mites (as needed)				█	█	█	█	█	█	█		
Monitor phylloxera symptoms												
Monitor omnivorous leafroller & treat (as needed)												
Monitor sharpshooters & treat (as needed)			█	█	█	█						
Monitor & treat mealybugs (as needed)												
Monitor nematodes												
Treat for powdery mildew (as needed)			█	█	█	█	█	█	█			
Treat for phomopsis (as needed)			█	█								
Treat for botrytis (as needed)					█	█		█	█			
Monitor for summer bunch rot							█	█	█	█		
Monitor for Pierce's disease				█	█	█			█	█		
Monitor for Eutypa				█	█	█						
Monitor & treat weeds with pre- +/- post-emergent herbicides (as needed)	█	█	█	█	█						█	█

Table 7: Seasonal pest occurrence for the North Coast in California winegrapes.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Insects/Mites												
Leafhoppers				■	■	■	■	■	■	■		
Spider mites				■	■	■	■	■	■	■		
Phylloxera	■	■	■								■	■
Omnivorous leafroller				■	■	■	■	■	■	■		
Sharpshooters				■	■	■	■	■				
Mealybugs	■	■	■	■	■	■	■	■	■	■	■	■
Thrips				■	■							
Orange tortrix				■	■	■	■	■	■	■		
Branch and twig borer (adults)			■	■								
Cutworms			■	■								
False chinch bug					■	■	■					
Diseases (symptoms)												
Powdery mildew				■	■	■	■	■	■	■		
Phomopsis		■	■	■	■							
Botrytis										■		
Crown gall	■	■	■	■	■	■	■	■	■	■	■	■
Pierce's disease				■	■	■	■	■	■	■		
Eutypa				■	■	■	■	■	■	■	■	
Measles							■	■	■	■		
Nematodes												
Root lesion	■	■	■	■	■	■	■	■	■	■	■	■
Dagger	■	■	■	■	■	■	■	■	■	■	■	■
Ring	■	■	■	■	■	■	■	■	■	■	■	■
Weeds												
	■	■	■	■	■	■	■	■	■	■	■	■

Table 8: Seasonal pest occurrence for the Central Coast in California winegrapes.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Insects/Mites												
Leafhoppers				■	■	■	■	■	■	■		
Spider mites				■	■	■	■	■	■	■		
Phylloxera	■	■	■	■	■	■	■	■	■	■	■	■
Sharpshooters				■	■	■	■	■	■			
Mealybugs	■	■	■	■	■	■	■	■	■	■	■	■
Thrips			■	■	■							
Orange tortrix				■	■	■	■	■	■	■		
Branch and twig borer (adults)			■	■	■	■	■	■	■	■		
Cutworms			■	■	■							
False chinch bug					■	■	■	■				
Diseases (symptoms)												
Powdery mildew			■	■	■	■	■	■	■	■	■	
Phomopsis		■	■	■	■	■	■	■	■	■		
Botrytis						■	■	■	■	■	■	
Armillaria	■	■	■	■	■	■	■	■	■	■	■	■
Crown gall	■	■	■	■	■	■	■	■	■	■	■	■
Pierce's disease				■	■	■	■	■	■	■	■	
Eutypa				■	■	■	■	■	■	■	■	■
Measles							■	■	■	■	■	
Nematodes												
Root lesion	■	■	■	■	■	■	■	■	■	■	■	■
Dagger	■	■	■	■	■	■	■	■	■	■	■	■
Ring	■	■	■	■	■	■	■	■	■	■	■	■
Weeds												
	■	■	■	■	■	■	■	■	■	■	■	■

Table 9: Seasonal pest occurrence for the South Coast in California winegrapes.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Insects/Mites												
Leafhoppers				■	■	■	■	■	■	■		
Phylloxera	■	■	■	■	■	■	■	■	■	■	■	■
Sharpshooters	■	■	■	■	■	■	■	■	■	■	■	■
Thrips				■	■							
Orange tortrix				■	■	■	■	■	■	■		
Western grapeleaf skeletonizer				■	■	■	■	■	■	■		
Branch and twig borer (adults)			■	■	■							
Cutworms			■	■								
False chinch bug					■	■	■					
Diseases (symptoms)												
Powdery mildew				■	■	■	■	■	■	■		
Phomopsis		■	■	■	■							
Botrytis						■	■	■	■	■		
Armillaria	■	■	■	■	■	■	■	■	■	■	■	■
Crown gall	■	■	■	■	■	■	■	■	■	■	■	■
Pierce's disease				■	■	■	■	■	■	■		
Eutypa				■	■	■	■	■	■	■	■	
Measles						■	■	■	■	■		
Nematodes												
Root knot	■	■	■	■	■	■	■	■	■	■	■	■
Citrus	■	■	■	■	■	■	■	■	■	■	■	■
Weeds												
	■	■	■	■	■	■	■	■	■	■	■	■

Table 10: Seasonal pest occurrence for the Northern San Joaquin Valley in California winegrapes.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Insects/Mites												
Leafhoppers				■	■	■	■	■	■	■		
Spider mites				■	■	■	■	■	■	■		
Phylloxera	■	■	■	■	■	■	■	■	■	■	■	■
Omnivorous leafroller				■	■	■	■	■	■	■		
Sharpshooters				■	■	■	■	■	■	■		
Mealybugs	■	■	■	■	■	■	■	■	■	■	■	■
Thrips				■	■	■	■	■	■	■		
Western grapeleaf skeletonizer				■	■	■	■	■	■	■		
Branch and twig borer (adults)			■	■	■	■	■	■	■	■		
Cutworms			■	■	■	■	■	■	■	■		
False chinch bug					■	■	■	■	■	■		
Grape bud beetle			■	■	■	■	■	■	■	■		
Grape leafroller				■	■	■	■	■	■	■	■	
Diseases (symptoms)												
Powdery mildew				■	■	■	■	■	■	■	■	■
Phomopsis		■	■	■	■	■	■	■	■	■	■	■
Botrytis						■	■	■	■	■	■	■
Summer bunch rot						■	■	■	■	■	■	■
Armillaria	■	■	■	■	■	■	■	■	■	■	■	■
Crown gall	■	■	■	■	■	■	■	■	■	■	■	■
Pierce's disease				■	■	■	■	■	■	■	■	■
Eutypa				■	■	■	■	■	■	■	■	■
Measles							■	■	■	■	■	■
Nematodes												
Root knot	■	■	■	■	■	■	■	■	■	■	■	■
Root lesion	■	■	■	■	■	■	■	■	■	■	■	■
Dagger	■	■	■	■	■	■	■	■	■	■	■	■
Ring	■	■	■	■	■	■	■	■	■	■	■	■
Citrus	■	■	■	■	■	■	■	■	■	■	■	■
Weeds												
	■	■	■	■	■	■	■	■	■	■	■	■

Table 11: Seasonal pest occurrence for the Southern San Joaquin Valley in California winegrapes.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Insects/Mites												
Leafhoppers				■	■	■	■	■	■	■		
Spider mites			■	■	■	■	■	■	■	■		
Phylloxera	■	■	■	■	■	■	■	■	■	■	■	■
Omnivorous leafroller				■	■	■	■	■	■	■		
Sharpshooters	■	■	■	■	■	■	■	■	■	■	■	■
Mealybugs	■	■	■	■	■	■	■	■	■	■	■	■
Thrips				■	■	■	■	■	■	■		
Western grapeleaf skeletonizer				■	■	■	■	■	■	■		
Branch and twig borer (adults)			■	■	■	■	■	■	■	■		
Cutworms			■	■	■	■	■	■	■	■		
False chinch bug					■	■	■	■	■	■		
Grape bud beetle			■	■	■	■	■	■	■	■		
Grape leafroller				■	■	■	■	■	■	■		
Diseases (symptoms)												
Powdery mildew			■	■	■	■	■	■	■	■	■	■
Phomopsis		■	■	■	■	■	■	■	■	■	■	■
Downy mildew	■	■	■	■	■	■	■	■	■	■	■	■
Botrytis					■	■	■	■	■	■	■	■
Summer bunch rot						■	■	■	■	■	■	■
Armillaria	■	■	■	■	■	■	■	■	■	■	■	■
Crown gall	■	■	■	■	■	■	■	■	■	■	■	■
Pierce's disease				■	■	■	■	■	■	■	■	■
Eutypa				■	■	■	■	■	■	■	■	■
Measles							■	■	■	■	■	■
Nematodes												
Root knot	■	■	■	■	■	■	■	■	■	■	■	■
Root lesion	■	■	■	■	■	■	■	■	■	■	■	■
Dagger	■	■	■	■	■	■	■	■	■	■	■	■
Ring	■	■	■	■	■	■	■	■	■	■	■	■
Citrus	■	■	■	■	■	■	■	■	■	■	■	■
Weeds												
	■	■	■	■	■	■	■	■	■	■	■	■

REFERENCES

The California Association of Winegrape Growers. Sacramento, CA. <http://www.cawg.org>.

California Agricultural Statistics Service. Final Grape Crush Report, 2007. California Department of Food and Agriculture. <http://nass.usda.gov/bul/crush/indexgcb.htm>

California Sustainable Winegrowing Program Progress Report. 2006. California Sustainable Winegrowing Alliance. <http://www.sustainablewinegrowing.org>.

The Code of Sustainable Winegrowing Practices Self-Assessment Workbook. 2006. California Sustainable Winegrowing Alliance, Wine Institute, and California Association of Winegrape Growers. <http://www.sustainablewinegrowing.org>

California Department of Pesticide Regulation Pesticide Use Reports. <http://www.cdpr.ca.gov/docs/pur/purmain.htm>.

California Winegrape Pest Management Alliance Project Final Report. 2003. <http://cdpr.ca.gov/docs/empm/alliance/01-02/0194c.pdf>.

Crop/Pest Profile for Wine Grapes in California. 2002. California Grape Advisory Team. FQPA Grape Partnership. <http://pestdata.ncsu.edu/cropprofiles/docs/cagrapes-wine.html>.

Grape Pest Management, Second Edition. 1992. University of California Division of Agriculture and Natural Resources.

UC IPM Pest Management Guidelines: Grape. University of California Division of Agriculture and Natural Resources. <http://www.ipm.ucdavis.edu/PMG/selectnewpest.grapes.html>.