Contents (Dates in parenthesis indicate when each topic was updated)

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Authors

Insects and Mites: D. R. Haviland, UCCE Kern Co.; W. J. Bentley, UC IPM Program, Kearney Agricultural Center, Parlier; R. H. Beede, UCCE Kings Co.; K. M. Daane, Biological Control, UC Berkeley and Kearney Agricultural Center, Parlier

Diseases: T. J. Michailides, Kearney Agricultural Center, Parlier

Nematodes: B. B. Westerdahl, Nematology, UC Davis

Weeds: K. J. Hembree, UCCE Fresno Co.

Vertebrates: R. A. Baldwin, Department of Wildlife, Fish, and Conservation Biology, UC Davis

Crop Team: D. R. Haviland, UC Cooperative Extension, Kern County (crop team leader and IPM Facilitator); W. J. Bentley, UC IPM Program, Kearney Agricultural Center, Parlier; J. L. Azulai, UC IPM Program, Davis; R. H. Beede, UCCE Kings County; K. J. Hembree, UCCE Fresno County; C. E. Kallsen, UCCE Kern County; T. A. Martin, UC IPM Program, Davis; T. J. Michailides, Kearney Agricultural Center, Parlier; J. P. Siegel, USDA-ARS, Parlier; G. B. Weinberger, Weinberger & Associates, Visalia; T. A. Fukuda Weinberger, Weinberger & Associates, Visalia

Acknowledgments for contributions

Insects and Mites: R. E. Rice, Kearney Agricultural Center, Parlier

Diseases: B. L. Teviotdale, Kearney Agricultural Center, Parlier

Nematodes: U. C. Kodira, Plant Pathology, UC Davis

Weeds: A. Shrestha, UC IPM Program, Kearney Agricultural Center, Parlier

About this publication

Produced and edited by:
UC Statewide IPM Program
University of California Agriculture and Natural Resources
Guidelines Coordinator: R. DeBiase
Production: F. Rosa

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The UC IPM Pest Management Guidelines are available from:
- Online: http://www.ipm.ucanr.edu
- UC Cooperative Extension: County Offices
- University of California
  ANR Communication Services
  Richmond, CA 94804
  510-665-2195; 800-994-8849

Updates: These guidelines are updated regularly. Check with your University of California Cooperative Extension Office or the UC IPM Web site for information on updates.

Note to readers: These guidelines represent the best information currently available to the authors and are intended to help you in making the best choices for an IPM program. Not all formulations or registered materials are mentioned. Always read the label and check with local authorities for the most up-to-date information regarding registration and restrictions on pesticide use. Check with your agricultural commissioner for latest restricted entry intervals.
Pistachio Year-round IPM Program *(Reviewed 10/14)*

**ANNUAL CHECKLIST**

These practices are recommended for a monitoring-based IPM program that enhances the use of IPM practices to reduce the risks of pesticides on the environment and human health.

When a pesticide application is considered, review the Pesticide Application Checklist at the bottom of this page for information on how to minimize the risks of pesticide use to water and air quality. Water quality can be impaired when pesticides drift into waterways or when they move off-site. Air quality can be impaired when pesticide applications release volatile organic compounds (VOCs) into the atmosphere.

This year-round IPM program covers the major pests of pistachios in California. Track your progress through the year with the annual checklist form. Details on carrying out each practice, example monitoring forms, and information on additional pests can be found in the Pistachio Pest Management Guidelines.

<table>
<thead>
<tr>
<th>Dormancy to delayed-dormancy</th>
<th><strong>Special issues of concern related to environmental quality:</strong> runoff and drift. Mitigate pesticide effects to minimize air and water contamination.</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ Done</td>
<td><strong>What should you be doing during this time?</strong></td>
</tr>
<tr>
<td></td>
<td>Carry out dormant season sanitation activities:</td>
</tr>
<tr>
<td></td>
<td>• Prune trees. While pruning look for, and keep records of, Botryosphaeria cankers for management decisions later in the season:</td>
</tr>
<tr>
<td></td>
<td>• Remove and destroy, or disc under, mummy nuts to reduce navel orangeworm overwintering sites and inoculum sources of Botryosphaeria panicle and shoot blight. At a minimum, shake trees and remove mummy nuts from the berms.</td>
</tr>
<tr>
<td></td>
<td>• Destroy, or remove from the orchard floor, pruned wood and brush piles, to reduce overwintering sites for leaffooted plant bug and the incidence of Botrytis blossom and shoot blight and Botryosphaeria panicle and shoot blight.</td>
</tr>
<tr>
<td></td>
<td><strong>Manage orchard floor weeds:</strong></td>
</tr>
<tr>
<td></td>
<td>• Keep records <em>(PDF)</em> of weeds identified in the orchard, noting locations of problematic weeds.</td>
</tr>
<tr>
<td></td>
<td>• If using herbicides, before application:</td>
</tr>
<tr>
<td></td>
<td>• Create a custom herbicide chart for winter weeds in your field. <em>(Learn how online.)</em></td>
</tr>
<tr>
<td></td>
<td>• Mechanically remove leaves and debris from the treatment area.</td>
</tr>
<tr>
<td></td>
<td>• Use drift-reducing spray nozzles where possible, and apply herbicides only when environmental conditions are favorable.</td>
</tr>
<tr>
<td></td>
<td>• Scout the field following treatment and control escaped weeds.</td>
</tr>
<tr>
<td></td>
<td><strong>In early- to mid-January, examine one-year-old fruiting wood for live and parasitized soft scales, paying special attention to previously infested areas. Treat if needed in mid-February according to the Pistachio Pest Management Guidelines.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Consider performing a BUDMON test (detects bud colonization and infection) in February to mid-March to predict the risk of Botryosphaeria panicle and shoot blight at harvest.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Look for vertebrates and their damage and manage if needed:</strong></td>
</tr>
<tr>
<td></td>
<td>• Ground squirrels</td>
</tr>
<tr>
<td></td>
<td>• Jackrabbits</td>
</tr>
<tr>
<td></td>
<td>• Meadow voles</td>
</tr>
<tr>
<td></td>
<td>• Pocket gophers</td>
</tr>
</tbody>
</table>
### Budbreak through bloom

**Special issues of concern related to environmental quality:** runoff and drift. Mitigate pesticide effects to minimize air and water contamination.

#### What should you be doing during this time?

- **Continue weed management.** Mow ground cover before bloom for frost protection and to reduce small plant bug and false chinch bug populations. Do not mow during bloom.

- **If not done after the last harvest, at budbreak identify trees infested with mealybugs by looking for them on green bud tips. Note infested trees for more intense monitoring from mid-May to early June.**

- **If the orchard has a history of Botryosphaeria panicle and shoot blight, treat when panicles (flower clusters) appear in the spring. If wet and cool weather occurs during bloom, consider treating for Botrytis blossom and shoot blight.**

- **Hang navel orangeworm egg or pheromone traps on April 1. Check traps once or twice per week to monitor the first flight (typically in April to mid June with a peak in May) in pheromone traps and to observe the egg-laying peak (typically in May) using egg traps.**

- **In late March through April, adult leaffooted plant bugs and stink bugs may migrate into the orchard edges from overwintering sites. Monitor weekly for:**
  - Leaffooted plant bugs, small plant bugs, and stink bugs using a beating tray.
  - Plant bugs and stink bugs using a sweep net in surrounding cover crops and vegetation.

  Leaffooted plant bugs and stink bugs may require a pesticide application. Small plant bugs, with the exception of California buckeye bug, are less damaging. Areas heavily infested with green stink bug and leaffooted plant bug will require close monitoring after fruit set.

- **Look for obliquebanded leafroller strikes and leaf tying (rolled or folded leaves). Record observations for future pheromone trapping and treatment decisions.**

- **Look for vertebrates and their damage and manage if needed:**
  - Ground squirrels
  - Jackrabbits
  - Meadow voles
  - Pocket gophers

- **Sporadic or minor pests and disorders you may see:**

  **Invertebrates**
  - Darkling beetles
  - Thrips (onion, western flower)
  - Western tussock moth

  **Disease and abiotic disorders**
  - Armillaria root rot (oak root fungus) mushrooms
  - Delayed leafing
  - Frost damage
  - Wood decay fungi mushrooms (e.g. *Schizophyllum* spp., *Ganoderma* spp.)

### Fruit development

**Special issues of concern related to environmental quality:** drift and volatile organic compounds (VOCs). Mitigate pesticide effects to minimize air and water contamination.

#### What should you be doing during this time?

- **Avoid severe water stress in mid-May during stage one of kernel development (bloom through shell expansion) to reduce the incidence of early shell split and navel orangeworm infestations, which can introduce fruit molds that cause aflatoxin contamination.**
Fruit development

Special issues of concern related to environmental quality: drift and volatile organic compounds (VOCs). Mitigate pesticide effects to minimize air and water contamination.

- Check pheromone and egg traps once or twice per week:
  - Obliquebanded leafroller. Hang pheromone traps by mid- to late April in Fresno and northward. Note biofix (the first date when male moths are consistently caught in traps). Continue monitoring traps to determine treatment timing if needed.
  - Navel orangeworm. Identify the first (May) and second (late June to early July) generations using egg or pheromone traps. In late July use degree-days, pheromone trap catches, and inspections for eggs on early split nuts to identify the beginning of the third generation for treatment.

Monitor weekly for bugs, small plant bugs, and stink bugs and treat if needed according to the Pistachio Pest Management Guidelines. Look for:

- Plant bugs, stink bugs, and leaffooted plant bug nymphs, using a beating tray on clusters.
- Black (darkened) nuts and epicarp lesions. Cut open nuts to confirm if there is bug feeding (stink bug, leaffooted plant bug, small plant bugs).
- Stink bugs and leaffooted plant bug eggs on leaves or fruit.
- *Calocoris norvegicus* and lygus bugs by sampling with a sweep net in weeds and groundcover. Once nut shells harden in late May, small plant bugs no longer cause damage.

In mid-May to early July, check trees where mealybug infestations were noted after harvest or at budbreak. Look for adult females on the rachises and manage as needed at peak crawler emergence (typically the first week of June) according to the Pistachio Pest Management Guidelines. If no treatment was made in June, continue monitoring.

In July, sample 100 nuts weekly for early splits. Apply an insecticide for navel orangeworm if more than 2 early splits per 100 nuts are found.

Monitor for fruit scabbing and rachis darkening caused by citrus flat mite. If detected, consider a pesticide application.

Manage orchard floor weeds:

- Survey weeds in late spring and identify those not controlled with a fall or winter treatment.
- Keep records (PDF) noting the location of problematic weeds.
- Create a custom herbicide chart for summer weeds in your field. (Learn how online.)

Apply herbicides for weeds that escaped initial management using drift-reducing spray nozzles where possible. Apply herbicides only when environmental conditions are favorable.

Monitor and manage diseases:

- Alternaria blight (lesions) on foliage starting in mid-July. Manage if needed according to the Pistachio Pest Management Guidelines.
- Botryosphaeria panicle and shoot blight. Consider a fungicide application in early June or if rain occurs. Consider performing an ONFIT assay in June to predict blighted fruit at harvest. You may need to adjust your fungicide spray program accordingly.
- Verticillium wilt. Note trees for future removal.

Look for vertebrates and their damage and manage if needed:

- Ground squirrels
- Jackrabbits
- Meadow voles
- Pocket gophers

Sporadic or minor pests and disorders you may see:

<table>
<thead>
<tr>
<th>Invertebrates</th>
<th>Disease and abiotic disorders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Darkling beetles</td>
<td>Botrytis blossom and shoot blight</td>
</tr>
<tr>
<td>False chinch bugs</td>
<td>Epicarp staining (due to rain)</td>
</tr>
<tr>
<td>Webspinning spider mites (particularly where soils are alkaline)</td>
<td>Nut collapse</td>
</tr>
<tr>
<td></td>
<td>Pistachio pop</td>
</tr>
</tbody>
</table>
## Preharvest

**Special issues of concern related to environmental quality:** runoff, drift, volatile organic compounds (VOCs). Mitigate pesticide effects to minimize air and water contamination.

**What should you be doing during this time?**

- Treat for navel orangeworm at hull split (hull slip) according to the Pistachio Pest Management Guidelines, especially if early splits are abundant and infestation levels of early splits exceed 2%.
- Monitor newly budded trees for insect pests such as aphids, darkling beetles, and earwigs.

<table>
<thead>
<tr>
<th>Invertebrates</th>
<th>Diseases</th>
<th>Vertebrates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citrus flat mite</td>
<td>Alternaria late blight</td>
<td>Birds</td>
</tr>
<tr>
<td>Mealybugs</td>
<td>Botryosphaeria panicle and shoot blight</td>
<td>Ground squirrels</td>
</tr>
<tr>
<td></td>
<td>Verticillium wilt (late strikes)</td>
<td>Jackrabbits</td>
</tr>
<tr>
<td></td>
<td>Other canker diseases</td>
<td>Meadow voles</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pocket gophers</td>
</tr>
</tbody>
</table>

Manage as needed according to the Pistachio Pest Management Guidelines.

Prepare the orchard floor before harvest by managing weeds according to the Pistachio Pest Management Guidelines.

## Harvest

**Special issues of concern related to environmental quality:** None. Mitigate pesticide effects to minimize air and water contamination.

**What should you be doing during this time?**

- Expedite the harvest of problematic orchards infested with Alternaria late blight and navel orangeworm. If harvest is delayed or a second shake is planned, consider a treatment for navel orangeworm to reduce damage as well as the incidence of aflatoxin according to the Pistachio Pest Management Guidelines.
- Clean and wash harvest equipment before moving it to uninfested orchards to avoid spreading mealybugs.
- Evaluate current year’s pest management program using the processing plant grade sheet to prepare for next year’s program.
- Monitor the orchard for:
  - Alternaria late blight lesions (on foliage) and Botryosphaeria panicle and shoot blight. Note the severity of infected trees for next year’s management.
  - Cotton aphid (on first-year newly-budded trees). Manage if needed according to the Pistachio Pest Management Guidelines.
- Hull and dry nuts within 24 hours of harvest to reduce incidence of postharvest disease.

## Postharvest

**Special issues of concern related to environmental quality:** runoff, drift, volatile organic compounds (VOCs). Mitigate pesticide effects to minimize air and water contamination.

**What should you be doing during this time?**

- Carry out postharvest sanitation activities:
  - Prune trees and destroy infected, dead, and dying branches to reduce inoculum sources for Botrytis blossom and shoot blight and Botryosphaeria panicle and shoot blight.
  - Remove and destroy, or disc under, unharvested nuts and mummies from trees and the ground to reduce overwintering sites for navel orangeworm and sources of inoculum for Botryosphaeria panicle and shoot blight. At minimum, shake trees to remove mummies as soon as possible before rain.
<table>
<thead>
<tr>
<th>✓ Done</th>
<th>Postharvest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Special issues of concern related to environmental quality:</strong> runoff, drift, volatile organic compounds (VOCs). Mitigate pesticide effects to minimize air and water contamination.</td>
</tr>
</tbody>
</table>

Monitor for mealybugs.
- Look for sooty mold on leaves and mealybugs within the clusters.
- Once leaves fall, check tree trunks.
- Note infested trees for monitoring next season.

Survey weeds and keep records (PDF). Manage weeds according to the Pistachio Pest Management Guidelines.

Look for vertebrates and their damage and manage if needed:
- Ground squirrels
- Jackrabbits
- Meadow voles
- Pocket gophers

During the fourth week in October for 1- to 6-year-old trees, consider applying zinc sulfate to induce defoliation (prevents winter frost damage) and enhance zinc nutrient levels for spring growth.

<table>
<thead>
<tr>
<th>✓ Done</th>
<th>Pesticide application checklist</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>When planning for possible pesticide applications in an IPM program, consult the Pest Management Guidelines, and review and complete this checklist to consider practices that minimize environmental and efficacy problems.</td>
</tr>
</tbody>
</table>

**✓ Choose a pesticide from the Pest Management Guidelines for the target pest, considering:**

- Impact on natural enemies and pollinators. For more information see [Protecting Natural Enemies and Pollinators](http://www.ipm.ucanr.edu/mitigation/protect_beneficials.html).

- Potential for water quality problems using the UC IPM WaterTox database. See [www.ipm.ucanr.edu/TOX/simplewatertox.html](http://www.ipm.ucanr.edu/TOX/simplewatertox.html).

- Impact on aquatic invertebrates. For more information, see [Pesticide Choice](http://anrcatalog.ucdavis.edu/pdf/8161.pdf), UC ANR Publication 8161 (PDF).

- Chemical mode of action, if pesticide resistance is an issue. For more information, see [Herbicide Resistance: Definition and Management Strategies](http://anrcatalog.ucdavis.edu/pdf/8012.pdf), UC ANR Publication 8012 (PDF).

- Endangered species that may be near your site. Find out using the Department of Pesticide Regulation's PRESCRIBE program. ([http://www.cdpr.ca.gov/docs/endspec/prescint.htm](http://www.cdpr.ca.gov/docs/endspec/prescint.htm))

**✓ Before an application**

Ensure that spray equipment is properly calibrated to deliver the desired pesticide amount for optimal coverage. See [www.ipm.ucanr.edu/training/incorporating-calibration.html](http://www.ipm.ucanr.edu/training/incorporating-calibration.html).

Use appropriate spray nozzles and pressure to minimize off-site movement of pesticides.

Avoid spraying during these conditions to avoid off-site movement of pesticides.
- Wind speed over 5 mph
- Temperature inversions
- Just prior to rain or irrigation (unless it is an appropriate amount, such as when incorporating a soil-applied pesticide)
- At tractor speeds over 2 mph

Identify and take special care to protect sensitive areas (for example, waterways or riparian areas) surrounding your application site.

Review and follow labeling for pesticide handling, personal protection equipment (PPE) requirements, storage, and disposal guidelines.
## Pesticide application checklist

<table>
<thead>
<tr>
<th>✓ Done</th>
<th><strong>Pesticide application checklist</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Check and follow restricted entry intervals (REI) and preharvest intervals (PHI).</strong></td>
</tr>
<tr>
<td>✓ After an application</td>
<td><strong>Record application date, product used, rate, and location of application.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Follow up to confirm that treatment was effective.</strong></td>
</tr>
<tr>
<td>✓ Consider water management practices that reduce pesticide movement off-site.</td>
<td><strong>Consult relevant publications:</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Consult the Department of Pesticide Regulation Groundwater Protection Program (GWPA) Web site for pesticide information and mitigation measures.</strong> (<a href="http://www.cdpr.ca.gov">http://www.cdpr.ca.gov</a>)</td>
</tr>
<tr>
<td></td>
<td><strong>Install an irrigation recirculation or storage and reuse system. Redesign inlets into tailwater ditches to reduce erosion.</strong> <em>(For more information, see Reducing Runoff from Irrigated Lands: Tailwater Return Systems, <a href="http://anrcatalog.ucdavis.edu/pdf/8225.pdf">http://anrcatalog.ucdavis.edu/pdf/8225.pdf</a>.)</em></td>
</tr>
<tr>
<td></td>
<td><strong>Use drip rather than sprinkler or flood irrigation.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Limit irrigation to amount required using soil moisture monitoring and evapotranspiration (ET). For more information, see Reducing Runoff from Irrigated Lands: Understanding Your Orchard’s Water Requirements, UC ANR Publication 8212 (PDF), <a href="http://anrcatalog.ucdavis.edu/pdf/8212.pdf">http://anrcatalog.ucdavis.edu/pdf/8212.pdf</a>.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Consider using cover crops.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Consider vegetative filter strips or ditches.</strong> <em>(For more information, see Vegetative Filter Strips, UC ANR Publication 8195 (PDF), <a href="http://anrcatalog.ucdavis.edu/pdf/8195.pdf">http://anrcatalog.ucdavis.edu/pdf/8195.pdf</a>.)</em></td>
</tr>
<tr>
<td></td>
<td><strong>Apply polyacrylamides in furrow and sprinkler irrigation systems to prevent off-site movement of sediments.</strong></td>
</tr>
<tr>
<td>✓ Consider practices that reduce air quality problems.</td>
<td><strong>When possible, reduce volatile organic compound (VOC) emissions by decreasing the amount of pesticide applied, choosing low-emission management methods, and avoiding fumigants and emulsifiable concentrate (EC) formulations.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Use the Department of Pesticide Regulation calculators to determine VOC emission rates from fumigant and nonfumigant pesticides.</strong> <em>(<a href="http://www.cdpr.ca.gov">http://www.cdpr.ca.gov</a>)</em></td>
</tr>
</tbody>
</table>

More information about topics mentioned on this checklist is available at the UC IPM Web site: http://www.ipm.ucanr.edu/PMG/selectnewpest/ pistachios.html.

For more about mitigating the effects of pesticides, see the Mitigation pages: www.ipm.ucanr.edu/mitigation/.
## General Information

*(Section reviewed 10/14)*

### RELATIVE TOXICITIES of INSECTICIDES and MITICIDES USED IN PISTACHIOS to NATURAL ENEMIES and HONEY BEES *(10/14)*

<table>
<thead>
<tr>
<th>Common name (example trade name)</th>
<th>Mode of action</th>
<th>Selectivity</th>
<th>Predatory mites</th>
<th>General predators</th>
<th>Parasites</th>
<th>Honey bees</th>
<th>Duration of impact to natural enemies</th>
</tr>
</thead>
<tbody>
<tr>
<td>acephate (97Up)</td>
<td>1B</td>
<td>broad</td>
<td>H</td>
<td>H</td>
<td>M/H</td>
<td>I</td>
<td>moderate</td>
</tr>
<tr>
<td>acetamiprid (Assail)</td>
<td>4A</td>
<td>moderate</td>
<td>—</td>
<td>—</td>
<td>M/H</td>
<td>II</td>
<td>moderate</td>
</tr>
<tr>
<td><em>Bacillus thuringiensis</em> ssp. kurstaki (Dipel)</td>
<td>11A</td>
<td>narrow</td>
<td>L</td>
<td>L</td>
<td>L/M</td>
<td>III</td>
<td>none</td>
</tr>
<tr>
<td>bifenthrin (Brigade)</td>
<td>3A</td>
<td>broad</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>I</td>
<td>long</td>
</tr>
<tr>
<td>buprofenzo (Centaur)</td>
<td>16</td>
<td>narrow</td>
<td>L</td>
<td>H</td>
<td>L</td>
<td>II</td>
<td>long</td>
</tr>
<tr>
<td>carbaryl (Sevin 4F)</td>
<td>1A</td>
<td>broad</td>
<td>M/H</td>
<td>H</td>
<td>H</td>
<td>I</td>
<td>long</td>
</tr>
<tr>
<td>carbaryl (Sevin XLR Plus)</td>
<td>1A</td>
<td>broad</td>
<td>L</td>
<td>H</td>
<td>H</td>
<td>I</td>
<td>long</td>
</tr>
<tr>
<td>chlorantraniliprole (Altacor)</td>
<td>28</td>
<td>narrow</td>
<td>L</td>
<td>L</td>
<td>L/M</td>
<td>III</td>
<td>short</td>
</tr>
<tr>
<td>cyfluthrin (Baythroid)</td>
<td>3A</td>
<td>broad</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>I</td>
<td>moderate</td>
</tr>
<tr>
<td>emamectin benzoate (Proclaim)</td>
<td>6</td>
<td>narrow</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>etoxazole (Zeal Miticide 1)</td>
<td>10B</td>
<td>narrow</td>
<td>M</td>
<td>L</td>
<td>L</td>
<td>II</td>
<td>short</td>
</tr>
<tr>
<td>fenpropathrin (Danitol)</td>
<td>3A</td>
<td>narrow</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>I</td>
</tr>
<tr>
<td>fenpyroximate (Fujimite)</td>
<td>21A</td>
<td>narrow</td>
<td>H</td>
<td>L</td>
<td>L</td>
<td>III</td>
<td>short</td>
</tr>
<tr>
<td>imidacloprid (Admire Pro)</td>
<td>4A</td>
<td>narrow</td>
<td>M</td>
<td>M</td>
<td>H</td>
<td>I</td>
<td>short to moderate</td>
</tr>
<tr>
<td>lambda-cyhalothrin (Warrior II with Zeon)</td>
<td>3A</td>
<td>broad</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>I</td>
<td>moderate</td>
</tr>
<tr>
<td>methoxyfenozide (Intrepid)</td>
<td>1B</td>
<td>narrow</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>II</td>
<td>short</td>
</tr>
<tr>
<td>permethrin (Ambush, Pounce)</td>
<td>3A</td>
<td>broad</td>
<td>L</td>
<td>H</td>
<td>H</td>
<td>I</td>
<td>long</td>
</tr>
<tr>
<td>phosmet (Imidan)</td>
<td>1B</td>
<td>broad</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>I</td>
<td>moderate to long</td>
</tr>
<tr>
<td>pyriproxyfen (Seize)</td>
<td>7C</td>
<td>narrow</td>
<td>L</td>
<td>H</td>
<td>L</td>
<td>II</td>
<td>short</td>
</tr>
<tr>
<td>spinetoram (Delegate)</td>
<td>5</td>
<td>narrow</td>
<td>L/M</td>
<td>M</td>
<td>M/H</td>
<td>II</td>
<td>moderate 11</td>
</tr>
<tr>
<td>spinosad (Entrust, Success)</td>
<td>5</td>
<td>narrow</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>II</td>
<td>short</td>
</tr>
<tr>
<td>spirodiclofen (Envirod 2SC)</td>
<td>3A</td>
<td>narrow</td>
<td>M</td>
<td>L</td>
<td>L</td>
<td>II</td>
<td>short</td>
</tr>
<tr>
<td>spirotetramat (Movento)</td>
<td>23</td>
<td>narrow</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>II</td>
<td>short</td>
</tr>
<tr>
<td>sulfur</td>
<td>un</td>
<td>narrow</td>
<td>L/H</td>
<td>M/L</td>
<td>H</td>
<td>III</td>
<td>short</td>
</tr>
</tbody>
</table>

H = high  
M = moderate  
L = low  
— = no information  
un = unknown or uncertain mode of action
<table>
<thead>
<tr>
<th>Common name</th>
<th>Mode of action&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Selectivity&lt;sup&gt;2&lt;/sup&gt; (affected groups)</th>
<th>Predatory mites&lt;sup&gt;3&lt;/sup&gt;</th>
<th>General predators&lt;sup&gt;4&lt;/sup&gt;</th>
<th>Parasites&lt;sup&gt;4&lt;/sup&gt;</th>
<th>Honey bees&lt;sup&gt;5&lt;/sup&gt;</th>
<th>Duration of impact to natural enemies&lt;sup&gt;6&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rotate chemicals with a different mode-of-action Group number, and do not use products with the same mode-of-action Group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a Group number of 1B; chemicals with a 1B Group number should be alternated with chemicals that have a Group number other than 1B. Mode-of-action Group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their Web site at <a href="http://www.irac-online.org/">http://www.irac-online.org/</a>.</td>
<td>Selectivity: Broad means it affects most groups of insects and mites; narrow means it affects only a few specific groups.</td>
<td>Generally, toxicities are to western predatory mite, <em>Galendromus occidentalis</em>. Where differences have been measured, these are listed as pesticide-resistant strain/native strain.</td>
<td>Toxicities are averages of reported effects and should be used only as a general guide. Actual toxicity of a specific chemical depends on the species of predator or parasite, environmental conditions, and application rate.</td>
<td>Ratings are as follows: I—Do not apply or allow to drift to plants that are flowering; II—Do not apply or allow to drift to plants that are flowering, except when the application is made between sunset and midnight if allowed by the pesticide label and regulations; III—No bee precaution, except when required by the pesticide label or regulations. For more information about pesticide synergistic effects, see Bee Precaution Pesticide Ratings (available online at <a href="http://ipm.ucanr.edu/beeprecaution/">http://ipm.ucanr.edu/beeprecaution/</a>).</td>
<td>Duration: short means hours to days; moderate means days to 2 weeks; and long means many weeks or months.</td>
<td>May cause flare-ups of spider mite populations.</td>
</tr>
</tbody>
</table>

Acknowledgements: This table was compiled based on research data and experience of University of California scientists who work on a variety of crops and contribute to the Pest Management Guideline database, and from Flint, M. L. and S. H. Dreistadt. 1998. *Natural Enemies Handbook: An Illustrated Guide to Biological Pest Control*, ANR Publication 3386.
# General Properties of Fungicides Used in Pistachios (10/14)

<table>
<thead>
<tr>
<th>Common name (example trade name)</th>
<th>Chemical class (FRAC #)</th>
<th>Activity</th>
<th>Mode of action</th>
<th>Resistance potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>azoxystrobin (Abound)</td>
<td>QoI (11)</td>
<td>contact, systemic</td>
<td>single-site</td>
<td>high</td>
</tr>
<tr>
<td>boscalid (Endura)</td>
<td>carboxamide (7)</td>
<td>contact</td>
<td>single-site</td>
<td>high</td>
</tr>
<tr>
<td>cyprodinil (Vangard)</td>
<td>anilinopyrimidine (9)</td>
<td>mostly contact</td>
<td>single-site</td>
<td>high</td>
</tr>
<tr>
<td>cyprodinil / fludioxonil (Switch)</td>
<td>anilinopyrimidine / phenylpyrrole (9 / 12)</td>
<td>contact, slightly systemic</td>
<td>single-site / single-site</td>
<td>medium</td>
</tr>
<tr>
<td>fenhexamid (Elevate)</td>
<td>hydroxyanilide (17)</td>
<td>contact</td>
<td>single-site</td>
<td>high</td>
</tr>
<tr>
<td>iprodione (Rovral)</td>
<td>dicarboximide (2)</td>
<td>systemic (local)</td>
<td>single-site</td>
<td>medium</td>
</tr>
<tr>
<td>pyraclostrobin (Cabrio)</td>
<td>QoI (11)</td>
<td>contact, systemic (local)</td>
<td>single-site</td>
<td>high</td>
</tr>
<tr>
<td>pyrimethanil (Scala)</td>
<td>anilinopyrimidine (9)</td>
<td>slightly systemic (local)</td>
<td>single-site</td>
<td>high</td>
</tr>
<tr>
<td>tebuconazole (Elite)</td>
<td>DMI-triazole (3)</td>
<td>systemic (local)</td>
<td>single-site</td>
<td>high</td>
</tr>
<tr>
<td>Reynoutria sachalinensis extract</td>
<td>plant extract (P5)</td>
<td>contact</td>
<td>various</td>
<td>low</td>
</tr>
<tr>
<td>thiophanate-methyl (Topsin-M)</td>
<td>MBC (1)</td>
<td>systemic (local)</td>
<td>single-site</td>
<td>very high</td>
</tr>
<tr>
<td>trifloxystrobin (Gem)</td>
<td>QoI (11)</td>
<td>contact, systemic</td>
<td>single-site</td>
<td>high</td>
</tr>
</tbody>
</table>

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://www.frac.info/). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode-of-action group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode-of-action group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.

2 QoI = quinone outside inhibitor (strobilurin).

3 DMI = demethylation (sterol) inhibitor.

4 Generally considered to have systemic action based on performance data but has not been proven experimentally.

5 MBC = methyl benzimidazole carbamate

**FUNGICIDE EFFICACY** (5/17)

<table>
<thead>
<tr>
<th>Fungicide</th>
<th>Resistance risk (FRAC#)</th>
<th>Alternaria late blight</th>
<th>Botrytis blossom &amp; shoot blight</th>
<th>Botryosphaeria panicle &amp; shoot blight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fontelis</td>
<td>high (7)</td>
<td>++++</td>
<td>++++</td>
<td>++++/+++++</td>
</tr>
<tr>
<td>Luna Experience</td>
<td>medium (3/7)</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
</tr>
<tr>
<td>Luna Sensation</td>
<td>medium (7/11)</td>
<td>++++</td>
<td>+</td>
<td>++++/+++++</td>
</tr>
<tr>
<td>Merivon</td>
<td>high (7/11)</td>
<td>+++</td>
<td>++++</td>
<td>++++</td>
</tr>
<tr>
<td>Pristine</td>
<td>high (7/11)</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
</tr>
<tr>
<td>Quash</td>
<td>high (3)</td>
<td>++++</td>
<td>++++/+++++</td>
<td>++++</td>
</tr>
<tr>
<td>Quilt Xcel,Avaris 2XS</td>
<td>medium (3/11)</td>
<td>++++</td>
<td>++++</td>
<td>++++/+++++</td>
</tr>
<tr>
<td>Viathon</td>
<td>medium (3/33)</td>
<td>+++</td>
<td>++++</td>
<td>++++</td>
</tr>
<tr>
<td>Abound</td>
<td>high (11)</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
</tr>
<tr>
<td>Cabrio</td>
<td>high (11)</td>
<td>+++</td>
<td>++++</td>
<td>++++</td>
</tr>
<tr>
<td>Gem</td>
<td>high (11)</td>
<td>+++</td>
<td>++++</td>
<td>++++</td>
</tr>
<tr>
<td>Ph-D</td>
<td>medium (19)</td>
<td>+++</td>
<td>++++</td>
<td>++++</td>
</tr>
<tr>
<td>Quadris Top</td>
<td>medium (3/11)</td>
<td>+++</td>
<td>++++</td>
<td>++++/+++++</td>
</tr>
<tr>
<td>Switch</td>
<td>high (9/12)</td>
<td>+++</td>
<td>++++</td>
<td>++++</td>
</tr>
<tr>
<td>Tebucon,Teb,Toledo</td>
<td>high (3)</td>
<td>+++</td>
<td>+</td>
<td>++++</td>
</tr>
<tr>
<td>Vangard</td>
<td>high (9)</td>
<td>+++</td>
<td>++++</td>
<td>++++</td>
</tr>
<tr>
<td>Adament</td>
<td>medium (3/11)</td>
<td>++</td>
<td>++++</td>
<td>++++</td>
</tr>
<tr>
<td>Bravo,Chlorothalonil, Echo</td>
<td>low (M5)</td>
<td>++</td>
<td>++++</td>
<td>++++</td>
</tr>
<tr>
<td>Bumper, Tilt</td>
<td>high (3)</td>
<td>++</td>
<td>+</td>
<td>++++</td>
</tr>
<tr>
<td>Scala</td>
<td>high (9)</td>
<td>++</td>
<td>++++</td>
<td>++++</td>
</tr>
<tr>
<td>Inspire Super</td>
<td>medium (3/9)</td>
<td>++</td>
<td>++++</td>
<td>++++/+++++</td>
</tr>
<tr>
<td>Tpins-M, T-Methyl, Incognito,Cercobin</td>
<td>high (1)</td>
<td>---</td>
<td>+</td>
<td>++++</td>
</tr>
<tr>
<td>Elevate</td>
<td>high (17)</td>
<td>ND</td>
<td>++++</td>
<td>ND</td>
</tr>
<tr>
<td>K-Phite</td>
<td>low (33)</td>
<td>ND</td>
<td>ND</td>
<td>++++/+++++</td>
</tr>
</tbody>
</table>

**Organic treatments**

<table>
<thead>
<tr>
<th>Fungicide</th>
<th>Resistance (FRAC#)</th>
<th>Alternaria late blight</th>
<th>Botrytis blossom &amp; shoot blight</th>
<th>Botryosphaeria panicle &amp; shoot blight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actinovate</td>
<td>low</td>
<td>++</td>
<td>++++</td>
<td>++++</td>
</tr>
<tr>
<td>Regalia</td>
<td>low (natural product)</td>
<td>++</td>
<td>++++</td>
<td>++++/+++++</td>
</tr>
<tr>
<td>Copper</td>
<td>low (M1)</td>
<td>+</td>
<td>++++</td>
<td>++++/+++++</td>
</tr>
<tr>
<td>Liquid lime sulfur</td>
<td>low (M2)</td>
<td>----</td>
<td>----</td>
<td>Dormant +/- Delayed Dormant +</td>
</tr>
</tbody>
</table>

**Rating:**  ++++ = excellent and consistent; +++ = good and reliable; ++ = moderate and variable; + = limited and/or erratic; +/- = minimal and often ineffective; ---- = ineffective, and ND = no data

* Registration pending in California.

**Not registered, label withdrawn or inactive in California.**

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of action (for more information, see http://www.frac.info/). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode-of-action Group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode-of-action Group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action Group number.

2 Field resistance of Alternaria spp. to Abound and to other strobilurin fungicides (Gem and Cabrio) is widespread in pistachio orchards.

3 To reduce the risk of resistance development, start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications, use labeled rates (preferably the upper range), and limit the total number of applications/season.

4 Resistance to the SDHI (succinate dehydrogenase inhibitor) boscalid has been detected in high levels (80-90%) in some orchards; Pristine should not be applied if resistance to this fungicide is detected in an orchard. Cross-resistance of SDHI fungicides (FRAC Group 7) may occur.
5 Do not apply Bumper/Tilt within 60 days of harvest, Quash within 25 days of harvest, or tebuconazole fungicides (Tebucon/Teb/Toledo/Viathon) within 35 days before harvest.
6 Under low and moderate disease pressure.
7 Registered for bloom treatment only.
8 Dormant treatments and/or delayed dormant
9 Tested only under low disease pressure.


### TREATMENT TIMING FOR KEY DISEASES (6/17)

**Note:** not all indicated timings may be necessary for disease control.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Dormant</th>
<th>Bloom/ terminal shoot 1/2 to 1 inch April</th>
<th>Succulent shoot growth/before shell lignification May</th>
<th>Early fruit development/after shell lignification June</th>
<th>Fruit development/kernel development July</th>
<th>Fruit maturation August</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternaria3</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>+++</td>
<td>+++</td>
<td>+?</td>
</tr>
<tr>
<td>Botryosphaeria4</td>
<td>+?5</td>
<td>+++</td>
<td>+++6</td>
<td>+++</td>
<td>+++</td>
<td>+?</td>
</tr>
<tr>
<td>Botrytis</td>
<td>—</td>
<td>+++</td>
<td>+7</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

Rating: +++ = most effective, ++ = moderately effective, + = least effective (+? = under revision), — = ineffective
1 If only one application is done, the best timing is late June to early July.
2 Sprays not later than the first week in August.
3 Three applications during the season are recommended.
4 Treat once at bloom when the terminals on female trees are 1 to 2 inches long. Begin summer applications in late May or early June. Treat at 2 to 3 week intervals until mid-August. For resistance management, do not apply consecutive applications of any strobilurin (Abound, Flint/Gem, or Cabrio) or strobilurin-containing fungicides (Pristine, Luna Sensation), and make no more than two applications of a strobilurin or strobilurin-containing fungicide per season.
5 Liquid lime sulfur: some efficacy in some trials; no efficacy in other trials.
6 Early season sprays (April and May) are effective when timed before or after rains or both.
7 Protect young clusters if rain and cool weather occur.

Citrus Flat Mite

Scientific Name: Brevipalpus lewisi

Description of the Pest
Citrus flat mite is smaller than tetranychid (spider) mites. It is slow-moving, flat, and oblong in shape, being wider at the anterior end. Coloring ranges from red brown to reddish.

Citrus flat mite is a warm-season pest with populations increasing in June and peaking in late July and August, then gradually declining.

Damage
Mite feeding damages the stems (rachis) of clusters as well as nuts. Feeding on the stems causes a browning that gradually develops into a severely roughened, black area that resembles a scab. This feeding damage is usually on the inside or back portion of nut clusters. Under heavy population pressure, stems and nuts begin to shrivel. Damaged nuts remain on the tree and can provide an overwintering source for navel orangeworm. Close examination will reveal citrus flat mite. They are most easily observed around shriveled and damaged areas.

Management
No precise guidelines are available for when to treat. Populations can be initially spotty and in following years become more widespread in the orchard.

Biological Control
A predaceous phytoseiid mite, Metaseiulus mcgregori, which is common in several crops throughout California, feeds on citrus flat mite. Its numbers begin increasing in August and reach their highest level at the same time as citrus flat mite, but experience has been that their numbers are insufficient to reduce flat mite populations below economic injurious levels.

Organically Acceptable Methods
Sulfur sprays are acceptable for use in an organically managed orchard.

Monitoring and Treatment Decisions
During fruit development monitor for fruit scabbing and rachis darkening caused by citrus flat mite. Before harvest monitor for flat mite damage to nut clusters, while monitoring for other pests. If detected, consider a pesticide application. Begin treatments before nut shriveling.
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide’s properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.

<table>
<thead>
<tr>
<th>Common name (example trade name)</th>
<th>Amount per acre**</th>
<th>R.E.I.‡ (hours)</th>
<th>P.H.I.‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. WETTABLE SULFUR#</td>
<td>15–20 lb</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td>MODE OF ACTION: Unknown. An inorganic miticide. COMMENTS: May be applied by ground or air. Check label to confirm product is labeled for pistachio.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. SULFUR DUST 98%#</td>
<td>50 lb</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td>MODE OF ACTION: Unknown. An inorganic miticide. COMMENTS: Best results are obtained by ground treatments; however, aerial treatments are effective. Use higher rates by air. Check label to confirm product is labeled for pistachio.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** Unless otherwise noted, apply with enough water to ensure adequate coverage.
‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) is the number of days from treatment to harvest. In some cases the R.E.I. exceeds the P.H.I. The longer of two intervals is the minimum time that must elapse before harvest.
# Acceptable for organically grown produce.
COTTON APHID (10/14)

Scientific Name: *Aphis gossypii*

DESCRIPTION OF THE PEST

The cotton aphid, also called melon aphid, is a rather small aphid that ranges in color from yellowish green to greenish black. Both winged and wingless forms are produced. The winged individuals are somewhat slender and are not as robust as the wingless form. A mature individual measures about 1/16 inch (1.5 mm) in length. The cotton aphid develops in colonies and prefers the underside of leaves. Unlike other aphids, cotton aphid populations do not diminish with high temperatures; they can also be troublesome late in the season (September and October), particularly in the San Joaquin Valley and in northern California.

Cotton aphid has an extensive host range. Some of the crops it attacks besides pistachio are carrot, cotton, cucurbits, and citrus. Host weeds include milkweed, jimsonweed, pigweed, plantain, and field bindweed.

DAMAGE

Cotton aphids can be a major problem in first-year, newly budded trees. They distort and cause curling of growing leaves, and produce a large amount of honeydew. Clusters become coated with sticky honeydew, creating an environment favorable for the development of a sooty mold.

MANAGEMENT

Biological control can have a significant impact on aphids so be sure to evaluate predator and parasite populations when making treatment decisions.

Biological Control

Naturally-occurring populations of the convergent lady beetle, *Hippodamia convergens*, may provide effective control in early spring. However, releases of this beetle are not effective because it generally does not remain in the orchard following release. Other general predators, such as lacewing and syrphid larvae, and parasitic wasps, including *Lysiphlebus*, *Aphidius*, *Diaeretiella*, and *Aphelinus* species, also attack aphids.

Cultural Control

- It is a good practice, where feasible, to control weedy hosts of cotton aphid.
- Preserve habitat for beneficials around the orchard and keep dust down to encourage parasitism and predation.
- Avoid applying too much nitrogen fertilizer.
- Nearby fields infested with cotton aphid should be disced or plowed under as soon as harvest is complete to prevent movement into newly budded pistachio orchards.

Organically Acceptable Methods

Biological and cultural controls and sprays of rosemary oil, insecticidal soaps, and certain oils are acceptable for use in an organically grown crop.

Monitoring and Treatment Decisions

Monitor newly budded pistachio trees for cotton aphid. In most cases biological controls are sufficient to keep aphids at low levels. If unusually large numbers of aphids build up early in the season and appear to be retarding growth, consider applying an insecticide. No threshold has been established.
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide’s properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.

<table>
<thead>
<tr>
<th>Common name (example trade name)</th>
<th>Amount per acre**</th>
<th>R.E.I.+ (hours)</th>
<th>P.H.I.+ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. IMIDACLOPRID (Admire Pro)</td>
<td>3.5–7 oz</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER1: 4A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. ACETAMIPRID (Assail 30SG)</td>
<td>2.5 –9.6 oz</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER1: 4A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. SPIROTETRAMAT (Movento)</td>
<td>6-9 oz</td>
<td>24</td>
<td>7</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER1: 23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. INSECTICIDAL SOAPS (M-pede, etc.)</td>
<td>Label rates</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>MODE OF ACTION: A contact insecticide with smothering and barrier effects.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: This material has no residual and requires frequent applications and thorough coverage.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. NARROW RANGE OIL# (First Choice Narrow Range 415, etc.)</td>
<td>Label rates</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) is the number of days from treatment to harvest. In some cases the R.E.I. exceeds the P.H.I. The longer of two intervals is the minimum time that must elapse before harvest.

1 Rotate chemicals with a different mode-of-action Group number, and do not use products with the same mode-of-action Group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a Group number of 1B; chemicals with a 1B Group number should be alternated with chemicals that have a Group number other than 1B. Mode-of-action Group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their Web site at http://www.irac-online.org/.
DARKLING BEETLES (10/14)

Scientific Names: *Blapstinus* spp., *Coelus* spp., and others

DESCRIPTION OF THE PESTS

Darkling beetle adults range from 1/8 to 1/2 inches (3 to 6 mm) long and vary from black or bluish black to rusty brown. Darkling beetles may be hidden by dust or a thin layer of soil. Cylindrical, wireworm-like, soil-inhabiting larvae are light yellow to dark brown and range from 1/33 to 1/3 inch (0.8–8 mm) in length. They are often referred to as false wireworms.

Do not confuse darkling beetles (Tenebrionidae) with predatory ground beetles (Carabidae), which prey on various soil dwelling pests. Darkling beetles generally have clubbed antennae whereas predatory ground beetles do not.

DAMAGE

Adult darkling beetles can become a pest on young pistachio trees when they climb up the rootstock and eat the Kerman bud three to four weeks after budding. They can also damage emerging Kerman shoots during the spring following their first dormancy.

MANAGEMENT

Avoid discing weeds within the orchard or adjacent fields at the time of budding. Discing in crops like alfalfa has been known to promote migrations of darkling beetles. Monitor for darkling beetles during the first month after budding. If an unacceptable number of buds are being consumed, consider treating the orchard with a carbamate-based bait. It may also be possible to avoid damage by wrapping the trunk with double-sided sticky tape to prevent beetles from crawling up the rootstock.

<table>
<thead>
<tr>
<th>Common name (example trade name)</th>
<th>Amount per acre**</th>
<th>R.E.I.‡ (hours)</th>
<th>P.H.I.‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. CARBARYL (Sevin 5 Bait)</td>
<td>40 lb</td>
<td>12</td>
<td>365</td>
</tr>
</tbody>
</table>

The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide’s properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.

‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) is the number of days from treatment to harvest. In some cases the R.E.I. exceeds the P.H.I. The longer of two intervals is the minimum time that must elapse before harvest.

1 Rotate chemicals with a different mode-of-action Group number, and do not use products with the same mode-of-action Group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a Group number of 1B; chemicals with a 1B Group number should be alternated with chemicals that have a Group number other than 1B. Mode-of-action Group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their Web site at http://www.irac-online.org/.

Online with photos at http://www.ipm.ucanr.edu/PMG/selectnewpest.pistachios.html
FALSE CHINCH BUG (10/14)

Scientific Name: *Nysius raphanus*

DESCRIPTION OF THE PEST

The adult false chinch bug is a small bug, about 1/8 inch (3 mm) long. It is gray to light brown in color and looks somewhat like a small lygus bug. The nymph is gray with a reddish brown abdomen.

False chinch bugs can occur in high numbers on weeds within or adjacent to pistachio orchards. The eggs are laid randomly on the soil or within soil cracks near weeds. The false chinch bug spends the winter primarily in the immature stage (nymph) on weeds. As weeds dry in spring or are destroyed, chinch bugs migrate to pistachio trees where they feed. Nymphs predominate during migration but adults may also be present. Important weeds that serve as hosts include wild mustard, wild radish, shepherd’s-purse, and London rocket. The most serious infestations result from spring migrations; however, fall migrations can also occur. Movement occurs in early morning or evening.

DAMAGE

False chinch bugs can be a serious problem on newly planted pistachio trees, especially when cardboard or other trunk guards are used, which shelter the bugs during the day. In spring, they can build to very high densities. Their feeding can cause young trees to wilt and die. Feeding on older trees can cause leaves to drop.

MANAGEMENT

Mowing ground cover before bloom can reduce false chinch bug (and small plant bug) populations. On newly planted trees, if bugs are so numerous that wilting is evident, a treatment is warranted. Treat either in the evening or early morning when chinch bugs are active. Treatments are more effective when trunk wraps are removed.

<table>
<thead>
<tr>
<th>Common name (example trade name)</th>
<th>Amount per acre**</th>
<th>R.E.I.‡ (hours)</th>
<th>P.H.I.‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. ACEPHATE (97Up)</td>
<td>8–16 oz</td>
<td>24</td>
<td>365</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 1B</td>
<td>Comments: Where there is potential for runoff into waterways use caution in application to avoid off-site movement.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. BIFENTHRIN (Brigade WSB*)</td>
<td>8–32 oz</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 3</td>
<td>Comments: Do not apply near aquatic areas. Brigade WSB is a restricted-use pesticide because it is highly toxic to fish and aquatic organisms.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. FENPROPATHRIN (Danitol 2.4 EC*)</td>
<td>10.66–21.33 fl oz</td>
<td>24</td>
<td>3</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 3A</td>
<td>Comments: Do not apply near aquatic areas. Danitol 2.4EC is a restricted-use pesticide because it is highly toxic to fish and aquatic organisms.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. LAMBDA-CYHALOTHrin (Warrior II with Zeon Technology*)</td>
<td>1.28–2.56 fl oz</td>
<td>24</td>
<td>14</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 3</td>
<td>Comments: Do not apply near aquatic areas. Warrior II is a restricted-use pesticide because it is highly toxic to fish and aquatic organisms.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide’s properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.
### E. PERMETHRIN

(Pounce 25WP*)
12 oz
8–16 oz

(Ambush 25W*)
12.8–25.6 oz
12

**MODE-OF-ACTION GROUP NUMBER:** 3

**COMMENTS:** Highly toxic to honey bees. Do not apply near aquatic areas; Pounce 25WP and Ambush 25W are restricted-use pesticides because they are highly toxic to fish and aquatic organisms.

** Unless otherwise noted, apply with enough water to ensure adequate coverage.

‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) is the number of days from treatment to harvest. In some cases the R.E.I. exceeds the P.H.I. The longer of two intervals is the minimum time that must elapse before harvest.

* Permit required from county agricultural commissioner for purchase or use.

1 Rotate chemicals with a different mode-of-action Group number, and do not use products with the same mode-of-action Group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a Group number of 1B; chemicals with a 1B Group number should be alternated with chemicals that have a Group number other than 1B. Mode-of-action Group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their Web site at http://www.irac-online.org/.
LEAFFOO TED PLANT BUGS (10/14)

Scientific Names: Leptoglossus zonatus, Leptoglossus clypealis, Leptoglossus occidentalis

DESCRIPTION OF THE PESTS

Adult leaffooted plant bugs are relatively large insects, 3/4 to 1 inch in length. All three species are similar in appearance; they are brown in color with a narrow white band across the back, although this band is less distinct in L. occidentalis. The head appears pointed, and the hind legs have an expanded area that superficially resembles a leaf, hence its name. Leptoglossus zonatus can be distinguished by the presence of two yellow spots on the pronotum. Leptoglossus clypealis does not have the yellow spots and has a long pointed clypeus that points forward at the front of the head.

Leaffooted bugs overwinter as adults, typically in aggregations located in protected areas, such as in woodpiles, barns, under the bark of eucalyptus, citrus, palm, cypress, or juniper trees. These pests can also overwinter in the orchard in plant debris, pump houses, or cracks along the tree trunk. From late March through May, adults disperse to find food sources. These insects are primarily seed feeders and, once in the orchard, they will feed directly on the developing nuts or on ground vegetation. Adults are strong flyers and can disperse from overwintering sites and quickly move into and within the orchard. Overwintered adults are long-lived, from September or October to April or May. Their eggs are laid in spring usually on leaves, twigs, and nuts; some Leptoglossus species deposit over 200 eggs. After nymphs emerge from a round hole on top of the egg, they develop into adults in 6 to 8 weeks. Because the adults are long-lived and can lay eggs over an extended period, the population can consist of all life stages by late June. There may be 2 to 3 generations per year, depending on temperatures and food sources.

DAMAGE

These insects are capable of causing two types of damage. The first type (epicarp lesion) is produced early in the season and is similar to that caused by other plant bugs. Nuts damaged during or shortly after bloom blacken and drop. If nuts are damaged during the period in which they are enlarging, the damaged tissue turns brown and necrotic and the outside will often become sunken and appear almost water soaked. The internal lesions often develop a white, netted appearance in the shell tissue, with no deep pitting.

After shell hardening in June, leaffooted bugs may cause a second type of damage called kernel necrosis, which is not obvious on the shell. Externally all that is evident is a brown pinpoint mark. With kernel necrosis, the nutmeat is darkened, often develops a sunken or distorted area, and may have an off-flavor. If this occurs when humidity is high, a fungal breakdown of the nut causes it to turn slimy. This is referred to as STIGMATOMYCOSIS.

Leaffooted plant bugs typically damage most of the nuts in an attacked cluster.

MANAGEMENT

Leaffooted bugs typically first appear in orchards starting in April. However, if they overwinter in or near pistachio, they may be found earlier, usually feeding on nut clusters, and at this time they can cause considerable nut drop when their populations densities are high.

Biological Control

In most years leaffooted bug populations are controlled by natural mortality from extremely cold winter temperatures and an egg parasitoid (Gryon pennsylvanicum). However, these natural controls cannot be relied upon if there is a large overwintering population typically following a mild, dry winter. This is especially true during the critical spring period as the egg parasitoid will only impact the adult's offspring, and it is the overwintered adult that will cause most damage.

Cultural Control

During the season there are no cultural controls known to affect the density of the leaffooted bug or the damage it causes to pistachios. However, cultural controls such as cleaning debris from near the orchard may help reduce overwintering populations.

Monitoring and Treatment Decisions

During dormant and delayed dormant tree pruning, check for leaffooted plant bug when looking for Botryosphaeria cankers.
Starting in April monitor weekly through nut development.

1. Sample trees for leaffooted plant bug nymphs with a beating tray as done for small plant and stink bugs.
   a. Hold a beating tray under nut clusters while striking the limb sharply three times with a lightweight club (immature leaffooted bugs will drop onto the tray and can be easily examined; adults will either fly away or cling to the tree and not drop.)
   b. Examine bugs that drop onto the tray. If nymphs are present (e.g., 1 bug per 15 or 20 beats), particularly early in the season, treatment may be necessary.
   c. The best time to take beat samples is in the morning when bugs are less active and are easier to examine; one exception is for the flight of adult leaffooted bugs when the tree is shaken.
2. Also look for leaffooted plant bug and stink bug egg masses on the leaves and fruit.
3. There are no reliable sampling methods for adults in spring. Instead, look for adult leaffooted plant bugs migrating in from overwintering sites and small black nuts in clusters or on the ground in late April to early May.
4. If black nuts are found, cut them open to confirm damage (black lesions inside the hull).

Leaffooted bugs are capable of transmitting some pistachio diseases, such as stigmatomycosis and Botryosphaeria panicle and shoot blight, making control of these pests important.

<table>
<thead>
<tr>
<th>Common name (example trade name)</th>
<th>Amount per acre**</th>
<th>R.E.I.‡ (hours)</th>
<th>P.H.I.‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. BIFENTHRIN (Brigade WSB*)</td>
<td>8–32 oz</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Do not apply near aquatic areas. Brigade WSB is a restricted-use pesticide because it is highly toxic to fish and aquatic organisms.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. CYFLUTHRIN (Baythroid XL*)</td>
<td>2–2.4 fl oz</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Do not apply near aquatic areas. Baythroid XL is a restricted-use pesticide because it is highly toxic to fish and aquatic organisms.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. LAMBDA-CYHALOTHIRN (Warrior II with Zeon*, etc.)</td>
<td>1.28–2.56 oz</td>
<td>24</td>
<td>14</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Do not apply near aquatic areas. Warrior II is a restricted-use pesticide because it is highly toxic to fish and aquatic organisms.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. PERMETHRIN* (Pounce 25WP*)</td>
<td>8–16 oz</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>(Ambush 25W*)</td>
<td>12.8–25.6 oz</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: May be used on either early or late developing populations. Do not apply more than 0.8 lb a.i./acre/season for 25W formulation. Highly toxic to honey bees. Do not apply near aquatic areas; Pounce 25WP and Ambush 25W are restricted-use pesticides because they are highly toxic to fish and aquatic organisms.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** Unless otherwise noted, apply with enough water to ensure adequate coverage.
‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) is the number of days from treatment to harvest. In some cases the R.E.I. exceeds the P.H.I. The longer of two intervals is the minimum time that must elapse before harvest.
* Permit required from county agricultural commissioner for purchase or use.
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MEALYBUGS (10/14)

Scientific Name:
- Gill’s mealybug: Ferrisia gilli
- Grape mealybug: Pseudococcus maritimus

DESCRIPTION OF THE PEST

Adult female Gill’s mealybugs are roughly 1/12 to 1/5 inch (2–5 mm) in length and pinkish grey in color. They are often covered with white wax secreted from a pore, creating the appearance of 2 stripes (darker areas) on their backs. Larger nymphs and mature females produce a network of white filaments about 1/5 to 2/5 inch (5–10 mm) that protrude from the back of the insect.

Gill’s mealybug has three generations per year. Third generation crawlers are born live in mid-September to November and then overwinter in small cracks and crevices as small nymphs. During budbreak, overwintering nymphs migrate to the newly forming buds and begin to feed. They mature in May and produce crawlers in early June. The crawlers reach maturity in about 6 weeks and produce the second in-season generation, occurring from mid-July through harvest (mid-September). From May through September mealybugs are found almost exclusively in the clusters. After harvest adult females migrate out of the clusters to the trunk and main scaffolds where they form aggregations that give the bark a white fuzzy appearance.

Pistachio growers should be cautious not to confuse Gill’s mealybug with grape mealybug. Grape mealybug is sometimes found on pistachios, but does not cause economic damage and does not need to be treated. Grape mealybug has four slender white tails (two long ones and two short ones), whereas the female of F. gilli has two broad white tails. Grape mealybug also has short white lateral projections that extend from the sides of the body whereas F. gilli has none. Immature grape mealybugs hatch from egg sacs and usually crawl away from their mother after egg hatch whereas F. gilli have live birth with immature stages remaining aggregated around their mother. Lastly, when poked, adult females of grape mealybug extrude a bright red liquid through structures called ostioles towards both the rear and front of the top of the body. F. gilli does not extrude such a liquid.

DAMAGE

Mealybug feeding results in the production of large amounts of honeydew that acts as a substrate for black sooty molds. Thick layers of sooty molds on leaf surfaces can reduce photosynthesis.

Gill’s mealybug has a great affinity for feeding within the pistachio cluster. They use piercing-sucking mouthparts to suck out plant juices, extracting carbohydrates and other nutrients intended for nut development. This causes a decrease in nut quality because of increased shell staining and possibly smaller kernel size. Marketability can also be affected when severe hull damage causes nuts to dry up and shrivel on the tree. These nuts may serve as overwintering sites for navel orangeworm.

MANAGEMENT

Look for mealybug infestations in fall after harvest, and mark areas in the orchard where they occur. Monitor for mealybugs the following spring. If adult females are found in clusters, a treatment aimed at crawler emergence may be warranted.

Biological Control

The most common predators of mealybugs in pistachios are brown lacewings and a lady beetle whose larva resembles a mealybug. There are also several parasites that attack Gill’s mealybugs in California, such as Acerophagus sp., Chrysoplatycerus sp., and Anagyrus pseudococci. However, these parasites have only been found in other crops such as almonds, grapes, and persimmons, and not in pistachios, likely because of broad-spectrum insecticide use for true bugs.

Cultural Control

There are no cultural controls known to affect the density of Gill’s mealybug or the damage it causes to pistachios. However, cultural controls such as washing equipment (especially harvest equipment) when leaving infested orchards is essential for decreasing the rate of orchard-to-orchard spread of this new pest.
Monitoring and Treatment Decisions
The best time to find new mealybug infestations is the period from early fall through mid-winter when numbers are at their highest.

- Before trees become dormant, look for sooty mold on leaves and for mealybugs within the clusters.
- Once the leaves have fallen, look for white aggregations of mealybugs on the trunks and undersides of main scaffolds.

If mealybugs are found, note the locations for further evaluation the following spring.

At budbreak, determine if the overwintering populations survived by searching for mealybugs at the bases of new buds on trees and mark infestations for further sampling in May.

In mid-May start monitoring weekly, checking for adult females on the rachis and for the presence of crawlers. Make treatment decisions by determining the number of adult female mealybugs per cluster. One 3-year study showed that a treatment in early June was economically justified if one mealybug was found per every 10 clusters in May.

The most effective timing for insecticides is when most mealybugs are in the crawler stage of the first generation. For the lower San Joaquin Valley, this typically occurs in late May to early June. Applications later in the season are more variable in effectiveness.

Do not apply postharvest treatments in the orchard because this is when predators are most active, no damage occurs to the crop in winter, and there is already very high winter mealybug mortality.

<table>
<thead>
<tr>
<th>Common name</th>
<th>Amount per acre**</th>
<th>R.E.I.‡ (hours)</th>
<th>P.H.I.‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buprofezin (Centaur WDG)</td>
<td>34.5 oz</td>
<td>12</td>
<td>60</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Very effective when used while mealybugs are in the crawler stage of the first in-season generation of mealybugs (early to mid-June in the San Joaquin Valley). Other timings may be effective but have not been evaluated. Apply by ground only for a maximum of one application per season. Use allowed by FIFRA Section 2(ee) Recommendation, which must be in the possession of the user at the time of application.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPIROTETRAMAT (Movento)</td>
<td>6–9 fl oz</td>
<td>24</td>
<td>7</td>
</tr>
<tr>
<td>COMMENTS: Apply at crawler emergence in early June.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACETAMIPRID (Assail 70 WP)</td>
<td>2.3–4.1 oz</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 4A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: If mealybugs are not treated in early June, which is optimal time, this material can be effective against second-generation crawlers in mid to late July.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IMIDACLOPRID (Admire Pro)</td>
<td>2.8 fl oz</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 4A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Less effective than other treatment options. However, ease of application and low product cost make it a viable option when mealybug numbers are low.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common name (example trade name)</td>
<td>Amount per acre**</td>
<td>R.E.I.+ (hours)</td>
<td>P.H.I.+ (days)</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>-------------------</td>
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<td>---------------</td>
</tr>
</tbody>
</table>

** Unless otherwise noted, apply with enough water to ensure adequate coverage.
† Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) is the number of days from treatment to harvest. In some cases the R.E.I. exceeds the P.H.I. The longer of two intervals is the minimum time that must elapse before harvest.
* Permit required from county agricultural commissioner for purchase or use.
1 Rotate chemicals with a different mode-of-action Group number, and do not use products with the same mode-of-action Group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a Group number of 1B; chemicals with a 1B Group number should be alternated with chemicals that have a Group number other than 1B. Mode-of-action Group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their Web site at http://www.irac-online.org/.
NAVEL ORANGEWORM (10/14)

Scientific Name: Amyelois transitella

DESCRIPTION OF THE PEST
Young worms are reddish orange and later appear cream-colored, although their diet can influence coloration. They have a crescent-shaped sclerite on each side of the second body segment behind the head. As the worm matures, the head becomes reddish brown. Adult moths range from 1/2 to 1 inch (1.5-2.5 cm) long with a snoutlike projection at the front of the head. Most moths have gray forewings with black markings, though actual shades of grey vary from light grey to almost black, and the black markings (or wing scales) often rub off when moths get old or get caught in pheromone traps. Females begin egg laying about 2 nights after emergence. Eggs are laid on mummy nuts or on new crop nuts.

DAMAGE
The navel orangeworm feeds on a variety of fruits and nuts and is the most damaging caterpillar in pistachio. Almonds, figs, pomegranates, and walnuts are also major hosts. The pistachio nut is susceptible to infestation as soon as hull split occurs. The first signs of an infestation are small, pinhole-size entrances into the nutmeat. As worms grow in size, the entire nut is fed upon and extensive amounts of webbing and frass (insect excrement) are present.

Navel orangeworm also damage pistachios by predisposing nuts to contamination by fungal organisms (see FRUIT MOLDS) that produce aflatoxins.

MANAGEMENT
Navel orangeworm is managed by removing unharvested nuts in the fall and winter, the destruction of any nuts left on the soil surface, and protecting nuts with insecticides from the time they split through harvest. Early harvest is also an important component of a good management program.

Biological Control
There are several parasitoid species such as Goniozus legneri, Copidosomopsis plethorica and a Habrobracon species that can reduce damage from navel orangeworm. Goniozus legneri is commercially available for release and serves as an alternative control in organically managed orchards.

Small bugs in the genus Phytocoris (P. relativus and P. californicus) feed on navel orangeworm eggs. These bugs can be very abundant in pistachio clusters in the spring.

Cultural Control
Orchard sanitation plays a key role at reducing overwintering survival of navel orangeworm. After harvest, remove and destroy unharvested nuts (mummies) from trees and the ground to reduce overwintering sites for navel orangeworm. Be sure to remove nuts from tree crotches, blow the berms, and destroy the nuts. Destruction can be accomplished by discing or flailing in combination with degradation of the kernels by fungal organisms when moisture is high. For that reason it is advisable to remove mummies as soon as possible after harvest before rain. Grass or other cover crops between rows can also increase moisture on the soil surface that helps degrade mummies.

Avoid severe water stress in May during rapid shell growth to reduce the incidence of early shell split. In July and early August navel orangeworm develop in these early split nuts at a time when mummy nuts are both scarce and poor hosts, and the new crop is not yet susceptible. Navel orangeworm larva feeding in early split nuts can also introduce fruit molds and lead to aflatoxin contamination.

Harvest practices influence the amount of navel orangeworm in the current year as well as the next year. Poorly timed or poorly executed harvests can lead to an increase in the number of mummy nuts that stay on the tree as overwintering sites for navel orangeworm. Harvest date also influences the level of damage at harvest. For example, in the lower San Joaquin Valley where four flights of navel orangeworm occur, nuts harvested in late August through early September typically have low levels of damage compared to levels in nuts harvested after mid-September when the fourth flight has begun.
Organically Acceptable Methods
Biological and cultural controls are acceptable for use on organically certified crops, including predation of navel orangeworm eggs by *Phytocoris* sp., sprays of *Bacillus thuringiensis* and the Entrust formulations of spinosad, and releases of the parasite *Goniozus legneri*.

Monitoring and Treatment Decisions
Monitoring the first and second navel orangeworm generations should be done through the use of egg traps, pheromone traps, or both, and degree-day calculations. Egg traps contain a mixture of pressed almond meal and almond oil (3 to 5%) that encourages egg laying by female moths. Traps should be placed in the orchard at the beginning of April. A density of at least 1 trap per 5 acres should be used. Check traps twice a week to note how often eggs are laid and to identify egg-laying peaks. Peaks are typically observed in late April to early May and from late June to early July, signaling the start of the first and second generations.

Pheromone traps are used to monitor the flights of adult male moths. Pheromone lures should be placed into large delta or wing traps and hung in the orchard in mid-March. Count the number of moths in the trap at least once per week and track data to identify peaks in adult activity. Make sure not to confuse navel orangeworm with the meal moth (*Pyralis farinalis*) that is also attracted to the trap, but is a light brown color with dark brown bands on the wings.

Nearly all pistachio orchards should be sprayed for navel orangeworm approximately one month prior to harvest when the bulk of the new crop becomes susceptible to attack. Additional applications may be warranted in cases where navel orangeworm pressure is high, where large numbers of early split nuts are present, or where harvest is delayed until after the start of the fourth navel orangeworm flight.

Treatment timings are based on crop phenology and degree-days using a lower threshold of 55°F and an upper threshold of 94°F.

Second flight timing
In orchards with severe navel orangeworm pressure consider a treatment at the start of the second egg-laying period. This treatment should be made in late June to early July approximately 1050 degree-days after eggs are found on egg traps during the first egg-laying period in late April to early May. If using pheromone traps, the treatment should be made a few days after an increase in moth captures in late June to early July.

Early split timing
During the last two weeks of July monitor for damaged or otherwise compromised nuts that split early (pea splits). Consider making a treatment at this time if there are more than 2 early split nuts per 100 total nuts, and if navel orangeworm eggs are consistently found.

Hull split or hull slip timing
Nearly all pistachio orchards should be sprayed for navel orangeworm in August approximately one month prior to harvest. This is the period of time when the third flight of navel orangeworm is present as the bulk of the new crop of pistachios becomes susceptible to attack. This timing is often referred to as the hull split timing (a phrase adopted from almonds) and is when the pistachio hulls begin to slip free from the shell.

Treat at the start of the third egg-laying period. This starts approximately 2100 degree-days after the start of first egg-laying period in late April or May, or approximately 1050 degree-days after the start of the second egg-laying period in late June to early July.

Pheromone traps can also be used to predict treatment timing. Use pheromone traps to determine the start of the second flight of navel orangeworm in late June to early July. Adding 1050 degree-days to this date will estimate the start of the third navel orangeworm flight that typically occurs in August as the hulls start to slip. The hull split spray should be made at the start of the third egg-laying period about 4 to 7 days after pheromone traps indicate the start of the third moth flight.

Late timing
It may be necessary to make an additional insecticide application in orchards where harvest is delayed (or where a second shake will occur) and navel orangeworm pressure is high. When needed, this application should be made in early to mid-September approximately three weeks after the hull split spray or when insecticide residues have degraded.
Mating disruption

Mating disruption is a relatively new technique for managing navel orangeworm in almonds that has had limited effectiveness in research trials in pistachios. Nevertheless, it is registered in pistachios and can be used to supplement other control methods in conventional orchards. Based on data from almonds, puffers should be hung from sturdy limbs mid-way up the tree in April at a rate of two puffers per acre. In areas where the wind blows from one predominant direction, traps should be placed such that there is a higher density of traps on the edge of the field from which the wind originates. In orchards with mating disruption pheromone traps are not effective monitoring tools. For that reason there is an increased reliance on egg traps and monitoring for eggs on early-split nuts to determine the need for and timing of insecticide treatments in orchards using mating disruption.

<table>
<thead>
<tr>
<th>Common name (example trade name)</th>
<th>Amount per acre**</th>
<th>R.E.I.‡ (hours)</th>
<th>P.H.I.‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. METHOXYFENOZIDE (Intrepid 2F)</td>
<td>12–24 fl oz</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 18A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Apply at the beginning of egg hatch.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. CHLORANTRANILIPROLE (Altacor)</td>
<td>3–4.5 oz</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 28</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. LAMBDA-CYHALOTHIN + CHLORANTRANILIPROLE (Voliam Xpress*)</td>
<td>6–12.5 oz</td>
<td>24</td>
<td>14</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 3 + 28</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Do not apply near aquatic areas. Voliam Xpress is a restricted-use pesticide because it is highly toxic to fish and aquatic organisms.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. BIFENTHRIN (Brigade WSB*)</td>
<td>8–32 oz</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Do not apply near aquatic areas. Brigade WSB is a restricted-use pesticide because it is highly toxic to fish and aquatic organisms.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. FENPROPATHRIN (Danitol 2.4EC*)</td>
<td>10.66–21.33 fl oz</td>
<td>24</td>
<td>3</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 3A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Do not apply near aquatic areas. Danitol 2.4EC is a restricted-use pesticide because it is highly toxic to fish and aquatic organisms.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F. LAMBDA-CYHALOTHIN (Warrior II with Zeon*)</td>
<td>1.28–2.56 oz</td>
<td>24</td>
<td>14</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Do not apply near aquatic areas. Warrior II is a restricted-use pesticide because it is highly toxic to fish and aquatic organisms.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G. SPINETORAM (Delegate WG)</td>
<td>6–7 oz</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide’s properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.
<table>
<thead>
<tr>
<th>Common name (example trade name)</th>
<th>Amount per acre**</th>
<th>R.E.I.‡ (hours)</th>
<th>P.H.I.‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>H.</strong> EMAMECTIN BENZOATE (Proclaim*)</td>
<td>3.2–4.8 oz</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 6</td>
<td>COMMENTS: Do not apply near aquatic areas. Proclaim is a restricted-use pesticide because it is highly toxic to fish and aquatic organisms.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I. SPINOSAD (Entrust)#</td>
<td>1.25–3 oz</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J. BACILLUS THURINGIENSIS ssp. KURSTAKI# (Dipel ES)</td>
<td>2–4 pt</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>K. PERMETHRIN (Pounce 25WP*)</td>
<td>8–16 oz</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>(Ambush 25W*)</td>
<td>12.8–25.6 oz</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 3</td>
<td>COMMENTS: Highly toxic to honey bees. Do not apply near aquatic areas; Pounce 25WP and Ambush 25W are restricted-use pesticides because they are highly toxic to fish and aquatic organisms.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L. PHOSMET (Imidan 70W)</td>
<td>4 lb</td>
<td>72</td>
<td>14</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 1B</td>
<td>COMMENTS: Do not apply after hull split reaches 10%.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M. GONIOZUS LEGNERI#</td>
<td>2,500–5,000</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>COMMENTS: An alternative in organically managed orchards.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N. MATING DISRUPTANTS (Suterra Puffer NOW)</td>
<td>2 puffers</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

** Unless otherwise noted, apply with enough water to ensure adequate coverage.
‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) is the number of days from treatment to harvest. In some cases the R.E.I. exceeds the P.H.I.. The longer of two intervals is the minimum time that must elapse before harvest.
* Permit required from county agricultural commissioner for purchase or use.
# Acceptable for organically grown produce.
1 Rotate chemicals with a different mode-of-action Group number, and do not use products with the same mode-of-action Group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a Group number of 1B; chemicals with a 1B Group number should be alternated with chemicals that have a Group number other than 1B. Mode-of-action Group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their Web site at http://www.irac-online.org/.
— Not applicable.
OBliquebanded Leafroller (10/14)

**Scientific Name:** Choristoneura rosaceana

**DESCRIPTION OF THE PEST**

Larvae of the obliquebanded leafroller are yellowish green caterpillars with a dark head capsule. When disturbed, they wiggle backwards and drop to lower leaves or to the ground on a silken thread. Larvae fold or roll leaves together to form protective shelters in which they feed. Adult moths have dark brown bands running at oblique angles across their wings. Obliquebanded leafroller overwinters as second-instar larvae under bark and in crevices of trees. There are three generations each year in the pistachio-growing areas of the state.

**DAMAGE**

Obliquebanded leafroller larvae cause two types of damage to pistachios. When populations are high, leaves are tied together, which kills portions of leaves and reduces the overall photosynthetic capacity of the trees. The most important damage to the crop, however, is when larvae invade the clusters from June to August and feed on the peduncles (stems). This causes the peduncles to dry and shrivel, thus reducing crop yield.

**MANAGEMENT**

Spring treatments of young caterpillars with Bacillus thuringiensis or spinosad and monitoring with pheromone traps to time summer applications are the key approaches to monitoring this pest in pistachio.

**Biological Control**

There are several parasite species (Macrocentrus iridescens, Habrobracon gelechiae Bracon sp. and Goniozus sp.) that attack obliquebanded leafroller and can significantly reduce its populations in the second and third generations. None of these parasitoids are commercially available (the Goniozus species that attacks obliquebanded leafroller is not the same species (G. legneri) that attacks navel orangeworm.

**Organically Acceptable Methods**

Springtime sprays of Bacillus thuringiensis and summer spray of the Entrust formulation of spinosad are acceptable for use in an organically managed orchard.

**Monitoring and Treatment Decisions**

Right after budbreak, start looking for obliquebanded leafroller strikes and leaf ties. Record observations for future pheromone trapping and management decisions.

To time summer treatments,

1. Put out pheromone traps by late-April.
2. Check traps twice per week to identify the biofix date.
3. Continue to examine trees for leaf rolls, leaves tied together, and live larvae when traps indicate adults have emerged.
4. When male moths are first found in traps (biofix), begin degree-day calculations (upper threshold 94°F, lower threshold 43°F). For assistance in calculating degree-days, see "Degree-Days" on the UC IPM Web site at http://www.ipm.ucanr.edu.
5. Treat when 800 degree-days have accumulated.
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide’s properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.

<table>
<thead>
<tr>
<th>Common name (example trade name)</th>
<th>Amount per acre**</th>
<th>R.E.I.‡ (hours)</th>
<th>P.H.I.+ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SPRING</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. <strong>Bacillus thuringiensis</strong> ssp. Kurstaki**# (various products)</td>
<td>Label rates</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 11.B1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Apply when trees are beginning to leaf out and small larvae first emerge from bark scales. Bacillus thuringiensis is a stomach poison and must be consumed by the caterpillar; therefore, it is most effective when applied during warm, dry weather when larvae are actively feeding. Most effective when larvae are young. May require more than 1 treatment; apply second application 7 to 10 days after the first. Can be used during bloom.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SUMMER</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Spinosad</td>
<td>1.25–3 oz</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>(Entrust)#</td>
<td>4–6 oz</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Methoxyfenozide</td>
<td>8–16 fl oz</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>(Intrepid 2F)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 18A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. Chlorantraniliprole</td>
<td>3–4.5 oz</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>(Altacor)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 28</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. Emamectin Benzoate</td>
<td>3.2–4.8 oz</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>(Proclaim*)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Do not apply near aquatic areas. Proclaim is a restricted-use pesticide because it is highly toxic to fish and aquatic organisms.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. Bifenthrin</td>
<td>8–32 oz</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>(Brigade WSB*)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Do not apply near aquatic areas. Brigade WSB is a restricted-use pesticide because it is highly toxic to fish and aquatic organisms.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F. Lambda-Cyhalothrin</td>
<td>1.28–2.56 oz</td>
<td>24</td>
<td>14</td>
</tr>
<tr>
<td>(Warrior II with Zeon*, etc.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Do not apply near aquatic areas. Warrior II is a restricted-use pesticide because it is highly toxic to fish and aquatic organisms.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G. Fenpropathrin</td>
<td>10.66–21.33 fl oz</td>
<td>24</td>
<td>3</td>
</tr>
<tr>
<td>(Danitol 2.4EC*)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 3A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Do not apply near aquatic areas. Danitol 2.4EC is a restricted-use pesticide because it is highly toxic to fish and aquatic organisms.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H. Phosmet</td>
<td>4–4.33 lb</td>
<td>72</td>
<td>14</td>
</tr>
<tr>
<td>(Imidan 70W)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 1B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Do not apply after hull split reaches 10%. Buffer water to pH 5 prior to mixing insecticide.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common name (example trade name)</td>
<td>Amount per acre**</td>
<td>R.E.I.‡ (hours)</td>
<td>P.H.I.+ (days)</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>------------------</td>
<td>----------------</td>
<td>-------------</td>
</tr>
</tbody>
</table>

** Unless otherwise noted, apply with enough water to ensure adequate coverage.

‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) is the number of days from treatment to harvest. In some cases the R.E.I. exceeds the P.H.I. The longer of two intervals is the minimum time that must elapse before harvest.

# Acceptable for organically grown produce.

1 Rotate chemicals with a different mode-of-action Group number, and do not use products with the same mode-of-action Group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a Group number of 1B; chemicals with a 1B Group number should be alternated with chemicals that have a Group number other than 1B. Mode-of-action Group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their Web site at http://www.irac-online.org/.
PISTACHIO SEED CHALCID (10/14)

Scientific Name: *Megastigmus pistaciae*

DESCRIPTION OF THE PEST
The pistachio seed chalcid overwinters as a diapausing larva in infested nuts. In spring the larva pupates, and the pupa transforms to an adult that chews a tiny (1 mm) exit hole through the hard nut shell and emerges as the adult wasp. Female wasps lay their eggs in the hardening shells of maturing nuts in May and June, and the second adult generation emerges in mid- to late-summer. Some of the larvae of this generation do not emerge as adults the same year but remain in the nuts as mature larvae until the following spring. Adult female wasps that do emerge in August and September are able to oviposit through the hard shells of mature nuts, producing overwintering larvae.

DAMAGE
Although the seed chalcid is not a pest of commercial plantings of pistachios in California, it does occur throughout the Central Valley and is a pest in other areas of the world where pistachios are grown. Growers should be aware of this insect because it feeds directly on the pistachio nut and has the potential to reduce yields. It has become a serious pest in some areas of California where *Pistacia* seeds are produced for nursery rootstocks and in ornamental pistachios planted in urban areas.

MANAGEMENT
Examine nuts for small holes that indicate a seed chalcid has emerged from the nut. Adults can also be monitored by the use of yellow sticky traps that are placed in orchards in early August. Control of this pest consists primarily of orchard sanitation: remove and destroy nuts left on the tree following harvest as well as those that have fallen on the ground.
SMALL PLANT BUGS (10/14)

Scientific Names: Western tarnished plant bug (lygus bug): Lygus hesperus
California buckeye bug: Neurocolpus longirostris
Calocoris bug: Calocoris norvegicus
Phytocoris bug: Phytocoris spp., including P. relativus and P. californicus
Psallus vaccinicola

DESCRIPTION OF THE PESTS

A variety of small plant bugs in the family Miridae attack pistachio. The particular species varies depending upon location and natural vegetation. All of these bugs have a small, triangular-shaped marking on the back.

California buckeye bug adults are straw colored, slightly hunched, and about 1/3 inch (8.5 mm) in length. They often overwinter as eggs at the base of buds or leaf-petiole scars on 1-year-old pistachio wood. The nymphs are greenish with brown markings on the back. Both immatures and adults are easily identified by the relatively long, hairy first antennal segment and brown and white bands on legs and antennae. California buckeye bugs have been found only in orchards near their native plant hosts: California buckeye and Rhamnus species. However, once established in a pistachio orchard, buckeye bug will overwinter there.

Lygus bug adults are about 1/4 inch (6.4 mm) in length, vary from brownish to green, and it has a yellowish, triangular-shaped area on the back between the wings. They are most commonly found near alfalfa and beans, or plants such as clovers, Russian thistle, tarweed, London rocket, and lupine. Lygus bugs usually migrate into a pistachio orchard from nearby weeds. When rainfall and spring temperatures are ideal for the growth of broadleaf weeds, lygus bug numbers can be very high. When they move into the orchard, they tend to stay in the cover crop and move into the trees when the cover crop becomes unsuitable.

Calocoris bug adults are about 1/4 inch (6.4 mm) in length with a green body. The wings have a reddish brown tint and are black where they overlap. There are also two black dots on the thorax. Calocoris bug is usually found on mustard, wild radish, and vetch hosts and is most common in the northern San Joaquin and Sacramento valleys. Calocoris bug does not overwinter in pistachio trees but migrates into the orchards as native weed hosts dry or are cultivated in spring.

Phytocoris bugs overwinter in the egg stage on one-year-old fruit wood on pistachios as well as on other deciduous trees. Adults are about 1/4 inch (6.4 mm) long and are predominantly gray with flecks of black and white; they have long antennae and legs and can move rapidly when disturbed. The nymphs are also gray with white bands on the legs and antennae. Moderate numbers of phytocoris bugs are not considered damaging and seldom require treatment. They are predators of other insects, especially immature soft scale in March and April and second-instar scales that are migrating from leaves to woody shoots in fall; they also feed on navel orangeworm eggs in spring.

The least common of these small plant bugs is Psallus vaccinicola (there is no common name). The adults are about 1/8 inch (3.3 mm) long and are brownish red in color. They have been found predominantly near oaks in the Sacramento Valley.

DAMAGE

These bugs only cause damage for a short period of time, from bloom through shell hardening (early April–late May). However, during cool springs shell hardening is delayed and injury from plant bugs may be extended until June.

Small plant bugs insert their mouthparts into the nut, causing damage known as epicarp lesions, which on the inside of the nut appear as white netting. This damage is done before shell hardening and, except for damage caused by California buckeye bug, is more random in occurrence than damage caused by leaffooted plant bugs and stink bugs. Damage to small nuts results in blackening and nut drop. As the nuts enlarge, the hull tissue turns brown and necrotic, and the outside will often become sunken. On the inside of the nut there will be a small black spot or irregular-shaped pit in the area where the bugs fed on soft shell tissues.
MANAGEMENT
Careful attention to vegetation in and around orchards is the key to effective management of small plant bugs. The general pattern of bug appearance and distribution in an orchard is that phytoporis bugs and California buckeye bug overwinters in the trees. Calocoris and lygus bugs overwinter on preferred weed hosts in the ground cover. As vegetation in the pistachio orchard or surrounding areas dries, these bugs can move into the orchard canopy where they damage the developing crop.

Options to consider are
- Elimination of all herbaceous vegetation
- Maintenance of monitoring strips
- Use of trap crops with insecticides
- Use of cover crops that are not attractive to pest insects

Success or failure of each option will likely depend on the specific site and the species of bugs in the orchard.

Organically Acceptable Methods
Careful cover crop management is an organically acceptable management strategy. Mowing ground cover before bloom reduces small plant bug numbers.

Monitoring and Treatment Decisions
Monitor from early April until late May when shells harden and plant bugs no longer cause damage.
1. Sample the trees with a beating tray.
   a. Hold the tray under nut clusters while striking the limb sharply three times with a lightweight club.
   b. Examine bugs that drop onto the tray.
   c. The best time to take beat samples is in the morning when bugs are less active and easier to examine.
2. Sample the cover crop and surrounding vegetation with a sweep net for lygus bug and calocoris bug.
3. Phytocoris bugs can also be monitored with pheromone traps, but research has not been done to correlate trap catches with economic injury.
4. Look for small damaged or blackened nuts. Cut them open to confirm bug damage (black lesions inside the hull).

There are currently no treatment guidelines based on the number of small plant bugs found.
- If populations are found uniformly throughout the orchard after bloom, begin treatment.
- If insect numbers are low in the trees (three or less per ten beats), and lygus bug and calocoris bugs are present in the ground cover, consider treating just the ground cover.
- If lygus bugs and calocoris bugs move into the trees from drying vegetation, they (as well as phytocoris bugs) can cause damage into early May. California buckeye bug can also be a problem in May if it is established in the orchard or migrates in. By early June or after the shell has hardened, these bugs are no longer damaging.

Due to the variety of small bug species and range of dates they are present, more than one insecticide application may be justified. Be sure to rotate insecticides based on modes of action. Prior to using pyrethroids (Mode-of-action Group 3) for small bugs, also consider whether pyrethroid use is planned for leaffooted bug, stink bugs, or navel orangeworm and plan a resistance management program accordingly.
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide’s properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.

<table>
<thead>
<tr>
<th>Common name (example trade name)</th>
<th>Amount per acre**</th>
<th>R.E.I.‡ (hours)</th>
<th>P.H.I.‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. PERMETHRIN</td>
<td></td>
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<tr>
<td>(Pounce 25WP*)</td>
<td>8–16 oz</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>(Ambush 25W*)</td>
<td>12.8–25.6 oz</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 3</td>
<td></td>
<td></td>
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<tr>
<td>COMMENTS: Highly toxic to honey bees. Do not apply near aquatic areas; Pounce 25WP and Ambush 25W are restricted-use pesticides because they are highly toxic to fish and aquatic organisms.</td>
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<tr>
<td>B. BIFENTHRIN</td>
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<tr>
<td>(Brigade WSB*)</td>
<td>8–32 oz</td>
<td>12</td>
<td>7</td>
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<td>MODE-OF-ACTION GROUP NUMBER: 3</td>
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<td>COMMENTS: Do not apply near aquatic areas. Brigade WSB is a restricted-use pesticide because it is highly toxic to fish and aquatic organisms.</td>
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<tr>
<td>C. CYFLUTHRIN</td>
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<tr>
<td>(Baythroid XL*)</td>
<td>2–2.4 fl oz</td>
<td>12</td>
<td>14</td>
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<td>COMMENTS: Do not apply near aquatic areas. Baythroid XL is a restricted-use pesticide because it is highly toxic to fish and aquatic organisms.</td>
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<td>D. LAMBDA-CYHALOTHРИN</td>
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<tr>
<td>(Warrior II with Zeon Technology*)</td>
<td>1.28–2.56 oz</td>
<td>24</td>
<td>14</td>
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<tr>
<td>COMMENTS: Do not apply near aquatic areas. Warrior II is a restricted-use pesticide because it is highly toxic to fish and aquatic organisms.</td>
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<tr>
<td>E. FENPROPATHRIN</td>
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<td>(Danitol 2.4EC*)</td>
<td>10.66–21.33 fl oz</td>
<td>24</td>
<td>3</td>
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<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 3A</td>
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<tr>
<td>COMMENTS: Do not apply near aquatic areas. Danitol 2.4EC is a restricted-use pesticide because it is highly toxic to fish and aquatic organisms.</td>
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<tr>
<td>F. CARBARYL*</td>
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<tr>
<td>(Sevin 4F)</td>
<td>3–5 qt</td>
<td>12</td>
<td>14</td>
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<tr>
<td>(Sevin XLR Plus)</td>
<td>3–5 qt</td>
<td>12</td>
<td>14</td>
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<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 1A</td>
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<tr>
<td>COMMENTS: XLR formulation is the least toxic to honey bees when direct application to bees is avoided and the spray residues have dried. Apply from late evening to early morning when bees are not foraging. Usually applied with oil during the dormant season to reduce bugs and other pests (e.g., soft scale) that overwinter on the trees.</td>
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SOFT SCALES (10/14)

Scientific Names:
- Brown soft scale: *Coccus hesperidum*
- Black scale: *Saissetia oleae*
- Frosted scale: *Parthenolecanium pruinosum*
- European fruit lecanium: *Parthenolecanium corni*

DESCRIPTION OF THE PESTS

Brown soft scale is a mottled, yellow-brown when young, becoming darker at maturity. It has three to five generations per year and is often found on the nut. Adult scales are flattened and elongated, resembling a football sliced in half and about 1/8 inch (3.3 mm) in length.

Black scale is similar in size to the brown scale, dark brown to black, later becoming more mottled black and brown. It has an H-shaped ridge on the dorsum. There is generally only one generation per year in the Central Valley. However, in some years two generations have been detected.

Frosted scale is elongated, slightly humped, and has a waxy, white frostlike coating in spring. It is about 1/4 inch (6.4 mm) at maturity and has one generation per year. It is found in the warmer interior growing areas.

European fruit lecanium is identical to the frosted scale but does not have the frosted coating. High temperatures early in summer will increase mortality of immature stages of European fruit lecanium.

Immature stages of these scale species are very small (about 1/64 inch) and difficult to distinguish from each other; look for the adults nearby to determine which species is present. Soft scales molt twice before they reach maturity. The stage just before the adult is frequently referred to as the rubber stage. In this stage, the scales remain soft, somewhat translucent and are still susceptible to parasitism. Upon molting to adults, the shell hardens and becomes opaque.

DAMAGE

In spring, soft scales produce heavy amounts of honeydew, providing a substrate on which sooty mold grows. Sooty mold growth covers leaves and can affect photosynthesis. Moderate-to-high scale populations can also retard shoot growth and shell splitting. Scales are most common on vigorously growing trees.

MANAGEMENT

These scales are normally kept under control by native parasites. Because of the increase in the use of permethrin treatments for true bugs in pistachio, natural enemies of scales are more frequently killed, and soft scales are becoming more prevalent.

Biological Control

There are a number of effective parasites of these soft scales. Most are tiny parasitic wasps in the genus *Metaphycus*. *Metaphycus luteolus* destroys the scale in its early instars before it can reproduce or cause substantial injury. This parasite produces several generations during each scale generation. In addition, predators, including the predaceous lady beetle, *Rhyzobius (Lindorus) lophanthae*, and green lacewings, *Chrysopa* and *Chrysoperla* species, feed on these scales.

There is a strong relationship between phytocoris bugs and soft scale. Where phytocoris bugs are plentiful, scale density is commonly low. During March and April, young adult soft scales (prior to forming their crustlike covering and laying eggs) and soft scale eggs are a primary food source for phytocoris bugs. In fall, phytocoris bugs feed on second-instar scales that are migrating from the leaves to the woody shoots.

Organically Acceptable Methods

Biological control and oil sprays in the dormant period are acceptable for use in an organically certified crop.
Monitoring and Treatment Decisions
In early to mid-January, examine one-year-old fruiting wood for live and parasitized scale paying special attention to previously infested areas. Look at 12-inch dormant shoots that are randomly selected from throughout the orchard.

- A light-to-moderate population in early February would be an average of one to five live scale per inch of fruiting wood
- A heavy population would be an average of 10 or more live scale per inch.

Other factors to consider when making treatment decisions are the age, vigor, and split nut percentages.

Apply a dormant treatment in mid-February before the scales reach the rubber stage of development. For optimal control, treat frosted scale before its waxy coating develops, and treat European fruit lecanium before it reaches the rubber stage in late February.

Depending upon weather conditions and scale pressure, re-treatment may not be necessary for 3 to 5 years.

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<tr>
<td>A. NARROW RANGE OIL# (Omni Supreme Spray)</td>
<td>4–6 gal</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>MODE OF ACTION: Contact including smothering and barrier effect. COMMENTS: No more than 6% v/v solution permitted as a concentrate. Oil application can advance bud break by 7 to 10 days. Treatments made in November through December have a minimal effect on bloom timing. Use a distillation range of 440 to 470.</td>
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<tr>
<td>B. PYRIPROXYFEN (Seize 35WP)</td>
<td>4–5 oz</td>
<td>12</td>
<td>21</td>
</tr>
<tr>
<td>C. BUPROFEZIN (Centaur WDG)</td>
<td>34.5–46 oz</td>
<td>12</td>
<td>60</td>
</tr>
<tr>
<td>D. CARBARYL* (Sevin XLR Plus)</td>
<td>4–5 qt</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 1A NARROW RANGE OIL</td>
<td>0.7–2.5 gal</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>MODE OF ACTION: Improves translaminar movement and insecticide persistence COMMENTS: Best results are obtained with the addition of the oil to the spray for high populations. Moderate populations have been successfully controlled with oil alone. When dormant oil is applied in January or February, trees bloom somewhat earlier in spring, and they become more susceptible to frost damage. If dormant oil applications are made earlier (November–December), the effect on bloom timing is minimized.</td>
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STINK BUGS (10/14)

Scientific Name:  Redshouldered stink bug: *Thyanta pallidovirens*
Green plant bug: *Chlorochroa uhleri*
Green stink bug: *Chinavia hilaris (=Acrosternum hilare)*

DESCRIPTION OF THE PESTS

The redshouldered stink bug (*Thyanta pallidovirens*) is somewhat triangular in shape and about 1/3 inch (8.3 mm) in length. It is predominantly green with a narrow red band across the shoulder; sometimes the band is absent. There is also a brown-colored phase, usually found in overwintering bugs. The green stink bug (*Chinavia hilaris*) which was previously called *Acrosternum hilare* is dull to bright green and slightly larger (2/5–3/5 inch) and less common than the redshouldered stink bug. Adult green stink bugs are bright green with the entire lateral margin lined in yellow or orange. Two other species are similar to the green stink bug, these are the Uhler’s stink bug (*Chlorochroa uhleri*), and the Say’s stink bug (*Chlorochroa sayi*). Green stink bug nymphs are a mixture of green, black, and orange.

Stink bugs often develop in weeds or field crops and move to pistachio, but they have also been found overwintering in orchards, especially the green plant bug. Eggs of these stink bugs are laid in clusters, are barrel shaped, and have concentric dark rings at the top. Immature stages of these species range widely in coloration, often marked brightly with red, yellow, green and black or brown, different from the adult stage and changing as the nymphs develop.

Do not confuse pest stink bugs with the rough stink bug, *Brochymena quadripustulata*, a predator that is speckled white and gray and quite common in pistachio orchards throughout the year. Nymphs of *Brochymena* are colored red, white, and blue.

DAMAGE

Before shell hardening, stink bugs cause damage similar to their smaller relatives (small plant bugs) by causing epicarp lesions associated with a white netting inside the nut. Often these damaged nuts drop along with a large number of other naturally aborted nuts. Due to the relatively low number of stink bugs typically found early in the season, coupled with the ability of the tree to compensate for aborted nuts, stink bug damage prior to shell hardening rarely causes an economic loss of crop.

After shell hardening in July, stink bugs may cause kernel necrosis, which is identical to damage caused by leaffooted plant bugs, and contributes to offgrade nuts at harvest. Kernel necrosis is not obvious externally, but inside the nut, the nutmeat is darkened, often develops a sunken necrotic area, and has an off-flavor. In July and August, feeding damage is indicated by an external, brown pinpoint mark; no white netting is visible.

Stink bugs are capable of transmitting some pistachio diseases, such as stigmatomycosis and Botryosphaeria panicle and shoot blight, making control of these pests important.

MANAGEMENT

Stink bugs are primarily late season pests. When stink bug density is high in July and August, a treatment may be required to reduce the incidence of kernel necrosis.

Monitoring and Treatment Decisions

Starting in April monitor weekly through nut development.

1. **Spend about 30 minutes looking for adult stink bugs migrating into the orchard from overwintering sites.** Start from the edge of the orchard and work your way inward.
2. **Also sweep for redshouldered and green stink bugs in surrounding cover crops and vegetation.**
3. **Sample the trees with a beating tray for green stink bugs while also sampling for leaffooted bug and small plant bugs.**
   a. Hold the tray under nut clusters while striking the limb sharply three times with a lightweight club.
   b. Examine bugs that drop onto the tray.
   c. The best time to take beat samples is in the morning when bugs are less active and easier to examine.
4. **It is also helpful to look for small damaged or blackened nuts. Cut them open to confirm bug damage (black lesions inside the hull).**

Online with photos at http://www.ipm.ucanr.edu/PMG/selectnewpest.pistachios.html
Time insecticide applications after the majority of eggs have hatched and nymphs are easily found. In many cases broad-spectrum treatments already being used for small bugs, leaffooted bug, or navel orangeworm provide adequate control of stink bugs.

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<tr>
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<td>MODE-OF-ACTION GROUP NUMBER: 3</td>
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<td></td>
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<tr>
<td>COMMENTS: Highly toxic to honey bees. Do not apply near aquatic areas; Pounce 25WP and Ambush 25W are restricted-use pesticides because they are highly toxic to fish and aquatic organisms.</td>
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<td>B. BIFENTHRIN</td>
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<td>C. LAMBDA-CYHALOTHIN</td>
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<td>(Warrior II with Zeon*)</td>
<td>1.28–2.56 fl oz</td>
<td>24</td>
<td>14</td>
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<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Do not apply near aquatic areas. Warrior II is a restricted-use pesticide because it is highly toxic to fish and aquatic organisms.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. CYFLUTHRIN</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Baythroid XL*)</td>
<td>2–2.4 fl oz</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Do not apply near aquatic areas. Baythroid XL is a restricted-use pesticide because it is highly toxic to fish and aquatic organisms.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** Unless otherwise noted, apply with enough water to ensure adequate coverage.
‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) is the number of days from treatment to harvest. In some cases the R.E.I. exceeds the P.H.I. The longer of two intervals is the minimum time that must elapse before harvest.
* Permit required from county agricultural commissioner for purchase or use.
1 Rotate chemicals with a different mode-of-action Group number, and do not use products with the same mode-of-action Group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a Group number of 1B; chemicals with a 1B Group number should be alternated with chemicals that have a Group number other than 1B. Mode-of-action Group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their Web site at http://www.irac-online.org/.
WEBSPINNING SPIDER MITES (10/14)

Scientific names: Twospotted spider mite: *Tetranychus urticae*
Pacific spider mite: *Tetranychus pacificus*

DESCRIPTION OF THE PESTS

Pacific and twospotted mites overwinter as reddish orange mature females in protected places on the tree, in soil, and in decomposing leaf litter on the ground. During warm weather in spring, overwintered females begin feeding on pistachio leaves and ground cover in the orchard. During periods of active feeding twospotted mites have a dark spot on each side of the body. Pacific mites have a second pair of dark spots near the posterior end. Often, however, the spots are barely visible or may coalesce to large dark areas, making it difficult to distinguish the two species.

Colonies develop on the underside of leaves and also on the upper sides when numbers build up. Eggs are spherical and translucent when first laid, becoming opaque soon before hatching. Immature mites molt three times before becoming adults. Spider mites are tiny, less than 1/20 inch (1.3 mm) long. The first stage mites have six legs; later stages and adults have eight legs. These mites reproduce rapidly in hot weather and may become numerous in June or July. They produce many generations a year. If temperature and food supply are favorable, a generation can be completed in 7 days.

DAMAGE

Pacific and twospotted spider mite damage initially appears as a loss of green color on infested leaflets. Continued feeding causes the leaf to develop small, necrotic spots (stippling) with webbing. All mite life stages can be found feeding within this webbing. Low mite levels of 3 to 4 per leaflet are sufficient to cause defoliation in pistachio. Clusters of brown leaves are often the first sign of increasing mite numbers. Defoliation early in the season will greatly reduce nut yield and quality; defoliation late in the season will interfere with harvest.

Areas with somewhat alkaline soils are more likely to have spider mite problems. As in other crops, leaf loss relative to mite levels is enhanced by plant stress from lack of water or high salinity. Greater incidence of damage has been reported with increased pyrethroid use for plant bug control. Many cases involve severe defoliation and a shriveled crop on infested trees.

MANAGEMENT

Spider mites are rarely pests in pistachio orchards, except where natural enemies are absent due to the use of broad-spectrum pesticides or where trees are highly stressed. Tree health and use of selective materials for other pests usually provides adequate spider mite control.

Biological Control

Sixspotted thrips, *Scolothrips sexmaculatus*, are the most important predators of spider mites in pistachios. Since webspinning spider mite populations develop very slowly on pistachios, thrips often provide effective biological control and insecticides are not needed. Other predators include the spider mite destroyer, *Stethorus picipes*, and minute pirate bugs.

Cultural Control

Orchard management practices can reduce mite problems.
- Minimize dust by oiling orchard roads and maintaining a ground cover.
- Well-irrigated, vigorous trees sustain less damaged from mite infestations.
- Choose selective pesticides when controlling other pests and avoid pyrethroids, organophosphates, and carbamates until later in the season.

Organically Acceptable Methods

Biological control, cultural controls, and sprays of narrow range oil are acceptable for use in an organically certified crop.

Monitoring and Treatment Decisions

Monitor from June through August by looking for the presence of spider mites and their predators on leaves. If spider mites are found, wait one week and resample to determine if populations are increasing, decreasing, or
staying the same. Spider mite treatments in pistachios are rarely needed, but can be considered if populations and leaf stippling are increasing and defoliation occurs.

<table>
<thead>
<tr>
<th>Common name (example trade name)</th>
<th>Amount per acre**</th>
<th>R.E.I.‡ (hours)</th>
<th>P.H.I.‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPIRODICLOFEN (Envidor)</td>
<td>16–34 oz</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ETOXAZOLE (Zeal Mitecide 1)</td>
<td>2–3 oz</td>
<td>12</td>
<td>28</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 10B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FENPROXIMATE (FujiMite 5EC)</td>
<td>2–4 pt</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 21A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NARROW RANGE OIL# (TriTek, etc.)</td>
<td>See label</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>MODE OF ACTION: Contact including smothering and barrier effects.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide’s properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.

A. SPIRODICLOFEN (Envidor)
   MODE-OF-ACTION GROUP NUMBER: 23
   Amount: 16–34 oz
   R.E.I.: 12 hours
   P.H.I.: 7 days

B. ETOXAZOLE (Zeal Mitecide 1)
   MODE-OF-ACTION GROUP NUMBER: 10B
   Amount: 2–3 oz
   R.E.I.: 12 hours
   P.H.I.: 28 days

C. FENPROXIMATE (FujiMite 5EC)
   MODE-OF-ACTION GROUP NUMBER: 21A
   Amount: 2–4 pt
   R.E.I.: 12 hours
   P.H.I.: 14 days
   COMMENTS: Apply by ground and use a minimum of 100 gallons of water per acre.

D. NARROW RANGE OIL# (TriTek, etc.)
   MODE OF ACTION: Contact including smothering and barrier effects.
   Amount: See label
   R.E.I.: 4 hours
   P.H.I.: 0 days

‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) is the number of days from treatment to harvest. In some cases the R.E.I. exceeds the P.H.I. The longer of two intervals is the minimum time that must elapse before harvest.

1 Rotate chemicals with a different mode-of-action Group number, and do not use products with the same mode-of-action Group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a Group number of 1B; chemicals with a 1B Group number should be alternated with chemicals that have a Group number other than 1B. Mode-of-action Group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their Web site at http://www.irac-online.org/.
WESTERN TUSSOCK MOTH (10/14)

Scientific Name: Orgyia vetusta

DESCRIPTION OF THE PEST
Western tussock moth overwinters in the egg stage, and larvae begin emerging in March and April. Immature larvae are hairy and black. Mature western tussock moth larvae are large (almost 2 inches in length) caterpillars with numerous red and yellow spots and long tufts of hair. There are four white tufts of hair on the top of the first four abdominal segments, two black tufts on the head, and many grayish tufts over the body. Adult females are large, wingless, and predominantly gray. The males are winged moths. There is only one generation per year.

DAMAGE
As the tree begins to leaf out, larvae feed on the foliage. Localized high numbers of larvae can completely defoliate trees. Orchard workers that touch larvae may get rashes caused by the urticating setae, or hollow hairs, connected to poison sacs under the larval skin.

MANAGEMENT
Visually search trees for black caterpillars feeding on terminal growth and look for cocoons on major scaffolds. Levels of western tussock moth warranting treatment are very rare. If a treatment is needed, insecticides that are effective against navel orangeworm or obliquebanded leafroller are also effective against western tussock moth.

Organically Acceptable Methods
Sprays of Bacillus thuringiensis or the organic formulation of spinosad (Entrust) are acceptable for use in an organically managed orchard.
Diseases
(Section reviewed 10/14)

ALTERNARIA LATE BLIGHT (10/14)

Pathogen: *Alternaria alternata*, *A. tenuissima*, *A. arborescens*, and *Stemphylium* spp.

SYMPTOMS AND SIGNS

Alternaria late blight occurs as black angular or circular lesions on leaves of both male and female trees. When the pistachio fruit are maturing, black lesions with a red halo appear on hulls. Black spores develop in the center of the leaf lesions when humid conditions prevail in orchards. Rubbing the leaf lesions with a finger will blacken the finger. In contrast, rubbing a finger on a lesion caused by *Botryosphaeria dothidea* does not blacken fingers because there are no spores produced on the surface of these lesions. However, late in the season both fungi can be present in the same lesion and microscopic identification will be needed. Leaf infections can cause severe premature defoliation and create problems during shaking the trees at harvest.

Black lesions are also present on petioles and main veins of leaf blades. On immature fruit the symptoms appear as small black lesions about 1/25 inch (1 mm) in diameter. On mature fruit, both small 1/25 to 1/13 inch (1–2 mm) and large 1/5 inch (5 mm) black lesions are present on the epicarp, usually surrounded by a reddish purple margin. Multiple lesions on leaves and fruit cause leaf blight and deterioration of hulls, respectively. Deterioration of hulls results in shell staining. Excessive growth of the fungus can invade also the kernel, resulting in kernel decay.

COMMENTS ON THE DISEASE

Alternaria is a problem in orchards irrigated by sprinklers or flooding. It can also be a problem in orchards with low soil infiltration and those irrigated with microsprinklers, particularly in lower areas in these orchards where relative humidity can be high and dew formation frequent during late August and September. The pathogen causes latent infections on leaves and fruit. The disease is more severe on leaves from fruit-bearing shoots than those without fruit.

Losses occur mainly because of fruit staining, kernel decay, and from early defoliation, which can be severe enough to cause difficulties during harvest. In addition, the fungus can colonize the inner surface of the shell and endocarp, causing moldy nuts. Leaf and fruit lesions are common on both Kerman and Red Aleppo cultivars, as well as on the leaves of Peters and on leaves of 02-16 and 02-18 male selections. The newly released pistachio cultivars, Golden Hills, Lost Hills, and Randy seem to be as susceptible as Kerman and Peters cultivars.

MANAGEMENT

Late July to early August is the time when one can see the first symptoms of Alternaria late blight, depending on the orchard’s humidity conditions. By mid-September the disease can develop to epidemic levels. Orchards with cover crops have more Alternaria blight than orchards with mechanical or chemical mowing. Sunburned fruit become more susceptible to Alternaria blight than nonsunburned fruit.

Starting in mid-July through harvest monitor foliage for Alternaria late blight symptoms. If only one fungicide application is done, the best timing is late June to early July (see TREATMENT TIMING FOR KEY DISEASES).

Resistance of *Alternaria* spp. to Group 11 and 7 fungicides has been detected in some pistachio orchards. Take steps to avoid the development of fungicide resistance. Rotate among the fungicide classes and avoid repeated use of one class of fungicides. Other practices that often lead to resistance are using reduced concentrations and poor coverage.
Alternaria blight is difficult to control and requires a combination of management approaches. If water management is used, weigh disease severity against the impact of deficit irrigation on shell splitting.

- Winter pruning can improve air movement, reducing disease.
- Manage tall, dense weeds on the orchard floor to reduce humidity levels and leaf wetness, thereby reducing disease development.
- If the disease is serious, adjust the irrigation schedule and add calcium-based amendments to minimize standing water from August to harvest.
- Use subsurface irrigation to reduce this disease significantly.
- Harvest early, if possible, in orchards where Alternaria late blight is problematic.

### When choosing a pesticide, consider its usefulness in an IPM program by reviewing the pesticide’s properties, efficacy, application timing, and information relating to resistance management, honey bees, and environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.

<table>
<thead>
<tr>
<th>Common name</th>
<th>Amount per acre</th>
<th>R.E.I.‡ (hours)</th>
<th>P.H.I.‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. PYRACLOSTROBIN + BOSCALID (Pristine)</td>
<td>10.5–14.5 oz</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER): Quinone outside inhibitor (11) and carboxamide (7) COMMENTS: Do not apply in orchards where resistance to boscalid has been detected.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. AZOXYSTROBIN (Abound)</td>
<td>12.3–15 fl oz</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER): Quinone outside inhibitor (11) COMMENTS: Apply at 2- to 3-week intervals beginning late May to early June. Resistance of Alternaria spp. to Group 11 fungicides has been detected in some pistachio orchards.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. PYRACLOSTROBIN (Cabrio EG)</td>
<td>16 oz</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER): Quinone outside inhibitor (11) COMMENTS: Apply before disease onset and repeat at a 10-to-30 day interval.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. FLUOPYRAM + TEBUCONAZOLE (Luna Experience)</td>
<td>6–8 fl oz</td>
<td>12</td>
<td>35</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER): Succinate dehydrogenase inhibitor (7) and demethylation inhibitor (3) COMMENTS: 2(ee) label rate (listed above) is lower than the section 3 label rate.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. FLUOPYRAM + TRIFLOXYSTROBIN (Luna Sensation)</td>
<td>5–7.6 oz</td>
<td>12</td>
<td>28</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER): Succinate dehydrogenase inhibitor (7) and quinone outside inhibitor (11)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F. AZOXYSTROBIN + PROPICONAZOLE (Quilt Xcel)</td>
<td>12.5–21 oz</td>
<td>12</td>
<td>60</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER): Demethylation inhibitor (3) and quinone outside inhibitor (11)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G. POLYOXIN-D ZINC SALT (Ph-D)</td>
<td>6.2 oz</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER): Chitin synthesis inhibitor (19)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H. AZOXYSTROBIN + DIFENOCONAZOLE (Quadris Top)</td>
<td>12–14 oz</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER): Quinone outside inhibitor (11) and demethylation inhibitor (3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common name (example trade name)</td>
<td>Amount per acre</td>
<td>R.E.I.‡ (hours)</td>
<td>P.H.I.‡ (days)</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-----------------</td>
<td>-----------------</td>
<td>---------------</td>
</tr>
<tr>
<td>I. METCONAZOLE (Quash)</td>
<td>4 oz</td>
<td>12</td>
<td>25</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER): Demethylation inhibitor (3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J. PENTHIOPYRAD (Fontelis)</td>
<td>14–20 oz</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER): Succinate dehydrogenase inhibitor (7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K. TRIFLOXYSTROBIN (Gem 500SC)</td>
<td>2.9–3.8 oz</td>
<td>12</td>
<td>28</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER): Quinone outside inhibitor (11)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Apply at 2- to 3-week intervals beginning at late May to early June. Resistance of <em>Alternaria</em> spp. to Group 11 fungicides has been detected in some pistachio orchards.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L. CYPRODINIL + FLUDIOXONIL (Switch 62.5WG)</td>
<td>11–14 oz</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER): Anilinopyrimidine (9) and phenylpyrrole (12)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Make the first application in early June and a second application 2 to 3 weeks later.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M. PYRIMETHANIL (Scala SC)</td>
<td>18 fl oz</td>
<td>12</td>
<td>30</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER): Anilinopyrimidine (9)</td>
<td></td>
<td></td>
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</tbody>
</table>

‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://www.frac.info/). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode-of-action group numbers 1,4,9,11, or 17 before rotating to a fungicide with a different mode-of-action group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.
ARMILLARIA ROOT ROT (Oak Root Fungus) (10/14)

Pathogen: *Armillaria mellea*

**SYMPTOMS AND SIGNS**
Roots infected with *Armillaria mellea* have white to yellowish fan-shaped mycelial mats between the bark and the wood. Dark brown to black rhizomorphs can sometimes be seen on the root surface, especially during wet springs.

Wilted, downward-hanging foliage is often the first obvious symptom of Armillaria root rot. Other symptoms include foliage yellowing, leaf drop, and dieback of upper limbs. During the rainy fall and winter, groups of short-lived mushrooms often grow around the base of Armillaria-infected trees.

**COMMENTS ON THE DISEASE**
Although pistachio is susceptible to Armillaria root rot, the disease is infrequently reported. The relative susceptibility of pistachio rootstocks is unknown. The fungus survives on dead roots.

**MANAGEMENT**
Armillaria root rot is only occasionally a problem in pistachio orchards.

Management of this disease can be difficult and resistant rootstock may offer the best protection. Research indicates that *Pistacia terebinthus* and *P. atlantica x P. integerrima* hybrids are tolerant but *P. atlantica* and *P. integerrima* are susceptible. However, because pathogenicity and virulence in the natural population of the pathogen ranges from weak to severe, disease response may vary with different combinations of rootstocks and pathogen. Exposing an infected crown may help individual trees with the disease.
BOTRYOSPHAERIA PANICLE AND SHOOT BLIGHT (10/14)

**Pathogen:** *Botryosphaeria dothidea; Neofusicoccum mediteraneum, other Botryosphaeriaceae fungi; conidial stage: Neofusicoccum spp.*

**SYMPTOMS AND SIGNS**

Vegetative and flowering buds that were killed during the previous fall or winter do not emerge in spring. In mid-spring (end of May to June) buds that were partially infected the previous season produce fruit clusters and shoots that develop blight from the fungus in buds. The rachises of these blighted clusters turn black as do the shoots. When temperatures increase in May through July, the fungus moves into shoots of the previous year, causing blighting of fully developed clusters. These blighted shoots, leaves, and clusters turn brown.

Secondary infections of clusters originate where the rachises branch; they start as small black lesions that later coalesce and cause fruit blight. Secondary infections of fruit start as round, black, pin-sized lesions, some of which will expand and decay the hulls. In late August through September, infected fruit are covered with pycnidia (black flasklike structures containing the fungus spores of the *Neofusicoccum* sp.) and obtain a silvery color, in contrast to the noninvaded blighted fruit, which are brown.

Infections on leaves also start as small black lesions that later coalesce and cause leaf blight. From August through October, large necrotic lesions with pycnidia in the center develop on leaves of male and female trees. Infection of petioles start as longitudinal black areas and cause blight of the entire leaf or of individual leaflets and defoliation. Scars of abscised buds or leaves can also be infected, resulting in sunken cankers above and below the scars. Infected rachises usually hang on the tree for 3 to 4 years, providing inoculum for the following growing season(s). On branches, lenticels can also be infected, but the infections remain small and do not invade the shoot.

To distinguish from *Alternaria* spp., rub leaf lesions with a finger

- If finger blackens the lesion is caused by *Alternaria* spp.
- If finger does not blacken the lesion is caused by *Botryosphaeria dothidea* (no spores are produced on the surface of these lesions).

However, late in the season both fungi can be present in the same lesion and microscopic identification will be needed.

**COMMENTS ON THE DISEASE**

Sources of inoculum for this disease are rachises, shoots, and petioles killed during the previous growing season that remain on the trees. Cankers can also provide inoculum for as long as 6 years. Spores from these sources cause primary infections on the vegetative and flowering buds. Secondary infections subsequently occur on shoots, rachises, fruit, and leaves from spores produced in the primary infected plant parts. The pathogen can cause latent infections on buds, leaves, and fruit. Symptoms of the disease are triggered to develop by temperatures over 86°F (30°C).

Spores are spread in water from spring and summer rains, via water from sprinkler irrigation, or other means (birds, hemipteran insects, etc.). The optimum temperature range for disease development is 80° to 86°F, and the disease can become very severe during late spring to summer when temperatures and relative humidity in pistachio orchards are high.

**MANAGEMENT**

Botryosphaeria panicle and shoot blight is extremely difficult to control, especially if allowed to increase over several years. The best approach employs monitoring, pruning, fungicides, and irrigation management.

**Cultural Control**

To reduce disease incidence, lower sprinklers to prevent water from reaching the tree canopy or shorten the duration of irrigation from 48 to 24 hours. You may irrigate only during the daytime for 12 hours in 2 consecutive days to significantly reduce disease.

When disease incidence is low, pruning blighted shoots and panicles, shoots with cankers, dead and dying wood, and removing infected wood from the orchard can help reduce or eliminate inoculum for a few years. During late summer, after harvest, and during dormancy prune out infected areas 2 inches past blighted margins.
After harvest remove and destroy unharvested nuts and mummies to reduce sources of inoculum. At minimum shake trees and remove mummies as soon as possible before rain. Mummy removal will also reduce navel orangeworm.

**Organically Acceptable Methods**
Organic growers need to emphasize careful pruning to remove as much infected plant tissue as possible. Applying the fungicide Regalia is an organically acceptable method.

**Monitoring and Treatment Decisions**

**Monitoring**
During dormant and delayed dormant pruning activities, look for Botryosphaeria cankers noting trees of concern. Continue to look for shoot strikes two to three times during the growing season.

**Predictive Tests**
Two tests are available that predict disease risk at harvest. A preseason bud-monitoring test (BUDMON) detects bud infection incidence and predicts risk for panicle and shoot blight at harvest. A growing-season test (ONFIT = overnight freezing-incubation technique) of immature fruit provides treatment thresholds. For information on diagnostic labs that perform these tests ask your local farm advisor or pest control adviser.

**Management**
If your orchard has a severe history of Botryosphaeria panicle and shoot blight or you find cankers, plan to apply a fungicide when panicles appear in spring. When the disease is severe, both pruning and fungicide treatment are suggested.

Apply two to three applications of QoI strobilurins (azoxystrobin, pyraclostrobin, or trifloxystrobin) starting at bloom. Pyrimethanil (Scala) is only effective when the disease is low to moderate in severity.

Time your fungicide applications before a rain event (if missed, an application can be applied 2 to 3 days after rain occurs); it has been shown that applications before or after rain reduce the number of calendar sprays.

Also consider the results of BUDMON or ONFIT tests to decide whether additional sprays are necessary.

<table>
<thead>
<tr>
<th></th>
<th>Sampling</th>
<th>Risk Results (% infected plant part)</th>
</tr>
</thead>
</table>
| **BUDMON**     | Between February and mid-March randomly collect 100 flower or vegetative buds from each quadrant of the orchard, placing them in a paper or plastic bag and bringing them to a lab. | • 0%: no disease expected  
                     • 1–3%: low levels of disease  
                     • 4–8%: moderate levels of disease  
                     • ≥9%: high levels of disease expected  
                     • Consider treating when results show moderate to high risk. |
| **ONFIT**      | In mid June to early July (the latest), randomly collect 100 immature fruit from each quadrant of the orchard, placing them in a paper or plastic bag in an ice chest, and bringing to a lab. | • 0%: no additional treatment is needed  
                     • 1–3%: one fungicide application (treat last week June or first week July)  
                     • >5%: two fungicide applications may be needed (treat last week June or first week July; repeat 2 to 3 weeks later) |
When choosing a pesticide, consider its usefulness in an IPM program by reviewing the pesticide’s properties, efficacy, application timing, and information relating to resistance management, honey bees, and environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.

A. **FLUOPYRAM + TEBUCONAZOLE**  
   (Luna Experience)  
   MODE-OF-ACTION GROUP NAME (NUMBER): Succinate dehydrogenase inhibitor (7) and demethylation inhibitor (3).  
   Amount per acre: 6–8 fl oz  
   R.E.I.‡ (hours): 12  
   P.H.I.‡ (days): 35

B. **FLUOPYRAM + TRIFLOXYSTROBIN**  
   (Luna Sensation)  
   MODE-OF-ACTION GROUP NAME (NUMBER1): Succinate dehydrogenase inhibitor (7) and quinone outside inhibitor (11)  
   Amount per acre: 5–7.6 oz  
   R.E.I.‡ (hours): 12  
   P.H.I.‡ (days): 28

C. **POLYOXIN-D ZINC SALTS**  
   (Ph-D)  
   MODE-OF-ACTION GROUP NAME (NUMBER1): Chitin synthesis inhibitor (19)  
   Amount per acre: 6.2 oz  
   R.E.I.‡ (hours): 4  
   P.H.I.‡ (days): 0

D. **AZOXYSTROBIN + PROPICONAZOLE**  
   (Quilt Xcel)  
   MODE-OF-ACTION GROUP NAME (NUMBER): Demethylation inhibitor (3) and quinone outside inhibitor (11)  
   Amount per acre: 12.5–21 oz  
   R.E.I.‡ (hours): 12  
   P.H.I.‡ (days): 60

E. **AZOXYSTROBIN + DIFENOCONAZOLE**  
   (Quadris Top)  
   MODE-OF-ACTION GROUP NAME (NUMBER1): Demethylation inhibitor (3) and quinone outside inhibitor (11)  
   Amount per acre: 12–14 oz  
   R.E.I.‡ (hours): 12  
   P.H.I.‡ (days): 14

F. **TEBUCONAZOLE**  
   (Tebuzol 45DF)  
   MODE-OF-ACTION GROUP NAME (NUMBER1): Demethylation inhibitor (3)  
   Amount per acre: 8 oz.  
   R.E.I.‡ (hours): 12  
   P.H.I.‡ (days): 35

G. **PYRACLOSTROBIN + BOSCALID**  
   (Pristine)  
   MODE-OF-ACTION GROUP NAME (NUMBER1): Quinone outside inhibitor (11) and carboxamide (7)  
   Amount per acre: 10.5–14.5 oz  
   R.E.I.‡ (hours): 12  
   P.H.I.‡ (days): 14

H. **TRIFLOXYSTROBIN**  
   (Gem 500SC)  
   MODE-OF-ACTION GROUP NAME (NUMBER): Quinone outside inhibitor (11)  
   Amount per acre: 1.9–3.8 fl oz  
   R.E.I.‡ (hours): 12  
   P.H.I.‡ (days): 28  
   COMMENTS: Apply at 2- to 3-week intervals beginning at late May to early June. Do not apply more than 4 times per season.

I. **AZOXYSTROBIN**  
   (Abound 2EC)  
   MODE-OF-ACTION GROUP NAME (NUMBER): Quinone outside inhibitor (11)  
   Amount per acre: 12.3–15 fl oz  
   R.E.I.‡ (hours): 4  
   P.H.I.‡ (days): 7  
   COMMENTS: Apply at 2- to 3-week intervals beginning late May to early June. Do not apply more than 4 times per season.

J. **PYRACLOSTROBIN**  
   (Cábrio EG)  
   MODE-OF-ACTION GROUP NAME (NUMBER): Quinone outside inhibitor (11)  
   Amount per acre: 16 oz  
   R.E.I.‡ (hours): 12  
   P.H.I.‡ (days): 14  
   COMMENTS: Apply before disease onset and repeat at a 10- to 30-day interval.

K. **PYRIMETHANIL**  
   (Scala SC)  
   MODE-OF-ACTION GROUP NAME (NUMBER): Anilinopyrimidine (9)  
   Amount per acre: 18 fl oz  
   R.E.I.‡ (hours): 12  
   P.H.I.‡ (days): 30  
   COMMENTS: Use under low and moderate disease pressure.
<table>
<thead>
<tr>
<th>Common name (example trade name)</th>
<th>Amount per acre</th>
<th>R.E.I.‡ (hours)</th>
<th>P.H.I.‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L. THIOPHANATE-METHYL (Topsin M WSB)</td>
<td>1.5–2 lb</td>
<td>72 (3 days)</td>
<td>—</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER): Methyl benzimidazole (1) COMMENTS: Apply at bloom.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M. CYPRODINIL + FLUDIOXONIL (Switch 62.5WG)</td>
<td>11–14 oz</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER): Anilinopyrimidine (9) and phenylpyrrole (12) COMMENTS: Make first application at early bloom and a second 14 days later.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N. REYNOUTRIA SACHALINENSIS EXTRACT# (Regalia)</td>
<td>Ground application: 1–4 qt</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER): Plant extract (P5)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://www.frac.info/). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode-of-action group numbers 1,4,9,11, or 17 before rotating to a fungicide with a different mode-of-action group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.

— Not applicable.
BOTRYTIS BLOSSOM AND SHOOT BLIGHT (10/14)

Pathogen: *Botrytis cinerea*

**SYMPTOMS AND SIGNS**
Botrytis blossom and shoot blight occurs in early spring and fruit blight later in spring. The first symptom to be observed is wilting of tender shoots; later leaves shrivel and dry. Young shoots die and the leaves remain attached, a symptom called flagging (shepherd’s hook).

Botrytis blossom blight is more severe in male than female trees, especially in the 02-16 and 02-18 male selections. The fungus enters the flower and invades the wood where it causes cankers on current or two-year-old shoots. Cankers can coalesce and measure up to 10 inches (25 cm) long. When cool, wet weather prevails, diseased blossoms and basal portions of shoots are generally covered with buff-colored masses of spores. Large circular lesions can develop on blades of both female and male trees, and portions of the leaf blade (usually a V-shaped area near the terminal) mainly on male trees may also be infected and killed by the fungus. Late rains can result in infections of fruit clusters, killing parts or the entire cluster, which become beige in color.

**COMMENTS ON THE DISEASE**
Infections occur in spring on succulent current-season growth. Most Botrytis cankers occur at the base of shoots and most likely start from contaminated buds and bud scales. The fungus colonizes the bud scales and then grows and infects the developing tender shoot. Shoots wilt and form a shepherd’s crook. Inflorescences, especially in male trees, are also attacked.

Blighted shoots provide inoculum during the current growing season and in the following spring. Under humid conditions, the fungus colonizes and sporulates on male flowers that are on the tree or already dropped to the ground. Other sources of inoculum include infected weeds, leaves, and immature fruit dropped to the ground, or other crops neighboring the pistachio orchard. The disease is problematic during cool, wet springs and causes damage by killing current season shoots and fruit, thus reducing fruiting wood for the following season and yields (fruit blight phase).

**MANAGEMENT**
Orchard sanitation can help reduce the incidence of Botrytis blossom and shoot blight.

1. Prune blighted shoots, shoots with cankers, and dead or dying branches.
2. Destroy or remove infected pruned-out wood and brush piles.
3. Prune trees and clear the debris right after harvest and, if needed, during the dormant season.

If spring weather is cool and wet during bloom, consider applying a fungicide.
When choosing a pesticide, consider its usefulness in an IPM program by reviewing the pesticide’s properties, efficacy, application timing, and information relating to resistance management, honey bees, and environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.

<table>
<thead>
<tr>
<th>Common name (example trade name)</th>
<th>Amount per acre</th>
<th>R.E.I.‡ (hours)</th>
<th>P.H.I.‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. FLUOPYRAM + TEBUCONAZOLE (Luna Experience)</td>
<td>6–8 fl oz</td>
<td>12</td>
<td>35</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER): Succinate dehydrogenase inhibitor (7) and demethylation inhibitor (3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. FENHEXAMID (Elevate 50WDG)</td>
<td>1–1.5 lb</td>
<td>12</td>
<td>—</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER): Hydroxyanilide (17)</td>
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<td></td>
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</tr>
<tr>
<td>COMMENTS: Apply at 5 to 10% bloom and full bloom.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. PYRACLOSTROBIN + BOSCALID (Pristine)</td>
<td>10.5–14.5 oz</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER): Quinone outside inhibitor (11) and carboxamide (7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. POLYOXIN-D ZINC SALT (Ph-D)</td>
<td>6.2 oz</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER): Polyoxins (19)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. FLUOPYRAM + TRIFLOXYSTROBIN (Luna Sensation)</td>
<td>5–7.6 oz</td>
<td>12</td>
<td>28</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER): Succinate dehydrogenase inhibitor (7) and quinone outside inhibitor (11)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F. CYPRODINIL + FLUDIOXONIL (Switch 62.5WG)</td>
<td>11–14 oz</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER): Anilinopyrimidine (9) and phenylpyrrole (12)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Make first application at early bloom and a second 14 days later.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G. PYRIMETHANIL (Scala SC)</td>
<td>18 fl oz</td>
<td>12</td>
<td>30</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER): Anilinopyrimidine (9)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H. THIOPHANATE-METHYL (Topsin M WSB)</td>
<td>1.5–2 lb</td>
<td>72</td>
<td>—</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER): Methyl benzimidazole (1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Apply at bloom. Restricted entry interval is 3 days.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://www.frac.info/). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode-of-action group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode-of-action group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.

— Not applicable.
FRUIT MOLDS (10/14)


**SYMPTOMS AND SIGNS**

If humid conditions prevail during the maturation period of pistachio fruit, several fungi can colonize and decay pistachios, although infection by *Aspergillus* spp. can occur under drier than normal conditions.

*Alternaria* causes deterioration of fruit epicarp (see also ALTERNARIA LATE BLIGHT DISEASE). Small or large black lesions develop that may expand over the entire hull surface. Depending on the degree of colonization, *A. alternata* can invade the kernel, causing kernel discoloration and decay. Whether or not the kernel is infected, *Alternaria* can damage the quality of the nut by causing brown to black stain marks on the shells.

*Aspergillus niger* causes a blight that turns the hulls light beige to yellow. If hulls are removed, the black, powdery sporulation of the fungus is evident under the hull and on the surface of the shell. No characteristic or typical symptoms develop from infections by the other fungi listed as casual agents of these molds, although such infections will stain shells and causes hulls to adhere to shells. After shelling, however, characteristic sporulation by these fungi can be obvious by the naked eye.

**COMMENTS ON THE DISEASE**

Colonization of nuts by *Aspergillus* molds is often associated with insect infestations. Infection of the nuts by *A. flavus* may result in contamination with aflatoxin(s). Dry, hot weather favors infection by *Aspergillus* spp.

**MANAGEMENT**

Take preventive measures during the period that the fruit are maturing.

- Avoid water stress during mid-May when the shell is growing rapidly to reduce the incidence of early shell split and control infestations of navel orangeworm.
- Control navel orangeworm to reduce infection by *A. flavus* and *A. parasiticus* and reduce aflatoxin contamination.
- When establishing an orchard, select rootstocks that are not conducive to high incidence of early splits (e.g., UCB1).
PHYTOPHTHORA ROOT AND CROWN ROT (10/14)

Pathogen: *Phytophthora* spp.

**SYMPTOMS AND SIGNS**

Pistachio is subject to root and crown rots and trunk and branch cankers. Trees show poor vigor; leaf yellowing, wilting, and scorching; and shoot and branch dieback. Infected roots become necrotic, with dark brown to black discoloration of the cortex and stele. Small roots eventually disintegrate. Cankers develop at the root crown and may extend above the soil line. Infected pistachio bark turns brown to black. Active cankers often ooze and release a light cream exudate in balls, strands, or puddles. The exudate is not diagnostic because other diseases and injuries to the trunk will result in sap release.

Occasionally, *Phytophthora* spp. cause perennial cankers on trunks and scaffolds. Such cankers stop at the union of the scion and the rootstock and often lead to tree death.

**COMMENTS ON THE DISEASE**

The pathogens survive in soil and can be carried in irrigation water obtained from surface sources. Prolonged periods of saturated soil are optimal for root infection. Disease development is enhanced in poorly drained soils, where orchards receive long durations of flood irrigation, or in trees in lower spots or along creeks and natural drainage creeks in the orchard. Several species of *Phytophthora* are known to attack pistachio roots and crowns.

**MANAGEMENT**

Fungicides are not currently registered for control of Phytophthora root and crown rot in California pistachio. Management of this disease can best be achieved using strict planting practices and water management. Plant on raised berms in well-drained soil to allow for rapid water drainage following irrigation or rains.

Although the disease is not a major problem in California, growers have been losing trees to Phytophthora canker due to soil conditions. In heavy soils, a hard pan layer results in poor infiltration and lower spots in planting sites.

In general the *Pistacia* rootstocks are not considered very susceptible.
POWDERY MILDEW (10/14)

Pathogens: Oidium sp.

SYMPTOMS AND SIGNS
Powdery mildew starts as white powdery blotches on leaves, leaf stems, and fruit epicarp. Later in the season, these blotches turn brown to black and have a netted appearance. The blotches on fruit become russeted and multiple blotches cause leaves to yellow, turn brown, and die. Infected leaves and fruit may be distorted and misshapen. Similar symptoms can be found on rachises, fruit stems, petioles, underside of leaf blades, and young shoots.

COMMENTS ON THE DISEASE
The disease commonly occurs on the Trabonella cultivar. Red Aleppo is more susceptible than the Kerman cultivar.

MANAGEMENT
The occurrence of powdery mildew on pistachio trees is uncommon and sporadic. No management is recommended.

STIGMATOMYCOSIS (10/14)

Pathogens: Eremothecium coryli (syn. Nematospora coryli) and Aureobasidium pullulans

SYMPTOMS AND SIGNS
Stigmatomycosis of pistachio is characterized by the wet, smelly, rancid, slimy appearance of the kernel. There are three major symptoms of stigmatomycosis: small kernels that are dark and not fully developed; kernels that develop normally and fill the shell cavity but are partially or totally wet, smelly, rancid, and dark; and kernels that fill the shell cavity but look abnormal: white and jellylike.

COMMENTS ON THE DISEASE
The yeasts that caused stigmatomycosis are associated with hemipteran insects (true bugs) in the families Pentatomidae (stink bugs) or Coreidae. Hemiptera are common pests in pistachio orchards. Switching from sprinkler irrigation to drip, microjets, or flood irrigation reduces damage from bugs as well as stigmatomycosis. Feeding by plant bugs can also damage the kernel, causing kernel necrosis, a brown-to-black distinct lesion that sometimes shows concentric rings.

MANAGEMENT
Fungicide applications are not effective in controlling stigmatomycosis; however, an insecticide spray to control STINK BUGS and LEAFFOOTED PLANT BUGS has been shown to reduce the incidence of stigmatomycosis.
VERTICILLIUM WILT (10/14)

Pathogen: *Verticillium dahliae*

SYMPTOMS AND SIGNS
Generally Verticillium wilt causes a rapid desiccation and death of one or more scaffolds or the entire tree, usually in late spring or early summer. The first symptoms are interveinal patches of yellowing or scorching of the leaves on affected branches.

In some instances, however, it may also cause a condition known as thin leaf decline where the disease develops slowly over several years before the tree becomes economically unproductive or dies. Thin leaf decline is characterized by slow loss of vigor, reduction in growth and yield, and gradual thinning of the canopy until most of the remaining leaves are clustered in tufts at the ends of branches and shoots.

COMMENTS ON THE DISEASE
Verticillium wilt affects a large number of herbaceous and woody species. The causal fungus, *Verticillium dahliae*, infects susceptible plants through the roots. Pistachio trees of any age are subject to attack. The disease has been most destructive where pistachio trees were grown in fields previously planted to other susceptible crops such as tomato, cotton, melons, or peppers.

The fungus survives as microscopic, black resting structures (microsclerotia) capable of surviving in soil for many years. When a susceptible plant is grown in soil infested with the fungus, the microsclerotia germinate and infect the plant.

It invades and colonizes the plant's vascular system, plugging the xylem and preventing or reducing the transport of water from the roots to the above-ground portion of the tree. If dead or dying branches are cut in cross section, a darkened ring of plugged xylem tissue can be seen.

Verticillium wilt is favored by cool temperatures. Extended spring weather and mild summers often are accompanied by severe losses to this disease. The fungus apparently is eliminated from aboveground portions of trees in hot summer weather. Repeated attacks of wilt apparently represent new infections each year.

MANAGEMENT
The best defense against Verticillium wilt is the use of the resistant rootstock Pioneer Gold, *Pistacia integerrima*, PGII or Platinum (a *P. integerrima* x *P. atlantica* hybrid), or UCB I (a *P. atlantica* x *P. integerrima* hybrid). *Pistacia atlantica* and *P. terebinthus* rootstocks are very susceptible and should be avoided where *Verticillium* is present. During nut development, monitor trees for Verticillium wilt and note trees for future removal.
Nematodes
(Section reviewed 2/15)

Scientific Names:
- Pin nematode: *Paratylenchus hamatus*
- Root lesion nematode: *Pratylenchus neglectus*
- Dagger nematode: *Xiphinema americanum*
- Root knot nematode: *Meloidogyne* spp.

DESCRIPTION OF THE PESTS
Nematodes are microscopic, unsegmented, roundworms that live in diverse habitats. Plant parasitic nematodes feed on plant roots by piercing and sucking the cell contents with a spearlike mouthpart called a stylet. They usually live in soil and plant roots.

DAMAGE
The nematodes listed above have been found in pistachio orchards in California but have not been associated with damage to this crop.

SYMPTOMS
Tree symptoms may suggest but are never sufficient to diagnose a nematode problem. Infested trees exhibit nonspecific symptoms of yellowing, malnutrition, and decline. To adequately diagnose a nematode problem, soil and root samples must be examined by a diagnostic laboratory to determine if nematodes are present.

FIELD EVALUATION
Although nematodes have not previously been found to cause problems on pistachios in California, if the cause for a problem cannot be found, soil samples could be taken to determine if nematodes are present. Contact your farm advisor for more details about sampling and to help you find a laboratory for extracting and identifying nematodes.

Damage thresholds for nematodes on pistachio have not been developed. If high numbers of plant parasitic nematodes are present and no other cause for symptoms can be determined, contact your local farm advisor for help interpreting sample results and advice.

MANAGEMENT
No management practices are recommended because nematodes are not currently recognized as causing problems on pistachios in California.

In very sandy soils, close attention to irrigation and nutrient management can overcome unthrifty growth conditions in which root knot nematodes may play a role.

*Pistacia vera*, the commercial nut bearing species, is known to be susceptible to root knot nematode when planted from seed or when used as a rootstock in parts of the Middle East for example. The rootstocks *P. integerrima*; hybrids of *P. atlantica* and *P. integerrima*; *P. atlantica* and *P. terebinthus* currently appear to be resistant or poor hosts for root knot and lesion nematodes.
Weeds

(Section reviewed 10/14)

INTEGRATED WEED MANAGEMENT (10/14)

Weeds compete with pistachio trees for water and nutrients. The competition for these resources is of greater concern when trees are young because weeds can delay tree growth and productivity. Weeds can also harbor pests and pathogens, interfere with irrigation uniformity and distribution, and reduce harvest efficiency.

Integrated weed management involves the use of multiple strategies to manage weed populations in a manner that is economically and environmentally sound. Such strategies include cultural, mechanical, and chemical methods.

Integrated weed management strategies vary from orchard to orchard. Location in the state, climatic conditions, soils, irrigation practices, topography, and grower preferences influence pistachio floor management decisions and the tools used. Weeds are commonly controlled chemically in a 4- to 6-foot-wide strip within the tree row. The area between the tree rows is mechanically mowed, tilled, or sometimes chemically treated. Fabric or plant-based mulches, subsurface irrigation, and flamers can also be used to help manage weeds in orchards. Often several weed management options are used in an orchard depending on the types of weeds present, age of the trees, soil conditions, and grower preference.

Irrigation method, amount of water applied, and pattern of rainfall affect weed growth as well as the frequency and timing of cultivation and selection of herbicides and their residual properties. For example, soils that receive frequent, low-volume, drip or micro-sprinkler irrigation increase the rate of herbicide degradation in the soil. Herbicides are degraded faster in warm, moist soils as compared to cold, dry soils.

Herbicides registered in California for use in pistachios are an important component of an integrated weed management program. Herbicide selection is an important process and should be based on the species of weeds present, stage of weed development, weed density, herbicide toxicity, herbicide persistence, soil type, soil moisture, irrigation method, environmental conditions, labor and equipment availability, size of farming operation, and economics. Referring to the WEED SUSCEPTIBILITY CHARTS and HERBICIDE TABLE shown in this text can help in the process of herbicide selection and effectiveness.

Before using herbicides, remove leaves and debris from the treatment area. Use drift-reducing spray nozzles, other techniques (i.e. low spray pressure, slower travel speed, etc.), or a combination of them, and apply herbicides only during favorable environmental conditions to enhance coverage and reduce drift.

Herbicides are either applied to the soil surface before weeds germinate and emerge (preemergence) or are applied directly to the foliage of small, actively growing weeds (postemergence).

Preemergence herbicides inhibit weed germination and emergence; they usually do not control established plants. The effect of preemergence herbicides can last up to a year or more, depending on the solubility of the material, adsorption to the soil, soil temperature and moisture, weed species, and dosage applied. Soil type and irrigation methods greatly influence the effectiveness of these herbicides. In some situations, these herbicides can be lost as a result of leaching and runoff. Herbicide leaching is more extensive on sandy soils and runoff occurs more on clay soils. As a general rule, preemergence herbicides require rainfall or irrigation following treatment to activate them. After the activation and incorporation, subsequent irrigations have less of an impact on the movement of the herbicide. In most instances, combinations or sequential applications of herbicides will be needed to provide effective, economical control.

Postemergence herbicides are applied directly to weed foliage and they control weeds either by contact or through translocation. A contact herbicide, such as glufosinate, kills young weeds by directly damaging treated foliage. Therefore, it is essential to have good spray coverage and wetting for this type of herbicide to be effective. Effective control with contact herbicides is reduced as weeds become larger and denser because coverage is often reduced. Translocated herbicides, like glyphosate, move within the plant and damage tissues that were not directly sprayed. Complete coverage of weeds with translocated herbicides is not necessary. Furthermore, postemergence herbicides can be selective or nonselective in their control. Selective herbicides, like sethoxydim and fluazifop, control only grassy weed species. Nonselective herbicides, like glyphosate and paraquat, control a broad spectrum of both grasses and broadleaf weeds. Regardless of the type of postemergence herbicides used, the best time to treat weeds is when they are in the seedling stage and actively growing.
PREVENTION
A good weed management strategy in pistachio orchards begins with prevention. Keep irrigation canals, ditch banks, and irrigation systems free of weeds and weed seeds. Install filters in canals and irrigation systems to prevent weed seeds from entering the orchard. Prevent leaks in the irrigation system and the accumulation of water in furrows or low-lying areas, which encourage weed growth. Control weeds along field margins before they produce seed that can be dispersed readily into the orchard. Clean the undercarriage and tires of tractors and other equipment before entering new fields because weed seeds and reproductive parts of weeds can be transported along with them. This is especially important in preventing perennial weeds from entering a previously uninfested field.

MONITORING
Detecting new weeds and weeds that escaped previous control efforts is essential in preventing weed establishment or identifying changes or shifts in weed populations. Regular monitoring or scouting is a very important component of an integrated plan. For weed monitoring to be useful it is important to correctly identify the weed species present in and around the orchard. Try to identify and control weeds before they surpass the seedling stage. Most weeds are poor competitors for water and nutrients when they are small, but some can become very aggressive as they become large. Furthermore, it is easier to control annual weeds with chemical or mechanical tools when they are small and have not become established. Perennial weeds are more vulnerable to control at the early bud stage or during fall when the plants begin to go dormant. Herbicides applied at these stages can be translocated to the roots or rhizomes to better kill the weed. For assistance in identifying weeds in different stages of growth, consult the color photos in the online version of this guideline that are linked to the weeds listed in COMMON AND SCIENTIFIC NAMES OF WEEDS.

Monitor the orchard in a thorough and systematic manner. Include the entire orchard as well as field margins, ditch banks, and irrigation canals in your survey. Monitor weeds in fall, late spring, and following any control effort. Examine all areas that are susceptible to weed infestation, like areas of high moisture. Items of interest include weed species, location in the field, degree of control achieved with current program, and herbicides and other options used (including timing, rates, and dates treated). Record observations, noting locations of problematic weeds, so infested sites can be revisited for weed control. Maintain monitoring information for the life of the orchard. Over several years this information will help in determining changes in the weed species that are present. Comparing this information with the past and current weed management methods can help in evaluating the success of the techniques used and in deciding future strategies.

WEED MANAGEMENT BEFORE PLANTING
Whenever possible, avoid fields known to be infested with perennial weeds such as johnsongrass, field bindweed, bermudagrass, and nutsedge. If perennial weeds infest a potential orchard site, control them before the final land preparation for planting because they can cause problems and increase management costs in the future. Pendimethalin (Prowl) is the only preemergence herbicide that can be used before planting pistachio trees. It is important to note that young pistachio trees are very sensitive to soil residuals of certain preemergence herbicides such as diuron (Karmex), simazine (Princep), and bromacil (Hyvar); carefully follow all label plantback restrictions in orchard sites where preemergence herbicides have previously been used. The only other chemical option of controlling weed seeds in the orchard site during this time is soil fumigation, which can be expensive.

Identify and control weeds that are growing on the orchard site either chemically with postemergence materials or mechanically before planting. It is important to control annual weeds before they produce seeds. Perennial weeds can be mechanically controlled by repeated discings in summer or chemically treated with a postemergence herbicide in the early fall while the perennial weeds are still flowering. Re-treat with a postemergence herbicide the following spring to kill regrowth. Follow the re-treatment by discing the orchard site 2 to 3 weeks later to expose weed roots to drying.

Other herbicides, such as paraquat, can also be used to control weeds before planting. It may be necessary to irrigate the field before treatment to encourage weed emergence and growth. This can also significantly reduce the amount of weed seed remaining in the soil and increase the degree of control of perennial weeds.

WEED MANAGEMENT IN NEWLY PLANTED ORCHARDS
Weed control is especially important during the first few years of orchard establishment. Competition from weeds during this period can result in reduced tree vigor and productivity. Weedy orchards may require several more years to become economically productive than weed-free orchards. In addition, managing weeds that host
invertebrate pests helps reduce their numbers as well. For instance, London rocket and spotted spurge are preferred hosts for chinch bugs. Clovers, Russian thistle, and birdsfoot trefoil are a few of the weed hosts of lygus and stinkbugs. Regardless of the method to control weeds, be careful not to injure the young trees with herbicides or to mechanically damage the trunk or roots. Furthermore, grassy weeds, particularly foxtails, create a good habitat for vertebrate pests like field mice, which can feed on young tree trunks.

**Cultivation**

Weeds may be managed without the use of herbicides for the first few years after planting with cross discing or shallow (less than 2 inches deep) cultivation in the tree row; discing or mowing between tree rows; and hand weeding in the area at the base of the trees. Cultivation is best done when weeds are seedlings and easy to dislodge from the soil. Hand weeding is usually required close to the trees to remove weeds missed during cultivation. Hand-held weed eaters can be used to kill small weeds around the trees, but take care not to injure the bark of young trees. Damage to either the bark or the roots can allow soil pathogens in, causing further damage to the trees.

**Herbicides**

Tree age should always be considered when selecting specific herbicides to use, because it can affect whether or not tree injury could occur. Certain herbicides are registered only for use during the nonbearing period (normally the first five to six years after planting), some can be used only after trees have been planted for a given number of years, and still others can be used throughout most of the life of the trees.

**Preemergence herbicides**

Apply preemergence herbicides in a newly planted orchard only after the soil around the trees has completely settled in to reduce the likelihood of tree damage through direct contact with tree roots.

The only preemergence herbicide that can be used exclusively during the nonbearing years in pistachio is pendimethalin (Prowl). There are several preemergence herbicides registered for both the nonbearing and bearing years in pistachio including flumioxazin (Chateau), indaziflam (Alion), isoxaben (Trellis), oryzalin (Surflan), oxyfluorfen (Goal), and others. Refer to the HERBICIDE TREATMENT TABLE for herbicides registered, tree age restrictions, and general label recommendations.

Preemergence herbicides are most commonly applied in a 4- to 6-foot-wide strip down the center of the tree rows. For best results herbicides should be applied to a clean soil surface. A mechanical leaf blower can be used to remove leaves and other debris from the tree rows to improve herbicide contact with the soil surface. Adequate rainfall or irrigation is also required to activate the herbicides following application. Most herbicides require at least 0.25 to 0.5 inch of rainfall or irrigation water within 21 to 28 days of treatment to be adequately activated and incorporated.

**Postemergence herbicides**

Postemergence herbicides can also be used following planting once weeds have emerged. Herbicides registered for the nonbearing years only include clodhodim (Select Max), diquat (Reglone), and fluazifop (Fusilade). Postemergence herbicides registered for both the nonbearing and the bearing years include carfentrazone (Shark), glufosinate (Rely 280), glyposate (Roundup PowerMax, etc.), oxyfluorfen (Goal), and others. Refer to the HERBICIDE TREATMENT TABLE for herbicides registered, tree age restrictions, and general label recommendations. Postemergence herbicides usually require the addition of an adjuvant (either a nonionic surfactant or a nonphytotoxic oil) to be effective. Ammonium sulfate is often added to the spray water first, before adding herbicide(s), to condition the water and help improve herbicide uptake by weeds, particularly where water high in calcium, sodium, magnesium, and iron is used.

Regardless of the postemergence herbicide used, protect the foliage and bark of young trees from direct spray or spray drift in order to avoid tree injury. Young pistachio trees are very susceptible to damage from herbicides. Placing plastic or paper wraps around the tree trunks is helpful in preventing herbicide contact with young trees. However, using “protective” wraps will not compensate for poor spraying techniques.

**WEED MANAGEMENT IN ESTABLISHED OR BEARING ORCHARDS**

It takes about six years in most situations for pistachio trees to begin full production and mechanical harvest. Trees less than six years old are generally harvested by knocking the nuts onto tarp on the ground.
Weeds are generally controlled between the tree rows by discing or mowing and herbicide strip applications directed down the tree row.

**Cultivation**

Cultivation can be used to manage annual and biennial weeds both between and within tree rows. Large weeds, perennials, or weeds with hearty roots or crowns or both (like cheeseweed and hairy fleabane) will not be controlled mechanically and may require postemergence herbicide treatments.

Generally, weeds growing between the rows of trees, in the alleys or middles, are disced 3 to 5 times per year. The size of the weeds is usually not a concern as long as the disc blades cut deep enough to destroy the weeds and seed has not yet been produced. Weeds within the tree row can be managed with a second pass of the cultivator, perpendicular to the first pass. However, cross-discing must be carefully done to avoid damaging the trees and their roots. Injury to trees can lead to invasion by crown-rotting organisms. Leave a 1- to 2-foot strip next to the trees to prevent injury. Weeds in this undisturbed area can be removed by hand or spot-treated with postemergence herbicides where appropriate (see section below). In-row mulching cultivators also can be used as long as the trees are not damaged. Shallow (less than 2 inches deep) mulching will destroy most annual and seedling biennial weeds.

Some problems that can develop with repeated discing are soil compaction, dust, reduced water infiltration, and soil erosion in hilly terrains and sloping lands. Discing may also bring some buried weed seeds to the surface or spread reproductive structures like rhizomes, tubers, or stolons throughout the orchard. Therefore, some growers maintain a planted cover crop or resident vegetation (existing weeds) that they mow.

- Where resident vegetation is maintained, a flail mower is used as needed to maintain the plants in a low-growing state.
- Mowing too close to the soil surface creates dust and should be avoided.
- For frost protection and to reduce plant bug and false chinch bug numbers, ground cover should be mowed before pistachio bud break. Refrain from spraying herbicides during bloom to reduce potential injury to developing fruit.
- If self-reseeding of a cover crop is desired, a final mowing should not be made until the plants have set seed.

For more information on cover crops, consult UC ANR Publication 21471, *Covercrops for California Agriculture*.

**Herbicides**

Established trees are generally more tolerant of herbicides than newly planted ones. Preemergence herbicides registered for use in bearing pistachio orchards include flumioxazin (Chateau), indaziflam (Alion), penoxsulam + oxyfluorfen (Pindar GT), rimsulfuron (Matrix), and others. Refer to the HERBICIDE TREATMENT TABLE for herbicides registered, tree age restrictions, and general label recommendations. When using a preemergence herbicide or combination of herbicides, apply a treatment in fall following harvest, in late winter before bloom, or split into two applications (fall and late winter). Add a postemergence herbicide if weeds have emerged at the time of application. For the greatest safety, direct the spray to the base of the trees to avoid contact with young wood and foliage. Use spraying methods that reduce likelihood of spray drift (e.g., drift-reducing spray nozzles) where possible and apply herbicides only when environmental conditions favor less drift.

Apply preemergence herbicides before and as close to a rainfall event (0.25–0.50 inch) as possible to improve efficacy. Avoid applying herbicide if a large (2 or more inches) single precipitation event is expected before herbicide is incorporated into the soil. Before application, mechanically remove leaves or other debris that may be covering the tree row, preventing the herbicide from contacting the soil. Select the appropriate postemergence herbicide that best controls the weeds known to be present in the field. Occasionally, a tank-mix of one or more herbicides may be required to control all the weeds. In situations where weeds are spotty, the amount of herbicide needed can be reduced by making spot applications or using a visual weed-seeking sprayer. With postemergence herbicides, it is important that weeds are small, not stressed for moisture, or too large to adequately cover. Some weeds, like spotted spurge, set seed soon after emergence and should be sprayed when small to provide adequate control and prevent new seed formation. Two or more applications may be needed.

**Herbicides and irrigation**

In established pistachio orchards, chemical weed control has to be adjusted to the irrigation method used. In California, pistachios are irrigated by several methods, such as low-volume drip, micro-sprinklers, misters, solid-set sprinkler, furrow, or basin flood. Low-volume irrigation is common in California pistachio orchards because of better uniformity in irrigation application and efficiency than other methods. However, under certain
conditions, low-volume irrigation water applied too frequently can increase the chance of leaching and herbicide
degradation causing the areas around the emitters to have vigorously growing weeds. It is important to monitor
these areas closely and spot treat, when necessary, with postemergence sprays.
SPECIAL WEED PROBLEMS  (10/14)

Many of these special weed problems can be minimized by managing them before planting pistachio orchards.

HAIRY FLEABANE

Hairy fleabane is a summer annual that reproduces from seed, although under certain environmental conditions it can grow like a biennial. It germinates from fall through spring, and matures and produces seed from July through September. Hairy fleabane is a member of the sunflower family; its seed is readily disseminated by the wind. The preemergence herbicides flumioxazin (Chateau), indaziflam (Alion), isoxaben (Trellis), penoxsulam plus oxyfluorfen (Pindar GT), and rimsulfuron (Matrix) provide effective control. Hairy fleabane is difficult to control with postemergence herbicides because its stems are multi-branched, often woody, and lack significant leaf area. Hairy fleabane plants are most susceptible to control with postemergence herbicides or mechanical control when they are in the seedling stage. Effective postemergence herbicides are glufosinate (Rely 280), paraquat (Gramoxone), and saflufenacil (Treevix). Due to widespread distribution of glyphosate-resistant hairy fleabane biotypes, do not use glyphosate (Roundup) as a primary herbicide for control.

HORSEWEED (MARE'S TAIL)

Horseweed is a summer annual weed, closely related to hairy fleabane, with similar growth and reproductive characteristics. Unlike hairy fleabane, horseweed grows as a single stalk. Horseweed can become a prevalent weed in orchards where oryzalin (Surflan) and oxyfluorfen (Goal) are used as preemergence treatments over several years in a row. Control emerged plants in the same manner as hairy fleabane. Delaying treatments when plants are bolting will likely result in poor control and regrowth. Mowing is not recommended because cutting plants off above the soil line can result in the sprouting of lateral buds at the base of this weed. Due to widespread distribution of glyphosate-resistant horseweed biotypes, do not use glyphosate (Roundup) as a primary herbicide for control.

FIELD BINDWEED

Field bindweed is a vigorous perennial weed that grows from seed, which can survive as long as 30 years in the soil, or more commonly, from reproductive stolons, rhizomes, or extensive roots. It is important to control this weed before it has the chance to establish and produce seed. While cultivation can be used to control seedlings, cultivating mature plants can spread reproductive structures. Once field bindweed appears in an orchard, spot treat with high label rates of glyphosate (Roundup). Two or more treatments may be needed to eradicate the new infestation.

NUTSEDGE

Yellow and purple nutsedge are perennial weeds that reproduce mainly from underground tubers. Yellow nutsedge is the most common of the two species found in pistachio orchards. Most tubers of yellow nutsedge will survive in the soil for less than five years and are found primarily in the top eight inches of the soil profile. Yellow nutsedge grows and reproduces best under sandy, well-irrigated conditions. The tubers have several buds that can each give rise to additional plants. Under normal conditions, one or two buds sprout to form new plants; however, if killed by cultivation or an herbicide, then new buds are activated. Rimsulfuron (Matrix) provides some control in nonbearing and bearing orchards. Treat emerged plants with glyphosate (Roundup) or paraquat (Gramoxone) before they reach the 4- to 5-leaf stage. Repeated applications at 3- to 4-week intervals will be required during summer as new plants emerge.

LITTLE MALLOW (CHEESEWEED)

Little mallow is a winter annual or biennial weed that is controlled with preemergence herbicides like oxyfluorfen (Goal), flumioxazin (Chateau), and penoxsulam plus oxyfluorfen (Pindar GT). Once established, little mallow becomes woody and forms a thick crown and root, making it difficult to control mechanically or with postemergence herbicides. Plants that are less than 4 to 6 inches tall are easiest to control with a tank-mix application of oxyfluorfen (Goal) plus glyphosate (Roundup), glufosinate (Rely 280), or saflufenacil (Treevix). Repeated mowing is not an effective means of control.
# COMMON AND SCIENTIFIC NAMES OF WEEDS (10/14)

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>barley, hare</td>
<td><em>Hordeum murinin</em> ssp. <em>leporinum</em></td>
</tr>
<tr>
<td>barnyardgrass</td>
<td><em>Echinochloa crus-galli</em></td>
</tr>
<tr>
<td>bermudagrass</td>
<td><em>Cynodon dactylon</em></td>
</tr>
<tr>
<td>bindweed, field</td>
<td><em>Convolvulus arvensis</em></td>
</tr>
<tr>
<td>bluegrass, annual</td>
<td><em>Poa annua</em></td>
</tr>
<tr>
<td>brome grasses</td>
<td><em>Bromus</em> spp.</td>
</tr>
<tr>
<td>canarygrass</td>
<td><em>Phalaris canariensis</em></td>
</tr>
<tr>
<td>chickweed, common</td>
<td><em>Stellaria media</em></td>
</tr>
<tr>
<td>clovers</td>
<td><em>Trifolium</em> spp.</td>
</tr>
<tr>
<td>cockleburs</td>
<td><em>Xanthium</em> spp.</td>
</tr>
<tr>
<td>crabgrass</td>
<td><em>Digitaria</em> spp.</td>
</tr>
<tr>
<td>cudweeds</td>
<td><em>Gnaphalium</em> spp.</td>
</tr>
<tr>
<td>dallisgrass</td>
<td><em>Paspalum dilatatum</em></td>
</tr>
<tr>
<td>dock, curly</td>
<td><em>Rumex crispus</em></td>
</tr>
<tr>
<td>evening primrose, cutleaf</td>
<td><em>Oenothera laciniati</em></td>
</tr>
<tr>
<td>fescues</td>
<td><em>Festuca</em> spp.</td>
</tr>
<tr>
<td>fiddlenecks</td>
<td><em>Amsinckia</em> spp.</td>
</tr>
<tr>
<td>filarees</td>
<td><em>Erodium</em> spp.</td>
</tr>
<tr>
<td>fleabane, hairy (fleabane, flaxleaved)</td>
<td><em>Coryza bonariensis</em></td>
</tr>
<tr>
<td>foxtails</td>
<td><em>Setaria</em> spp.</td>
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<tr>
<td>goosefoot, nettleleaf</td>
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<tr>
<td>groundcherrys</td>
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<td><em>Senecio vulgaris</em></td>
</tr>
<tr>
<td>henbit</td>
<td><em>Lamium amplexicaule</em></td>
</tr>
<tr>
<td>horseweed</td>
<td><em>Coryza canadensis</em></td>
</tr>
<tr>
<td>johnsongrass</td>
<td><em>Sorghum halepense</em></td>
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<tr>
<td>junglerice</td>
<td><em>Echinochloa colona</em></td>
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<tr>
<td>knotweed, common</td>
<td><em>Polygonum arenastrum</em></td>
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<tr>
<td>lambsquarters, common</td>
<td><em>Chenopodium album</em></td>
</tr>
<tr>
<td>lettuce, prickly</td>
<td><em>Lactuca serriola</em></td>
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<td>lovegrassess</td>
<td><em>Eragrostis</em> spp.</td>
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<tr>
<td>marrow, little (cheeseweed)</td>
<td><em>Malva parviflora</em></td>
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<tr>
<td>mullein, turkey</td>
<td><em>Eremocarpus setigerus</em></td>
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<tr>
<td>mustards</td>
<td><em>Brassica</em> spp.</td>
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<tr>
<td>nettle, burning</td>
<td><em>Urtica urens</em></td>
</tr>
<tr>
<td>nightshades</td>
<td><em>Solanum</em> spp.</td>
</tr>
<tr>
<td>nutsedge, yellow</td>
<td><em>Cyperus esculentus</em></td>
</tr>
<tr>
<td>nutsedge, purple</td>
<td><em>Cyperus rotundus</em></td>
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</tbody>
</table>

Online with photos at [http://www.ipm.ucanr.edu/PMG/selectnewpest.pistachios.html](http://www.ipm.ucanr.edu/PMG/selectnewpest.pistachios.html)
<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
</tr>
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<tbody>
<tr>
<td>oat, wild</td>
<td><em>Avena fatua</em></td>
</tr>
<tr>
<td>pigweeds</td>
<td><em>Amaranthus spp.</em></td>
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<tr>
<td>pineapple-weed</td>
<td><em>Chamomilla suaveolens</em></td>
</tr>
<tr>
<td>puncturevine</td>
<td><em>Tribulus terrestris</em></td>
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<td>purslane, common</td>
<td><em>Portulaca oleracea</em></td>
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<tr>
<td>radish, wild</td>
<td><em>Raphanus raphanistrum</em></td>
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<td>rocket, London</td>
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<td><em>Lolium multiforum</em></td>
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<td>shepherd's-purse</td>
<td><em>Capsella bursa-pastoris</em></td>
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<tr>
<td>sowthistles</td>
<td><em>Sonchus spp.</em></td>
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<tr>
<td>sprangletops</td>
<td><em>Leptochloa spp.</em></td>
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<td>spurge, spotted</td>
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<tr>
<td>thistle, Russian</td>
<td><em>Salsola tragus</em></td>
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<td>willowerb, panicle-leaf</td>
<td><em>Epilobium brachycarpum</em></td>
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<tr>
<td>witchgrass</td>
<td><em>Panicum capillare</em></td>
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### SUSCEPTIBILITY of SPRING and SUMMER WEEDS in PISTACHIO to HERBICIDE CONTROL 10/14

<table>
<thead>
<tr>
<th>Mode of Action</th>
<th>ANNUAL WEEDS</th>
<th>PREEMERGENCE</th>
<th>POSTEMERGENCE</th>
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<tbody>
<tr>
<td></td>
<td>Grasses</td>
<td>FLM  IND ISO</td>
<td>PEN PEO CLE</td>
</tr>
<tr>
<td>Barnyardgrass</td>
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<td>C P C C P P P</td>
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<tr>
<td>Broadleaves</td>
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<tr>
<td>Cocklebur</td>
<td>— — — N P N —</td>
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<td>Cudweeds</td>
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<td>— N N N N N N</td>
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<td>Evening primrose, Cutleaf</td>
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<td>Fleabane, Hairy</td>
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<td>Goosefoot, Nettleleaf</td>
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<td>Lambsquartets, Common</td>
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<td>Lettuce, Prickly</td>
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<td>Mullein, Turkey</td>
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<td>Nightshades</td>
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<td>Pigweeds</td>
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<tr>
<td>Puncturevine</td>
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<td></td>
</tr>
<tr>
<td>Purslane, Common</td>
<td>C C C C C C C C</td>
<td>N C N C P N C C C</td>
<td></td>
</tr>
<tr>
<td>Sowthistles</td>
<td>C C C P C N N C</td>
<td>N C N C C C C N C</td>
<td></td>
</tr>
<tr>
<td>Spurge, Spotted</td>
<td>— — C C P P P P</td>
<td>N C N C N C C N N</td>
<td></td>
</tr>
<tr>
<td>Thistle, Russian</td>
<td>— C C P P P C P</td>
<td>N P N C N C N C N P</td>
<td></td>
</tr>
<tr>
<td>Willowherb, Panicle-Leaf</td>
<td>C C C P C C P C</td>
<td>N P N P N P C N —</td>
<td></td>
</tr>
<tr>
<td>PERENNIALS</td>
<td>Seedlings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bermudagrass</td>
<td>— — N C P C N</td>
<td>C P C C N C N C N</td>
<td></td>
</tr>
<tr>
<td>Bindweed, Field</td>
<td>— — P P C P P</td>
<td>N C N C N C C N C</td>
<td></td>
</tr>
<tr>
<td>Clovers</td>
<td>C P N N P N C</td>
<td>N P N C N P P N N</td>
<td></td>
</tr>
<tr>
<td>Dallisgrass</td>
<td>— — N C N C N C</td>
<td>C P C C N C N C N</td>
<td></td>
</tr>
<tr>
<td>Dock, Curly</td>
<td>— — C P C C —</td>
<td>N C N C C C C C N C</td>
<td></td>
</tr>
<tr>
<td>Johnsongrass</td>
<td>— — N C P C N</td>
<td>C P C C N C N C N</td>
<td></td>
</tr>
</tbody>
</table>

Online with photos at http://www.ipm.ucanr.edu/PMG/selectnewpest.pistachios.html
### Susceptibility of spring and summer weeds in pistachio to herbicide control

<table>
<thead>
<tr>
<th>Established Perennials</th>
<th>PREEMERGENCE</th>
<th>POSTEMERGENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FLM  IND ISO¹ ORY OXY PEN¹ PEO</td>
<td>CLE¹ DIQ¹ FLU¹ GLY OXY PAR SAF SET¹ 2,4-D</td>
</tr>
<tr>
<td>Mode of Action²</td>
<td>14 29 21 3 14 3 2+14</td>
<td>1 22 1 9 14 22 14 1 4</td>
</tr>
<tr>
<td>Bermudagrass</td>
<td>— N N N N N N</td>
<td>P N P C N P N P N</td>
</tr>
<tr>
<td>Bindweed, Field</td>
<td>N N N P N P N</td>
<td>N P N P N P N N N</td>
</tr>
<tr>
<td>Closers</td>
<td>— P N N N N N</td>
<td>N N N P N N P N N</td>
</tr>
<tr>
<td>Dallisgrass</td>
<td>— N N N N N N</td>
<td>P N P C N N N P N</td>
</tr>
<tr>
<td>Dock, Curly</td>
<td>— ---- N N N N N</td>
<td>N N N P N N N N N</td>
</tr>
<tr>
<td>Johnsongrass</td>
<td>— N N N N P N</td>
<td>P N P C N N N P N</td>
</tr>
<tr>
<td>Nutsedge, Purple</td>
<td>N N N N N N N N</td>
<td>N P N P N P N N N</td>
</tr>
<tr>
<td>Nutsedge, Yellow</td>
<td>P N N N N N N N N</td>
<td>N P N P N P N N N</td>
</tr>
</tbody>
</table>

C = Control  
P = Partial control  
N = No control  
— = No information  

2,4-D = (Orchard Master, etc.)  
CLE = clethodim (Select Max)  
DIQ = diquat (Reglone)  
FLM = flumioxazin (Chateau)  
FLU = fluazifop-p-butyl (Fusilade DX)  
GLY = glyphosate (Roundup PowerMax, Touchdown)  
IND = indaziflam (Alion)  
ISO = isoxaben (Trellis)  

ORY = oryzalin (Surflan, Oryzalin)  
OXY = oxyfluorfen (Goal)  
PAR = paraquat (Gramoxone)  
PEO = penoxsulam + oxyfluorfen (Pindar GT)  
SAF = salflufenacil (Treevix)  
SET = sethoxydim (Poast)  

MOA: 4  
MOA: 1  
MOA: 22  
MOA: 14  
MOA: 9  
MOA: 21  

* Permit required from county agricultural commissioner for purchase or use.

¹ For use in nonbearing orchards only.  
² Group numbers are assigned by the Weed Science Society of America (WSSA) according to different modes of action. Although weeds may exhibit multiple resistance across many groups, mode-of-action numbers are useful in planning mixtures or rotations of herbicides with different modes of action. For more information, see http://www.hracglobal.com.
### SUSCEPTIBILITY of WINTER WEEDS in PISTACHIO to HERBICIDE CONTROL (10/14)

<table>
<thead>
<tr>
<th>Mode of Action²</th>
<th>PREEMERGENCE</th>
<th>POSTEMERGENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FLM</td>
<td>IND</td>
</tr>
<tr>
<td>ANNUAL WEEDS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grasses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barley, Hare</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Bluegrass, Annual</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Bromegrasses</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Oat, Wild</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Ryegrass, Italian</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Broadleaves</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chickweed, Common</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Cudweeds</td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>Chickweed, Common</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Mallow, Little (Cheeseweed)</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Mustards</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Nettle, Burning</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Radish, Wild</td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>Shepherd's- Purse</td>
<td>C</td>
<td>C</td>
</tr>
</tbody>
</table>

C = control    P = partial control    N = no control    — = no information

2,4-D = (Orchard Master, etc.)  MOA: 4
CLE = clethodim (Select Max)  MOA: 1
DIQ = diquat (Reglone)  MOA: 22
FLM = flumioxazin (Chateau)  MOA: 14
FLU = fluazifop-p-butyl (Fusilade DX)  MOA: 1
GLY = glyphosate (Roundup PowerMax, Touchdown)  MOA: 9
IND = indaziflam (Aliion)  MOA: 29
ISO = isoxaben (Trellis)  MOA: 21
ORY = oryzalin (Surflan, Oryzalin)  MOA: 3
PAR = paraquat (Gramoxone)  MOA: 22
PEO = penoxsulam + oxyfluorfen (Pindar GT)  MOA: 2&14
SAF = salflufenacil (Treevix)  MOA: 14
SET = sethoxydim (Poast)  MOA: 1

* Permit required from county agricultural commissioner for purchase or use.
1 For use in nonbearing orchards only.
2 Group numbers are assigned by the Weed Science Society of America (WSSA) according to different modes of action. Although weeds may exhibit multiple resistance across many groups, mode-of-action numbers are useful in planning mixtures or rotations of herbicides with different modes of action. For more information, see http://www.hracglobal.com.
## HERBICIDE TREATMENT TABLE (10/14)

<table>
<thead>
<tr>
<th>Herbicide (example trade name)</th>
<th>Amount per acre</th>
<th>R.E.I.‡ (hours)</th>
<th>P.H.I.‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SITE PREPARATION</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Established weeds</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. GLYPHOSATE (Roundup PowerMax)</td>
<td>0.4–3.3 lb a.e.</td>
<td>4</td>
<td>—</td>
</tr>
<tr>
<td>WSSA MODE-OF-ACTION GROUP NUMBER: 9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Apply to young, actively growing annual weeds or perennial weeds when flowering. Some perennials may require the higher label rate for control. Apply with a ground sprayer with low-pressure, flat fan nozzles or a controlled droplet applicator. Use 10 to 40 gal water/acre with 1 lb a.i./acre for annual weeds. Add ammonium sulfate at 5 to 10 lb/100 gal water to improve control. Application can be made in strips where the trees will be planted into the line of dead weeds. Do not cultivate weeds for 7 to 14 days after treatment to maximize control.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>. . . or . . . (Touchdown)</td>
<td>1–3.75 lb a.e.; 0.8–3 qt</td>
<td>12</td>
<td>—</td>
</tr>
<tr>
<td>COMMENTS: Use 1 lb a.i. when susceptible annual weeds are less than 12 inches tall. For perennial weeds, use 1.5 to 3.75 lb a.i. in 10 to 30 gal water/acre. Use flat fan nozzles at a low pressure, not flood jets. A nonionic surfactant can be added at 0.25% volume by volume.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. PARAQUAT* (Gramoxone)</td>
<td>0.3–0.9 lb a.i.</td>
<td>12</td>
<td>—</td>
</tr>
<tr>
<td>WSSA MODE-OF-ACTION GROUP NUMBER: 22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Use in 20 to 60 gal water/acre when weeds are in the seedling stage with good cover of the weed foliage. Add a non-ionic surfactant at 0.5% volume by volume. Repeated applications will be required as new growth occurs.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>AFTER PLANTING</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Before weeds emerge</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. FLUMIOXAZIN (Chateau)</td>
<td>6–12 oz</td>
<td>12</td>
<td>60</td>
</tr>
<tr>
<td>WSSA MODE-OF-ACTION GROUP NUMBER: 14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: For use in bearing and nonbearing orchards. Helps provide preemergence control of annual grasses, horseweed, heavy fleabane, and other annual broadleaves. Apply as a directed spray, avoiding contact with young wood or foliage. Rainfall or irrigation of 1/4 inch needed within 21 to 28 days after treatment for activation. Can be tank-mixed with other preemergence herbicides for broader weed control and with contact herbicides for burndown of weeds already present. Residual period: 1 month for each 2 oz/acre product used.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. INDAZIFLAM (Alion)</td>
<td>0.065–0.085 lb a.i.</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>WSSA MODE-OF-ACTION GROUP NUMBER: 29</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Registered for use in bearing and nonbearing orchards established at least 3 years. Applied in 10 to 30 gal water/acre. Requires rainfall or irrigation within 21 days following treatment. Can be mixed with other preemergence herbicides for broader weed control. For tank mixes, observe all directions for use on all labels, and employ the most restrictive limits and precautions. Never exceed the maximum a.i. on any label when tank mixing products that contain the same a.i. Residual period: 5 to 8 months.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. ISOXABEN (Trellis)</td>
<td>0.5–1 lb a.i.</td>
<td>12</td>
<td>60</td>
</tr>
<tr>
<td>WSSA MODE-OF-ACTION GROUP NUMBER: 21</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: For use in bearing and nonbearing orchards. It controls broadleaf weeds only. If annual grasses are expected, mix with another effective herbicide. Rainfall or irrigation of at least 1/2 inch should occur within 21 days of treatment to activate herbicide. Apply in at least 10 gal water/acre. Residual period: 4 to 6 months</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Online with photos at http://www.ipm.ucanr.edu/PMG/selectnewpest.pistachios.html
### Herbicide Treatment Table

#### After weeds emerge

<table>
<thead>
<tr>
<th>Herbicide (example trade name)</th>
<th>Amount per acre</th>
<th>R.E.I.‡ (hours)</th>
<th>P.H.I.‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>D. ORYZALIN</strong> (Surflan)</td>
<td>2.4–6 lb a.i.</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td><strong>E. OXYFLUORFEN</strong> (Goal)</td>
<td>1.2–1.5 lb a.i.</td>
<td>24</td>
<td>See comments</td>
</tr>
<tr>
<td><strong>F. PENDIMETHALIN</strong> (Prowl H20)</td>
<td>3.8–5.985 lb a.i.</td>
<td>24</td>
<td>60</td>
</tr>
<tr>
<td><strong>G. PENOXISULAM + OXYFLUORFEN</strong> (Pindar GT)</td>
<td>0.016–0.031 lb a.i. (penoxisulam) + 0.74–1.47 lb a.i. (oxyfluorfen)</td>
<td>24</td>
<td>60</td>
</tr>
<tr>
<td><strong>H. RIMSULFURON</strong> (Matrix FNV)</td>
<td>0.031–0.063 lb a.i.</td>
<td>4</td>
<td>14</td>
</tr>
</tbody>
</table>

**Coments:** For use in bearing and nonbearing orchards. Apply in 20 to 40 gal water/acre to soil that is relatively clean of leaves and other debris. If rainfall of 1/2 to 1 inch does not occur within 21 days of treatment, sprinkle irrigate with 1/2 to 2 inches of water. Often mixed with oxyfluorfen. Mix with a postemergence herbicide if weeds are present. For tank mixes, observe all directions for use on all labels, and employ the most restrictive limits and precautions. Never exceed the maximum a.i. on any label when tank mixing products that contain the same a.i. Usually used at 4 lb a.i. For longer residual control, apply at 6 lb a.i., especially in high rainfall years. Chemigation is allowed: see label for instructions. Residual period: 4 to 10 months.

**Coments:** Registered for use in orchards established at least 9 months. Apply in 10 to 30 gal water/acre. Requires rainfall or irrigation within 14 days following treatment. Can be mixed with other preemergence herbicides for broader weed control. For tank mixes, observe all directions for use on all labels, and employ the most restrictive limits and precautions. Never exceed the maximum a.i. on any label when tank mixing products that contain the same a.i. Residual period: 5 to 8 months. Certain oxyfluorfen formulations emit high amounts of volatile organic compounds (VOCs); use low-VOC formulations of oxyfluorfen.

**Coments:** Registered for use in orchards established at least 1 year. Apply in 20 to 40 gal water/acre. Requires rainfall or irrigation within 21 days following treatment. Can be mixed with other preemergence herbicides for broader weed control. For tank mixes, observe all directions for use on all labels, and employ the most restrictive limits and precautions. Never exceed the maximum a.i. on any label when tank mixing products that contain the same a.i. Residual period: 5 to 8 months.

**Coments:** Registered for use in orchards established at least 9 months. Apply in 10 to 30 gal water/acre. Requires rainfall or irrigation within 14 days following treatment. Can be mixed with other preemergence herbicides for broader weed control. For tank mixes, observe all directions for use on all labels, and employ the most restrictive limits and precautions. Never exceed the maximum a.i. on any label when tank mixing products that contain the same a.i. Residual period: 5 to 8 months.

**Coments:** Registered for use in orchards established at least 1 year. Apply in 20 to 40 gal water/acre. Requires rainfall or irrigation within 21 days following treatment. Can be mixed with other preemergence herbicides for broader weed control. For tank mixes, observe all directions for use on all labels, and employ the most restrictive limits and precautions. Never exceed the maximum a.i. on any label when tank mixing products that contain the same a.i. Residual period: 5 to 8 months.

**Coments:** Registered for use in orchards established at least 9 months. Apply in 10 to 30 gal water/acre. Requires rainfall or irrigation within 14 days following treatment. Can be mixed with other preemergence herbicides for broader weed control. For tank mixes, observe all directions for use on all labels, and employ the most restrictive limits and precautions. Never exceed the maximum a.i. on any label when tank mixing products that contain the same a.i. Residual period: 5 to 8 months.

**Coments:** Registered for use in orchards established at least 1 year. Apply in 20 to 40 gal water/acre. Requires rainfall or irrigation within 21 days following treatment. Can be mixed with other preemergence herbicides for broader weed control. For tank mixes, observe all directions for use on all labels, and employ the most restrictive limits and precautions. Never exceed the maximum a.i. on any label when tank mixing products that contain the same a.i. Residual period: 5 to 8 months.

**Coments:** Registered for use in orchards established at least 9 months. Apply in 10 to 30 gal water/acre. Requires rainfall or irrigation within 14 days following treatment. Can be mixed with other preemergence herbicides for broader weed control. For tank mixes, observe all directions for use on all labels, and employ the most restrictive limits and precautions. Never exceed the maximum a.i. on any label when tank mixing products that contain the same a.i. Residual period: 5 to 8 months.

**Coments:** Registered for use in orchards established at least 1 year. Apply in 20 to 40 gal water/acre. Requires rainfall or irrigation within 21 days following treatment. Can be mixed with other preemergence herbicides for broader weed control. For tank mixes, observe all directions for use on all labels, and employ the most restrictive limits and precautions. Never exceed the maximum a.i. on any label when tank mixing products that contain the same a.i. Residual period: 5 to 8 months.

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**Coments:** Registered for use in orchards established at least 1 year. Apply in 20 to 40 gal water/acre. Requires rainfall or irrigation within 21 days following treatment. Can be mixed with other preemergence herbicides for broader weed control. For tank mixes, observe all directions for use on all labels, and employ the most restrictive limits and precautions. Never exceed the maximum a.i. on any label when tank mixing products that contain the same a.i. Residual period: 5 to 8 months.

**Coments:** Registered for use in orchards established at least 9 months. Apply in 10 to 30 gal water/acre. Requires rainfall or irrigation within 14 days following treatment. Can be mixed with other preemergence herbicides for broader weed control. For tank mixes, observe all directions for use on all labels, and employ the most restrictive limits and precautions. Never exceed the maximum a.i. on any label when tank mixing products that contain the same a.i. Residual period: 5 to 8 months.

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**Coments:** Registered for use in orchards established at least 9 months. Apply in 10 to 30 gal water/acre. Requires rainfall or irrigation within 14 days following treatment. Can be mixed with other preemergence herbicides for broader weed control. For tank mixes, observe all directions for use on all labels, and employ the most restrictive limits and precautions. Never exceed the maximum a.i. on any label when tank mixing products that contain the same a.i. Residual period: 5 to 8 months.

**Coments:** Registered for use in orchards established at least 1 year. Apply in 20 to 40 gal water/acre. Requires rainfall or irrigation within 21 days following treatment. Can be mixed with other preemergence herbicides for broader weed control. For tank mixes, observe all directions for use on all labels, and employ the most restrictive limits and precautions. Never exceed the maximum a.i. on any label when tank mixing products that contain the same a.i. Residual period: 5 to 8 months.

After weeds emerge

<table>
<thead>
<tr>
<th>Herbicide (example trade name)</th>
<th>Amount per acre</th>
<th>R.E.I.‡ (hours)</th>
<th>P.H.I.‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. CARFENTRAZONE</strong> (Shark EW)</td>
<td>0.03 lb a.i.</td>
<td>12</td>
<td>3</td>
</tr>
</tbody>
</table>

**Coments:** For use in bearing and nonbearing orchards. Selective on small, vigorously growing broadleaf weeds. Applications made under windy conditions, or when trees are in bloom can result in tree injury. Add a surfactant to the tank per label recommendations. A spray volume of 20 to 40 gallons water/acre is needed to thoroughly wet the weed foliage. Ensure the sprayer is thoroughly cleaned following treatment per label recommendations.

Online with photos at http://www.ipm.ucanr.edu/PMG/selectnewpest.pistachios.html
<table>
<thead>
<tr>
<th>Herbicide (example trade name)</th>
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<th>R.E.I.‡ (hours)</th>
<th>P.H.I.‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. CLETHODIM (Select Max)</td>
<td>0.09–0.12 lb a.i.</td>
<td>24</td>
<td>365</td>
</tr>
<tr>
<td><strong>COMMENTS:</strong> For use in nonbearing orchards only. For selective control of annual grasses that are actively growing, before tillering, and not stressed for moisture. Repeated applications needed on perennial grasses when their growth meets label requirements. A crop oil concentrate (1% volume by volume) or nonionic surfactant (0.25% volume by volume) must be added. Use in 20 to 40 gallons water/acre.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. DIQUAT (Reglone)</td>
<td>0.375–0.5 lb a.i.</td>
<td>24</td>
<td>365</td>
</tr>
<tr>
<td><strong>COMMENTS:</strong> For use in nonbearing orchards only. Add a nonionic surfactant at 0.25% volume by volume. Apply in 20 to 60 gallons water/acre. Apply when weeds are less than 4 inches tall. Control is improved during warm, dry weather.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. FLUAZIFOP-P-BUTYL (Fusilade DX)</td>
<td>0.25–0.375 lb a.i.</td>
<td>12</td>
<td>—</td>
</tr>
<tr>
<td><strong>COMMENTS:</strong> For use in nonbearing orchards only. For selective control of annual grasses that are actively growing, before tillering, and not stressed for moisture. Repeated applications needed on perennial grasses when their growth meets label requirements. A crop oil concentrate (1% volume by volume) or nonionic surfactant (0.25% volume by volume) must be added. Apply in 20 to 40 gallons water/acre; thorough coverage is important.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. GLUFOSINATE (Rely 280)</td>
<td>1–1.75 lb a.i.</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td><strong>COMMENTS:</strong> For use in bearing and nonbearing orchards. Nonselective on small, vigorously growing annual broadleaf and grass weeds. Adding sprayable ammonium sulfate at 17 lb/100 gallons water may improve control. A spray volume of 20 to 40 gallons water/acre is needed to thoroughly wet the weed foliage. Ensure the sprayer is thoroughly cleaned following treatment per label recommendations.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F. GLYPHOSATE (Roundup PowerMax, etc.)</td>
<td>0.4–3.3 lb a.e.</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td><strong>COMMENTS:</strong> For use in bearing and nonbearing orchards. Apply to young, actively growing annual weeds or perennial weeds when flowering. Some perennials may require the higher label rate for control. Apply with a ground sprayer with low-pressure, flat fan nozzles or a controlled droplet applicator. For annual weed control, use 1 lb a.i. in 10 to 40 gallons water/acre. Adding sprayable ammonium sulfate at 17 lb/100 gallons water may improve control. Avoid drift onto green bark and foliage, or injury will result. To maximize control, do not cultivate weeds for 7 to 14 days after treatment. Can be mixed with low rates of oxyfluorfen or other postemergence herbicides for broader weed control. For tank mixes, observe all directions for use on all labels, and employ the most restrictive limits and precautions. Never exceed the maximum a.i. on any label when tank mixing products that contain the same a.i. If glyphosate-resistant weeds are present, consider other effective products. . . or . . . (Touchdown)</td>
<td>0.4–3.3 qt</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td><strong>COMMENTS:</strong> Use 1 lb a.i. when susceptible annual weeds are less than 12 inches tall. For perennial weeds, use 1.375 to 4 lb a.i. in 10 to 30 gallons water per acre. Use flat fan nozzles at a low pressure, not flood jets. A nonionic surfactant can be added at to 0.25% volume by volume. Avoid drift onto green bark and foliage or injury will result.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G. OXYFLUORFEN (Goal)</td>
<td>0.5–1 lb a.i.</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td><strong>COMMENTS:</strong> For use in bearing and nonbearing orchards. Dormant application to young (4-leaf stage) weeds. May be combined with other postemergence herbicides for specific weeds. Can be applied in-season following bloom. Apply between May and 7 days before harvest. Certain oxyfluorfen formulations emit high amounts of volatile organic compounds (VOCs); use low-VOC formulations of oxyfluorfen.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H. PARAQUAT* (Gramoxone)</td>
<td>0.3–0.9 lb a.i.</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td><strong>COMMENTS:</strong> For use in bearing and nonbearing orchards. May be combined with other postemergence herbicides for specific weeds. Can be applied in-season following bloom. Apply between May and 7 days before harvest. Certain oxyfluorfen formulations emit high amounts of volatile organic compounds (VOCs); use low-VOC formulations of oxyfluorfen.</td>
<td>1.2–3.6 pt</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>Herbicide (example trade name)</td>
<td>Amount per acre</td>
<td>R.E.I.‡ (hours)</td>
<td>P.H.I.‡ (days)</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-----------------</td>
<td>----------------</td>
<td>---------------</td>
</tr>
<tr>
<td><strong>COMMENTS:</strong> For use in bearing and nonbearing orchards.**</td>
<td><strong>For use in bearing and nonbearing orchards.</strong></td>
<td><strong>Selective on small, vigorously growing annual broadleaf weeds.</strong></td>
<td><strong>Selective on small, vigorously growing annual broadleaf weeds.</strong></td>
</tr>
<tr>
<td>I. PYRAFLUFEN-ETHYL (Venue)</td>
<td>0.000925–0.0053 lb a.i.</td>
<td>12</td>
<td>Prebloom</td>
</tr>
<tr>
<td>WSSA MODE-OF-ACTION GROUP NUMBER: 14</td>
<td><strong>COMMENTS:</strong> For use in bearing and nonbearing orchards before bloom.**</td>
<td><strong>Selective on small, vigorously growing annual broadleaf weeds.</strong></td>
<td><strong>Selective on small, vigorously growing annual broadleaf weeds.</strong></td>
</tr>
<tr>
<td>J. SAFLUFENACIL (Treevix)</td>
<td>0.04375 lb a.i.</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>WSSA MODE-OF-ACTION GROUP NUMBER: 14</td>
<td><strong>COMMENTS:</strong> For use in bearing and nonbearing orchards.**</td>
<td><strong>Selective on small, vigorously growing annual broadleaf weeds.</strong></td>
<td><strong>Selective on small, vigorously growing annual broadleaf weeds.</strong></td>
</tr>
<tr>
<td>K. SETHOXYDIM (Poast)</td>
<td>0.28–0.468 lb a.i.</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>WSSA MODE-OF-ACTION GROUP NUMBER: 1</td>
<td><strong>COMMENTS:</strong> For use in bearing and nonbearing orchards.**</td>
<td><strong>Selective on small, vigorously growing annual broadleaf weeds.</strong></td>
<td><strong>Selective on small, vigorously growing annual broadleaf weeds.</strong></td>
</tr>
<tr>
<td>L. 2,4-D AMINE* (Orchard Master, etc.)</td>
<td>1–1.4 lb a.e.</td>
<td>48</td>
<td>60</td>
</tr>
<tr>
<td>WSSA MODE-OF-ACTION GROUP NUMBER: 4</td>
<td><strong>COMMENTS:</strong> For use in bearing and nonbearing orchards that have been established for at least 1 year.**</td>
<td><strong>Selective on small, vigorously growing annual broadleaf weeds.</strong></td>
<td><strong>Selective on small, vigorously growing annual broadleaf weeds.</strong></td>
</tr>
</tbody>
</table>

1. Group numbers are assigned by the Weed Science Society of America (WSSA) according to different modes of action. Although weeds may exhibit multiple resistance across many groups, mode of action numbers are useful in planning mixtures or rotations of herbicides with different modes of action. For more information, see http://www.hracglobal.com.

* Permit required from county agricultural commissioner for purchase or use.

‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) is the number of days from treatment to harvest. In some cases the R.E.I. exceeds the P.H.I. The longer of two intervals is the minimum time that must elapse before harvest.

— Not applicable.
Vertebrates

MANAGING VERTEBRATES (7/16)

Bird and mammal pests are found in and around virtually every cropping system in the state, although they may not always present a significant problem. In some crops, damage caused by birds generally results in a loss of a portion of the current crop but does not decrease future yield potential. Some pests, however, can cause major problems by feeding on fruit and tree bark, shoots, and roots, which can stunt growth or kill plants. Injury to trees by rodents or rabbits, for example, is often serious, killing the tree outright or causing permanent damage that lowers yields for years following the initial feeding.

Some pests will chew or destroy flexible irrigation lines and emitters. Other pests will dig holes through the soil surface, thereby channeling surface irrigation water to undesired areas. Food safety also becomes an issue if pest residues come into contact with the marketable commodity.

Manage your fields in order to keep pest numbers low and to discourage new invasions so that significant damage does not occur.

- Before planting, remove vertebrate pests and destroy habitats (such as burrows) within the field boundaries. Preventive measures cost less and are more successful before planting, when one can easily see the pests or their habitats.
- Be aware of the location, as vertebrate pests can easily reinvade if the field is adjacent to rangeland, waterways, or unmanaged areas. It is much easier to manage vertebrate pests by implementing controls on the perimeter versus inside.
- Baiting, fencing, fumigating burrows, shooting, and trapping are easier and usually more effective if employed before you plant instead of after.
- Where feasible, deep plow and disc to destroy burrows, disperse or kill resident populations, and reduce the risk of reinvasion by pocket gophers, voles, and (to a lesser extent) ground squirrels.

Guidelines for reducing vertebrate pest problems and making control more economical:

- Correctly identify the species causing the problem using damage signs, burrows or habitat, tracks, feces, etc.
- If feasible, alter the habitat to make the area less favorable to the pest species (e.g., eliminate cover crops and weeds or keep them mowed low.)
- Take early action and use the control methods appropriate for the crop and time of year. Consider the environment and nontarget species when choosing a control method.
- Establish a monitoring system to detect reinfestation so you can determine when additional corrective measures or controls are necessary.

A successful pest management program requires good records and regular monitoring. Some vertebrate pest populations can easily "explode" because of high reproductive rates and abundant food. Keep a record of the management procedures you use and their effectiveness. Good records will help you plan and improve future control strategies.

For most vertebrate pests, there is more than one control option for reducing numbers and damage. The following table summarizes the various control measures appropriate for common vertebrate pests. Details on how to use these controls are given in the individual pest sections.
### Control Measures

<table>
<thead>
<tr>
<th>Pest</th>
<th>Habitat modification</th>
<th>Trapping</th>
<th>Baiting</th>
<th>Fencing</th>
<th>Tree guards</th>
<th>Frightening</th>
<th>Shooting</th>
<th>Fumigating</th>
<th>Repellents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deer</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X(^1)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eastern fox squirrel</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>California ground squirrel</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pocket gophers</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rabbits</td>
<td>X(^2)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rats</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voles</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coyote</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wild pig</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birds(^3)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. During hunting season or with a permit.
2. Cottontails are relatively easy to trap. Jackrabbits are difficult to trap, but trapping may be useful.
3. Not all of these techniques will be effective for all species. More specific information can be found in the bird section.

Adapted from Salmon and Lickliter 1984. Wildlife Pest Control Around Gardens and Homes. UC ANR Publication 21385.

Vertebrate control equipment and supplies (baits, fumigants, propane explorers, traps, etc.) are available at local retail outlets such as farm supply and hardware stores. In addition, some county agricultural commissioner’s offices make certain rodenticides and fumigants available to growers. For further information or sources of special control materials, consult your local Cooperative Extension advisor or agricultural commissioner’s office.

**Legal aspects of vertebrate pest management**

Under the California Fish and Game Code, if California ground squirrels, meadow voles, pocket gophers, eastern fox squirrels, roof rats, black-tailed jackrabbits, cottontail rabbits, American crows, house sparrows, starlings, and yellow-billed magpies are causing or are anticipated to cause crop depredation, the owner or tenant of a property may use lethal methods to remove them at any time.

For other pests such as deer, wild pigs, western gray squirrels, and most bird species, depredation permits are required for removal. However, these regulations can change at any time, so it is always a good idea to check current California Fish and Game Code (http://leginfo.legislature.ca.gov/faces/codes.xhtml) to ensure removal of a particular species is legal.

**Pesticides**

Only pesticides that are registered with the California Department of Pesticide Regulation (DPR) can legally be used for vertebrate pest control. Registered materials are listed in DPR’s databases that are available online (http://www.cdpr.ca.gov/). You may also contact your county agricultural commissioner for current product registrations and the latest information on legal pesticide use, including current information on restrictions that apply to pest control activities in order to protect endangered species. *Follow label directions carefully* and understand the hazards when using poison baits and fumigants.

The U.S. Environmental Protection Agency (EPA) has placed restrictions on most rodenticides used to control vertebrates in agricultural production. The applicator must have a permit to purchase and use the product. These products will be identified with an asterisk (*).
Trapping
Trapping is often used to control vertebrate pests. Mark all traps clearly with the owner’s name and contact address or phone number. In California, trapping mammals, even for pest purposes, requires a trapping license issued by the California Department of Fish and Wildlife. However, rats, mice, moles, voles, and pocket gophers do not have this requirement. Additionally, you do not need a trapping license for ground squirrels or rabbits if trapping on your own property for pest control purposes. However, if trapping either of these species for profit (e.g., pest control operator), a trapping license is required.

Protected species
In some areas of California, crop fields are located within the range of federally- and state-protected threatened or endangered species. Species likely to be of concern include the San Joaquin kit fox, several species of kangaroo rats, and, where burrow fumigants are used, the blunt-nosed leopard lizard, California red-legged frog, and California tiger salamander.

Typical guidelines
Special guidelines apply to the use of toxic baits and fumigants for vertebrate pest control in these areas. These include

- Modification of ground squirrel bait stations to exclude protected species
- Restrict broadcast applications of bait
- Prohibit fumigation at certain locations or during some times of the year
- Require that applications be supervised by someone trained to avoid harming endangered species

Your county agricultural commissioner has the latest detailed maps that show the ranges of endangered species and the latest information on restrictions that apply to pest control activities in those areas. You can also get more information on endangered species regulations from the DPR website (http://www.cdpr.ca.gov/docs/endspec/).

For more information on vertebrate management, see the Vertebrate Pest Control Handbook online (http://vpcrac.org/about/vertebrate-pest-handbook/).
**BIRDS (7/16)**

Common Name: Scientific Name:
Crow: *Corvus brachyrhynchos*
Crowned sparrow: *Zonotrichia* spp.
European starling: *Sturnus vulgaris*
House finch: *Carpodacus mexicanus*
Scrub-jay: *Aphelocoma californica*
Yellow-billed magpie: *Pica nuttalli*

**DESCRIPTION OF THE PEST**

Several bird species may cause serious problems in pistachio production in California.

**Crow**
The crow is chunky, black, 17 to 21 inches long with a thick, black bill and feet. They are easy to recognize by their loud *caw caw caw* sound. Crows are gregarious and often feed in large numbers, moving from orchard to orchard.

California Fish and Wildlife regulations allow crows to be taken only by landowners or tenants, or by persons authorized in writing by such landowners or tenants, when crows are committing or about to commit depredations (damage to crops).

**European starling**
Starlings are dark colored birds with light speckling on the feathers. They are about 7.5 to 8.5 inches long with a short tail. They have a long, slender yellow bill in summer and a dark one during the winter. Starlings have a wide habitat range but prefer areas with trees. If their excrement or droppings contact the fruit, it will cause unsightly blemishes and may transmit diseases.

Starlings are an invasive, exotic species and can be lethally removed at any time.

**House finch**
House finches are highly adapted to human environments. House finches are typically 5 to 6 inches long and feed in small flocks. Male finches have a rosy-red or orange head, rump, and breast with brownish wings and back, and a brown streak on their sides. Females have the brown body and wings, but lack the red or orange coloration.

House finches are migratory, nongame birds, and can only be lethally removed with a depredation permit from the U.S. Fish and Wildlife Service or under supervision of the local county agricultural commissioner.

**Magpie**
Yellow-billed magpies are noisy birds, 16 to 20 inches long. Adults have bold, distinct markings; they are mostly black with white stripes and a white belly. Their black wings and tails have a metallic blue green iridescent hue. The bill and the skin around the eyes are yellow. They feed in small flocks of a few birds to several dozen. They may be abundant locally.

A federal permit is not required to control magpies when they are found committing or about to commit depredations (damage to crops). However, you should always consult with state and local authorities before taking magpies as legal mandates can change.

**Scrub-jay**
Scrub-jays are aggressive birds, 10 to 12 inches long, and are distinguished by their crestless head, olive-gray back, and white throat with a blue outline. Their head, tail, and wings are blue. Scrub-jays are usually solitary birds but occasionally feed in pairs. Where jay habitat is adjacent
to an orchard, however, several dozen may invade the trees daily, forming almost continuous lines moving to and from trees.

Scrub-jays are classed as a migratory nongame bird and may only be removed under permit from the U.S. Fish and Wildlife Service.

**Sparrow**
White-crowned and golden-crowned sparrows cause damage in California. Both are about 6 to 7 inches long. White-crowned sparrows have a distinct pink or yellowish bill, erect posture, gray throat and breast, and a visible crown streaked with black and white. Their call is a clear whistle. Golden-crowned sparrows are similar, except they have no white head stripes. A golden-yellow central crown stripe is prominent with black borders. Their call is three to five clear whistles. Overall, golden-crowned sparrows are less numerous and cause fewer problems than white-crowned sparrows.

Crowned sparrows are migratory, nongame birds, and can only be lethally removed with a depredation permit from the U.S. Fish and Wildlife Service or under supervision of the local county agricultural commissioner.

**DAMAGE**
**Tree fruit (except citrus) and nut crops**
Several bird species including scrub-jays, magpies, sparrows, house finches, crows, and starlings may cause substantial damage by feeding on ripening fruit or developing nuts. In general, scrub-jays and magpies feed in smaller numbers. However, they can congregate in larger flocks when orchards are found adjacent to perennial, thick vegetation. Crows and starlings typically fly in larger flocks. Bird species that congregate in large flocks are more difficult to control.

Sparrows and house finches can also damage fruit buds during the dormant season. Bird damage usually is most severe in areas that are adjacent to wild or brushy areas or power line poles where birds find refuge, breeding sites, and other sources of food. This damage will often go undetected until the trees are in full bloom unless the trees are observed closely during bud break or the birds are caught in the act. This leads to loss of fruit production and can be the most significant form of bird damage for some growers.

**MANAGEMENT**
**Biological Control**
Natural predators such as raptors and bobcats will feed on some of the smaller bird species, although these numbers mean little for controlling such bird pests.

**Cultural Control**
**Habitat modification**
Always consider habitat modification as a first step for controlling bird pests.
- Look for and eliminate brush or pruning piles, stacks of irrigation pipes, piles of boxes, etc., where birds may rest and nest.
- Consider removing roosting trees along perimeters to reduce bird invasion into fields.

However, there are few situations when habitat modification can be used to control high bird numbers. As such, alternative control methods will likely be needed.

**Monitoring and Treatment Decisions**
Count birds weekly to help you determine when damage will occur so you can take action early. This is particularly important to reduce damage to fruiting buds and newly sprouted row crops.
1. Watch for bird movement into or within the field.
2. Keep track of species, numbers, and location if you have had substantial damage in the past.
3. As fruit begins to ripen or as the nuts develop, look for fruit or nuts that are damaged or that have been knocked from the tree or vine. These records will help you plan control strategies in advance and assess the effectiveness of previous control actions.

**Frightening devices**

Frightening devices can deter some species (e.g., crowned sparrows, crows, magpies, starlings), but are less effective for others (e.g., house finches, scrub-jays).

The most effective way to frighten birds from a field is to use a combination of noisemakers and visual repellents such as mylar streamers and "scare-eye" balloons. For example, scare-eye balloons may be attached to trees or posts that are next to electronic distress call devices. This combination may increase effectiveness over using either approach by itself. For maximum effectiveness, rotate from one type of frightening device to another and do not use one combination of devices for more than a week; otherwise, birds will become used to it.

Common noisemakers include roving patrols of bird bombs and shell crackers. Stationary devices such as gas cannons and electronic distress calls also provide relief. These stationary devices are most effective when you have at least 1 device per 5 acres and when they are elevated above the canopy.

Regardless of the approach used, pay attention to bird responses when using frightening devices. When birds no longer respond negatively to a specific approach, you must switch to a different frightening tactic to continue to scare birds out of the field. At best, an appropriate rotation of frightening devices will control bird pests for a few weeks. Therefore, only use these scare-tactics when needed to prevent birds from habituating to these auditory and visual repellents. Additionally, once birds become accustomed to feeding in a field, frightening tactics become much less effective. Therefore, have frightening devices ready to implement before damage occurs so that birds can be deterred right at the onset of damage.

**Shooting**

Birds that invade orchards in small numbers, such as scrub-jays and magpies, can often be controlled by shooting. Check with California Department of Fish and Wildlife, U.S. Fish and Wildlife Service, and county agricultural commissioner officials before shooting any birds as depredation permits are often needed.

Where permissible, occasionally shooting at a few birds will increase the effectiveness of your noisemaking techniques, especially if noise makers go off at the same times as the actual shots, because birds will begin associating loud noises with the real hazards of firearms.

**Trapping**

Trapping can be an effective way to control house finches, crowned sparrows, and starlings, especially if conducted over a relatively large area such as several orchards or vineyards. The most effective trap for these species is the modified Australian crow trap.

Successful trapping must take into account the behavior patterns of the birds being controlled. These traps use live birds as decoys to attract additional birds. Therefore, place traps in suitable locations with adequate food, water, shade, and roost locations to keep the trapped birds alive.

Trapping is best carried out by someone experienced with the technique. For house finches and crowned sparrows, trapping must be conducted under supervision of the county agricultural commissioner.

Trapped birds are usually euthanized through the use of a CO₂ chamber. Leave some birds alive to serve as future decoys.
CALIFORNIA GROUND SQUIRRELS (7/16)

Scientific Name: *Otospermophilus beecheyi* and *O. douglasii*

DESCRIPTION OF THE PEST

The adult California ground squirrel:

- Head and body 9 to 11 inches long
- Somewhat bushy tail is about as long as its body
- Fur is mottled dark and light brown or gray

Ground squirrels live in colonies that may grow very large if left uncontrolled. They are active during the cooler times on hot days and sunny periods during the cooler months; they are usually most active in morning and late afternoon. In periods of high winds, ground squirrels retreat to their burrows.

California ground squirrels live in underground burrows and form colonies of 2 to 20 or more animals. Each ground squirrel burrow system can have several openings with scattered soil in front. Individual ground squirrel burrows may be 5 to 30 feet long, 2.5 to 4 feet below the surface, and about 4 to 6 inches in diameter. Burrows provide the ground squirrels a place to retreat, sleep, hibernate, rear their young, and store food. Ground squirrels often dig their burrows along ditches and fencerows around buildings, within and bordering many agricultural crops, and on other uncultivated land. They tend to avoid flood irrigated areas, thick chaparral, dense woods, very moist areas, and lands that are under complete and frequent cultivation. They will travel 100 yards or more to feed in adjacent crops. When uncontrolled, they frequently move into perennial crops, such as orchards and vineyards, and dig burrows beneath the trees or vines.

The California ground squirrel can be active throughout the year in coastal areas of Southern California. Ground squirrels in the southern San Joaquin Valley become much less active during the winter, but seldom truly hibernate. Especially in hot locations, adult ground squirrels become temporarily dormant (estivate) when food is scarce or temperatures are extreme, primarily in late summer. Winter hibernation and summer estivation are more typical among ground squirrels in inland areas where temperature variations are more extreme. Regardless of location, young ground squirrels tend to be active all summer.

Ground squirrels that do hibernate generally emerge around January when weather begins to warm. In late winter and spring, they feed on green vegetation but switch to seeds and fruit in late spring and early summer as the vegetation dries up. Females have one litter, averaging 8 young, in spring. Young ground squirrels emerge from their burrow when about 6 weeks old; they do not estivate their first summer, and many may not hibernate during their first winter.

DAMAGE

California ground squirrels are responsible for major damage throughout the state. Their damage is most prevalent in crops adjacent to uncultivated areas where ground squirrels are not controlled.

- They easily climb trees and vines and feed on fruit and nuts from set to maturity and through harvest. Adult ground squirrels often cache seeds and nuts in their burrows, especially in the late summer and early fall. During this period, crop losses greatly exceed the amount the ground squirrels have consumed. Ground squirrels also consume vegetative crops (e.g., alfalfa, cole crops, and lettuce) and berries.
- Ground squirrels also gnaw fruit and bark, girdle trunks and scaffold limbs, and are capable of girdling and killing trees or vines in a relatively short time.
- In addition to above ground damage, they can damage roots, enabling fungal pathogens to infect trees.
- They often chew plastic irrigation lines, and their burrows can contribute to soil erosion.
- When digging burrows, ground squirrels bring soil and rock to the surface and deposit it in mounds near burrow openings. They enlarge burrow systems each year by constructing new tunnels and creating more entrances, so the longer the ground squirrels occupy the burrow,
the more extensive it becomes. They create more entrances to serve a growing population. Large and numerous burrow openings and soil mounds are hard on equipment and can make mechanical harvesting especially difficult.

- The burrows of ground squirrels can divert irrigation water and have been known to cause severe damage to levees and other water retention systems.
- In some areas, ground squirrels can also pose a health risk to humans through the spread of sylvatic plague.

MANAGEMENT

The management action needed for ground squirrels depends on their activity pattern and feeding preferences during the time of year when action is taken. The choice of tactics is also influenced by the location of the infestation and number of ground squirrels present. For more detailed information on managing ground squirrels, see Ground Squirrel Best Management Practices (available online at http://www.groundsquirrelbmp.com/management-cgs.html).

Biological Control

Predators such as coyotes and hawks are usually not sufficient to effectively control ground squirrels. These predators consume a number of ground squirrels, but usually not enough to keep populations at sufficiently low numbers to eliminate the need for additional control measures.

Cultural Control

Habitat modification

Ground squirrels often burrow beneath long-standing piles of prunings, wood, or rock, or use them as harborage. Removing such piles may make the area somewhat less desirable to them, but the base of trees, fence lines, and ditch banks still offer burrowing sites. Peripheral cleanup may somewhat reduce the potential for ground squirrels. In addition, it makes burrow detection and monitoring easier and improves access to burrows during control operations. Ground squirrels are extremely adaptable so habitat modification has limited benefit in a management program. Squirrels may quickly reinvade abandoned burrow systems. Deep plowing (ripping) along field perimeters will destroy burrow entrances and will help slow the rate of invasion. Burrow fumigants, toxic baits, and traps currently are the most effective control methods.

Monitoring and Treatment Decisions

To make it easier to monitor and help reduce numbers, remove brush piles, debris, and stumps in and around the crop fields. Monitor for ground squirrels year round, even in winter, especially during midmorning when they feed most actively. Monitor within the crop field during routine activities. Mid morning is usually the best time of day to observe squirrel activity.

To monitor:

1. Observe feeding grounds and watch for other signs of activity especially the appearance of burrows.
2. Check the perimeter of the crop fields at least once a month during the times of year when ground squirrels are active.
3. Periodically monitor areas from which ground squirrels are likely to invade, such as along ditch or road banks or in crops adjacent to your field.

Keep records and use them as the basis for future management decisions, noting:

- When ground squirrels emerge from hibernation
- When the first young are seen above ground
- Approximate number of ground squirrels you see and the location and number of burrows
- Changes in the general number of ground squirrels
- Management actions implemented, dates of use, and their effect
Treatment options

When even one or two ground squirrels are present in or immediately adjacent to the crop field, be prepared to take action. Treatment options for ground squirrels include the use of fumigants (e.g., gas cartridges, aluminum phosphide,* and carbon monoxide-producing devices) and baiting with multiple-dose anticoagulants (e.g., chlorophacinone* and diphacinone*) or zinc phosphide*. These are restricted-use pesticides that require a permit from the county agricultural commissioner for purchase or use.

Select the control method best suited for the time of year.

- The most effective time to control ground squirrels is in late winter or early spring when adults have emerged from their burrows but before they reproduce. For best control, use burrow fumigation about 2 to 3 weeks after the first ground squirrels emerge from hibernation.
- Because ground squirrels feed almost exclusively on green vegetation early in the season, poisoned grain baits are generally not effective until late spring or early summer.
- Trapping can be used year round but is most effective when numbers are low.
- In late spring or summer, at locations where squirrels are moving from adjacent lands into the crop field to feed, baiting or trapping along the perimeter offers the most effective control if access to the neighboring property is not possible.

Fumigants

Fumigation can be very effective against ground squirrels. The best time to fumigate is late winter or early spring when the ground squirrels are active and soil is moist. Fumigation is also possible later in the year as long as sufficient soil moisture is present, although it is not effective when ground squirrels are hibernating or estivating; at those times, they seal themselves off from within their burrows. When the soil is dry, fumigation is much less effective because more of the toxic gas escapes from burrows through cracks in the soil.

When using a fumigant, make sure to treat all active burrow systems in and around the crop field. Recheck all areas a few days after fumigation and re-treat any that have been reopened. For safety’s sake, do not fumigate burrow systems that are adjacent to buildings or may open under structures.

A relatively easy way to fumigate is with the use of gas cartridges. They are available commercially and from some county agricultural commissioners’ offices. Use one or two cartridges for each burrow that shows signs of activity. A large burrow system may require more than two.

1. Quickly shove the ignited cartridge into the burrow using a shovel handle or stick and seal the burrow entrance with soil.
2. Watch nearby burrow entrances; treat and seal any that begin to leak smoke.
3. If smoke is observed escaping from other entrances, it means the burrows are connected. If the burrow is believed to be small, this additional entrance only needs to be sealed. If the burrow appears to be large, an additional cartridge may need to be inserted following the above-outlined protocol.

The larger and more complex the burrow system, the more smoke it takes to be effective.

Aluminum phosphide* is also a highly effective burrow fumigant. In fact, studies of this material for ground squirrel management indicate an efficacy of 95 to 100%. When aluminum phosphide* tablets come into contact with moist soil and air in the burrow they produce phosphine gas, which is highly toxic to any animal (never add water directly to the burrow to increase moisture as spontaneous combustion can occur if the product contacts water). When using aluminum phosphide*, treat every active burrow, fill the entrance with a wad of newspaper, and cover with soil. In addition to being somewhat more effective than gas cartridges, aluminum phosphide* is also much cheaper to apply. However, aluminum phosphide* is a highly restricted-use material, and these restrictions are frequently changing. Be
Sure to understand the current restrictions in place before using for ground squirrel control. Application personnel should be trained in the material’s proper use and on its potential hazards.

As of 1 January 2012, pressurized exhaust machines can now be used to apply carbon monoxide to burrow systems. As of 2014, the author is aware of two commercial products available: the Pressurized Exhaust Rodent Controller (PERC®) machine and the Cheetah rodent control machine. Initial research into the efficacy of these devices has indicated that the PERC® is moderately effective for California ground squirrels, although results were highly variable. The Cheetah rodent control machine did not prove to be effective. Plans are in place to further test these devices in the future.

**Baiting**

Poison bait is usually the most cost-effective method for controlling ground squirrels, especially when numbers are high. Bait consists of grain or pellets treated with a poison registered for ground squirrel control. To be effective, bait must be used at a time of year when ground squirrels are feeding on seeds and will readily accept baits such as in late spring or early summer. In fall, ground squirrels store a lot of the seed instead of eating them, so it may require more bait to control the population.

Before you use baits, place a small amount of untreated grain, such as breakfast oats, near burrows in the morning and check in the late afternoon to see if the ground squirrels have taken it (this ensures that nocturnal animals have not eaten the grain). If the grain is taken during the day, proceed with baiting. If it is not taken, wait several days or a week and try again. Remember: bait is only effective if eaten by the target pest. In a nut orchard, once squirrels begin feeding on nuts, they no longer show much interest in grain baits. Therefore, baiting programs must be initiated before this time to ensure effective control of ground squirrels. When using poison baits, make sure to follow label directions carefully to reduce hazards to nontarget species.

Multiple-dose anticoagulant baits (e.g., chlorophacinone* and diphacinone*) can be applied in bait stations, as spot treatments near burrows, or broadcast over larger infested areas. Check the label to make sure that the bait you plan to use is registered for the method you intend to use. For a multiple-dose bait to be effective, animals must feed on it over a period of 3 to 5 days so if spot or broadcast treatments are used, 2 or 3 applications may be necessary.

Zinc phosphide* is an acute toxicant that can also be used to control ground squirrels. It kills ground squirrels after a single feeding, so it can reduce numbers more quickly than anticoagulants. However, zinc phosphide* has a distinctive odor and taste that many ground squirrels seem to avoid. Likewise, ground squirrels will occasionally consume a sublethal dose of zinc phosphide* that will cause individuals to get sick but will not kill them. This leads to bait shyness in a ground squirrel population. These problems with bait acceptance and bait shyness sometimes result in greater control of ground squirrels when using anticoagulant baits. Pre-baiting the area with untreated grain 2 to 3 days prior to the application of zinc phosphide* may reduce the chances of bait shyness and improve the effectiveness of baiting programs. Control with zinc phosphide* is usually achieved within 48 hours of the bait application.

**Baits applied as broadcast or spot treatments**

When specified on the label, zinc phosphide* and anticoagulant baits* can be applied as spot-treatments, which are economical and effective for small populations. Reapply according to label directions to make sure there is no interruption in exposure to the bait. Scattering the bait takes advantage of the ground squirrels’ natural foraging behavior and minimizes risks to nontarget species that are not as effective at foraging for seeds. Never pile the bait on the ground because piles increase the hazard to livestock and certain nontarget wildlife.

When ground squirrel populations are larger or cover a broader area, broadcast applications of zinc phosphide* or anticoagulants* may be used. This can be an effective and economical method for controlling this species over a large area. Usually squirrels retreat back to burrows when sick and will die there, although up to 20 to 30% of ground squirrels may die aboveground.
Baits applied in bait stations
Various kinds of bait stations are commonly used with diphacinone* and chlorophacinone* 0.005% baits; all are designed to let ground squirrels in but to exclude larger animals. Special types of stations must be used within the ranges of the San Joaquin kit fox or endangered kangaroo rats to ensure that these species are excluded. Consult your local agricultural commissioner or the California Department of Pesticide Regulation website (http://www.cdpr.ca.gov/docs/endspec/) for the latest recommendations on use of poison baits in areas that are within the range of endangered species.

1. Place bait stations near runways or burrows and secure them so they cannot easily be tipped over. If ground squirrels are moving into the crop field from adjacent areas, place bait stations along the perimeter of the field where ground squirrels are invading, one station every 100 feet. Use shorter intervals between stations when the number of ground squirrels is high.

2. Check bait stations daily at first, then as often as needed to keep the bait replenished. If bait feeding is interrupted, the bait's effectiveness will be greatly decreased. Make sure to pick up any bait that spills and to replace bait that is wet or moldy. Successful baiting usually requires 2 to 4 weeks. Continue to supply bait until feeding ceases and you observe no ground squirrels; then remove and properly dispose of unused bait if there is not a threat on continued reinvasion.

3. Zinc phosphide* cannot be used in bait stations.

After treatment, pick up and dispose of any carcasses whenever possible to prevent secondary poisoning of dogs or other scavengers. Burial is a good method for disposal as long as the carcasses are buried deep enough to discourage scavengers. Do not touch dead animals with bare hands.

Assess the potential hazard to humans, livestock, and nontarget wildlife before you use baits; if it is risky, use another method for ground squirrel control.

Trapping
Because trapping is time-consuming, it is most practical for small infestations any time of year when ground squirrels are active. Trapping is especially effective from mid-spring through fall. Ground squirrel traps include Conibear traps and modified gopher box traps. As with all traps, take precautions to minimize trapping of nontarget wildlife and pets.

Conibear traps
Conibear kill traps are usually placed unbaited in the burrow entrance, where ground squirrels are trapped as they pass through. Trap effectiveness can be increased by putting a tunnel of roofing paper (24 inches long) at the entrance of the burrow. The ground squirrel will mistake the light at the end of the tunnel for the burrow opening and run full speed through the trap. The tunnel also minimizes any sun reflection off the metal trap.

If you are using this type of trap within the range of the San Joaquin kit fox, you must place the trap in a covered box with an entrance no larger than 3 inches wide to exclude the fox, or you must spring the traps at dusk and reset them again in the morning.

Box traps
Modified wooden pocket gopher box traps consist of a pair of box traps that have been joined together by removing the backs, connecting the two traps with wire mesh, and then to a board. Another very effective trap is a single wooden box trap. The single wooden box trap (Critter GetterDK-3) is larger than the pocket gopher box trap (DK-2) and has a pull trigger rather than the push type for pocket gophers. The traps are baited with foods such as almonds, barley, melon rinds, oats, or walnuts. Place bait in traps well behind the trigger or tied to the trigger without setting the traps for several days, until the ground squirrels become used to taking the bait. Then
put in fresh bait and set the traps. With the single pull trap, secure the bait to the trigger and wire the trap to a stake, fence, or other stationary object. Place traps so that nontarget animals are not likely to be caught. For example, place traps inside a larger box with openings no larger than 3 inches wide, just large enough to allow ground squirrels to enter.

**Live traps**

Live-traps, such as wire-cage and multiple-capture traps, can also be used to capture ground squirrels. The Black Fox repeating live trap has proven to be very effective in catching several individuals at one time. This 24” x 24” x 4” heavy gauge wire trap has doors that are wired open for several days for pre-baiting. When the self-closing doors are dropped down after pre-baiting, the ground squirrel pushes to get in but cannot get out. As with box traps, pistachios, almonds, walnuts, oats, barley, and many fruits and vegetables are all effective baits. Because these traps keep ground squirrels alive after capture, they are useful in areas where nontarget captures are a concern (e.g., areas with pets, children, etc.). However, ground squirrels must be euthanized by the trapper upon capture as translocation of ground squirrels is illegal unless in possession of a permit issued by the California Department of Fish and Wildlife, unloads your problem on others, and can spread disease such as sylvatic plague. It is this extra step that limits the utility of live-trapping for some growers. Methods considered humane by the American Veterinary Medical Association include: gassing with carbon dioxide and shooting. Drowning is not an approved method of euthanasia and is illegal in California. Traps need to be checked once daily, and any animals found must be removed and should be euthanized.

**Gas explosive device**

The use of a gas explosive device that combines propane with oxygen has been used to kill ground squirrels through concussive force. This device has the added benefit of destroying part or all of the ground squirrel’s burrow system, thereby potentially slowing reinvasion rates. This control method carries with it a substantial fire hazard. To date no scientific studies have shown this method to be overly effective at ground squirrel control.

**Repellents**

No repellents have proven effective at substantially reducing damage caused by ground squirrels.

**Frightening devices**

No frightening devices have proven effective at substantially reducing damage caused by ground squirrels.

* User must be a certified applicator or be under the supervision of someone who is. Some products also require a permit from the county agricultural commissioner for purchase or use.
POCKET GOPHER (7/16)

Scientific Name: Thomomys spp.

DESCRIPTION OF THE PEST
Pocket gophers are stout-bodied rodents with short legs. Adults:
- 6 to 8 inches long
- brown, gray, or yellowish
- large clawed front paws
- small ears and eyes
- a short, scantly haired tail

On each side of the mouth pocket gophers have external cheek pouches or “pockets” used extensively for carrying food.

Pocket gophers are rarely seen above ground. They live almost entirely underground spending most of their time in a tunnel system they construct 6 to 12 inches beneath the soil surface. A single burrow system can cover several hundred square feet and consists of main tunnels with lateral branches used for feeding or for pushing excavated soil to the surface. Because gophers are extremely territorial, you rarely find more than one gopher per burrow system, unless it is during the breeding season or females are tending their young.

The conspicuous, fan-shaped soil mounds over tunnel openings are the most obvious sign of a gopher infestation. These tunnel openings are almost always closed with a soil plug unless the gopher is actively excavating a tunnel.

Gophers feed primarily on the roots of herbaceous plants. They may also come aboveground to clip small plants within a few inches of the tunnel opening and pull vegetation into the burrow to eat.

Gophers breed throughout the year on irrigated land, with a peak in late winter or early spring. Females bear as many as three litters each year, although typically only one or two per year, each averaging five young. Once weaned, the young gophers travel to a favorable location to establish their own burrow system. Some take over previously vacated burrows. The buildup of gophers in crop fields is favored by extensive weed growth, including nutsedge, or the presence of many cover crops, especially perennial clovers and legumes.

DAMAGE
Pocket gophers can be serious pests. They are active throughout the year and if uncontrolled and food is plentiful, can increase to 30 to 40 gophers per acre.

While herbaceous cover crops are their preferred food, pocket gophers also feed on the bark of tree crowns and roots, particularly when cover crops or weeds dry up. Bark consumption may be extensive enough to girdle and kill young vines or trees or reduce the vigor of older vines or trees. Usually gophers feed on trees from underground so the damage may not be evident until they show signs of stress. Pocket gophers also feed on the roots of vegetable and berry plants. Plants with more fibrous root systems often suffer minimal damage; plants with large taproots are most susceptible. Gophers sometimes gnaw on plastic irrigation lines. These holes lead to uneven water distribution, with some areas receiving too much water, and other parts not receiving any. Fixing pocket gopher punctures of subsurface drip tape can be time-consuming and quite expensive. Tunnel systems often lead to a loss or diversion of irrigation water and may lead to severe erosion.

MANAGEMENT
Persistent efforts can control pocket gophers and even eliminate them. Pocket gopher damage typically occurs belowground; therefore, it often goes undetected until individual plants or trees exhibit stress. By that time the tree or plant may be beyond saving. Gopher activity is readily
Gophers make the greatest numbers of fresh mounds in the spring and fall, when the soil is amply moist.

Take action as soon as you see any sign of gopher activity. Common control methods include trapping, aluminum phosphide* fumigation, or hand-applied poison bait. Trapping and hand-baiting can be used at any time of year, but they are easier when the soil is moist and not dry and hard; aluminum phosphide* must be used when the soil is moist. Control of vegetative cover can reduce the attractiveness of fields to gophers by removing preferred food sources (e.g., nutsedge, clovers, and legumes). In addition, consider managing gophers in adjacent areas to reduce the potential for gopher reinvasion.

Gopher control is best done in late fall through late winter when mounding activity is high. Additionally, because numbers are usually lowest during early winter, management during this time of year can be more effective than after gophers have reproduced.

**Biological Control**
Snakes, owls, and hawks are usually not sufficient to effectively control gophers. These predators consume a number of gophers but usually not enough to keep populations at low enough numbers to eliminate the need for additional control measures.

**Cultural Control**

*Flood irrigation*
If flood irrigation is possible, it can help control gophers; they are not aquatic. This type of irrigation often drives gopher activity to the edges of the field where they are more easily located to control, if not killed by flooding. Growers and their dogs can also actively seek out voles at this time to further reduce population size.

*Tilling*
When taking a field out of production, deep tilling of soil will kill some gophers and destroy most or all burrow systems in a field. This can slow reinvasion rates and provides more time to get gopher populations under control.

**Monitoring and Treatment Decisions**
The best times to monitor for gopher activity are after irrigation and when mound building peaks in fall and spring.
- Monitor monthly.
- Pay close attention to field perimeters to determine whether gophers are invading the field from adjacent property.
- Monitor closely in weedy areas such as roadsides and in young orchards with extensive weed growth or ground cover. This type of vegetation is more likely to support gophers, and low-growing vegetation makes signs of burrowing activity more difficult to see.
- Look for darker-colored mounds, which indicate newly removed, moister soil.
- If you find mounds, trees or vines showing signs of stress, or both, look for girdling of roots or crowns at or below the soil.

**Treatment options**
The preferred control methods are baiting with multiple-dose anticoagulants, strychnine* or zinc phosphide*; trapping; and burrow fumigation. Neither chemical nor mechanical repellents have been found effective against pocket gophers. Remove vegetative cover and preferred food sources (e.g., clovers and legumes) to reduce the attractiveness of cover crops in orchards and vineyards to gophers. Often, a single approach is not sufficient to effectively control gophers. An integrated approach that uses more than one control option should provide greater control.

Strychnine*, zinc phosphide*, anticoagulants*, and aluminum phosphide* are currently restricted materials that require a permit from the county agricultural commissioner for purchase or use in agricultural fields. Be aware that restrictions for use of baits and fumigants around buildings may exist. However, restriction criteria of baits and fumigants often change, so it is best to consult...
your local agricultural commissioner before using any baits or fumigants to assure full compliance with current laws and regulations.

All treatment options require access to the main tunnel, located about 6 to 12 inches belowground. Finding the main tunnel takes practice, skill, and the use of a probing device. To find a main tunnel:
1. Locate a fresh gopher mound. The key is to look for mounds that contain moist dirt.
2. Start by finding the plug of the mound.
3. Begin probing anywhere from 4 to 12 inches behind this plug.
4. You will know you have found the tunnel when you feel a drop in the probe (i.e., less resistance) of a couple of inches. Tunnels typically run in only one or two directions. Occasionally you will have tunnels running in three or more directions.

**Baiting**

While multi-dose anticoagulants (e.g., chlorophacinone* and diphacinone*) are available for gopher control, single-dose acute baits (e.g., strychnine* and zinc phosphide*) have historically been the most effective.

Gophers often back-fill old tunnels with loose soil and these backfilled tunnels can feel like open tunnels to inexperienced bait applicators. Applying bait in these backfilled tunnels will greatly limit the efficacy of this management approach; gophers will not find bait placed here.

Before initiating a baiting program, train all bait applicators to identify backfilled tunnel systems. An effective way to conduct this training is to:
1. Have novice bait applicators probe for open (non-back-filled) tunnel systems.
2. Once they have found a tunnel, they dig down into these tunnel systems to verify whether they are open or backfilled.
3. Repeat until the bait applicator successfully identifies open tunnel systems with at least 90% accuracy.

Following these methods should result in consistently more efficacious control efforts when using baits and burrow fumigants.

Apply bait below ground. For small infestations or where the use of a mechanical burrow builder is not feasible, use a probe to find the main tunnel next to a fresh mound or between two fresh mounds. Once you find the main tunnel,
1. Enlarge the probe opening by rotating the probe back-and-forth
2. Place a small amount of grain or pelletized bait in the burrow; a funnel can also be used to pour the bait into the tunnel.
3. Place a dirt clod, stone, or another covering over the hole to keep out light and prevent soil from falling onto the bait.

Place bait in two or three places along the tunnel. This hand-application method can be used for single-dose or multiple-dose baits.

If gophers have infested a large area, reservoir-type hand probes designed to deposit single-dose baits are available. Bait application is faster with these devices because they eliminate the need to stop and place the bait by hand. Once you have located a tunnel using the probe, a trigger releases a measured amount of bait into the tunnel. It is important to check the probe periodically to make sure that is has not been clogged with soil. Generally, strychnine* or zinc phosphide* bait is used with such an applicator because it can dispense only a small quantity of bait at a time. Anticoagulant* baits are less toxic and require greater volumes of bait to be effective, thereby limiting the utility of bait probes for these baits.

A mechanical burrow builder can also be effective and economical for infestations that cover large areas. This device is pulled behind a tractor to construct artificial gopher tunnels into which it places bait. Artificial burrows either intercept some of the gopher’s natural burrows, or the gopher will soon discover the artificial burrow and consume the bait. Prior to using this
application device, it is important to know the average depth of active pocket gopher burrows before setting up the burrow builder. Use a probe to find burrows and a shovel to verify they are active (open). After starting the application, use a shovel to occasionally open a small section of the artificial burrow and inspect its depth and condition. It is also important that the compaction drive wheels properly compact the soil over the burrow. Soil moisture is important, as tunnels created in dry soil will cave in, while tunnels created in wet soil may not form properly. Soil moisture must be intermediate to produce a well-formed, smooth, artificial burrow. Follow the manufacturer’s manual to properly set the depth and calibration of bait application. All baits used in burrow builders are restricted-use materials. Use of a mechanical burrow builder may be feasible in situations such as unplanted borders or between widely spaced young trees when the terrain is relatively level and the soil is not too rocky or before planting a field. However, because the burrow builder creates an extensive network of burrows, only use it when gopher numbers are high as these new burrows will increase the speed with which gophers can invade new areas.

**Trapping**

Traps are effective against small numbers of gophers but are labor intensive. As such, they can be relatively expensive to use over large acreage. However, trapping often results in greater control of gophers than baiting, so the cost may be offset by effectiveness. Use either pincher traps (most common) or box-type kill traps. The smaller size and lower cost of pincer traps typically makes them a more practical choice in a field setting. Pincher traps such as the Macabee, Cinch, or Gophinator have a vertical metal or wire pan which the gopher triggers by pushing against it. Studies have shown the Gophinator and Cinch traps to be more effective than other tested traps.

Pincher-type traps can be placed in the main tunnel of a gopher burrow system or in lateral tunnels. Setting traps in lateral tunnels is quicker and easier than trapping in the main tunnel. However, trapping in lateral tunnels may be less effective at certain times of the year (e.g., summer) and for more experienced gophers (e.g., adult males).

To place traps in the main tunnel find a fresh mound and probe as described in the Treatment Decisions section. When found, clear out the tunnel until the opening is just wide enough to insert the traps. Place traps in the main tunnel, one facing each direction the tunnel goes.

1. Set traps and place them entirely into the tunnels. The number of traps required will depend on the number of tunnels present.
2. Stake the traps by fastening wire, light cable, or twine to the trap and stake to prevent predators from carrying away traps with catches. Stakes also serve as markers to indicate trap location.
3. You can cover up the trap-hole with sod, plywood, canvas, or some other material to keep light from entering the tunnel system. However, a recent study has shown that covering trap-holes has only a minor effect on capture success. When trapping a large area, leave trap-holes uncovered to save substantial time; however covering trap-holes may keep children and pets out of traps, if this is a concern.
4. If there is no evidence that a gopher has visited the trap within 24 hours, move it to a new location.

To place traps in lateral tunnels, remove the plug from a fresh mound and place the trap entirely into the lateral tunnel. In many areas, the plugs in these lateral tunnels are quite extensive; in these situations, trapping laterals becomes counterproductive given the extensive period of time required to remove these plugs.

**Fumigants**

Most fumigants, such as gas cartridges, are not effective because gophers quickly seal off their tunnels when they detect the smoke or poison gases. However, aluminum phosphide* can be effective if applied underground into tunnels during a time of year when soil is moist enough to retain the toxic gas, typically in late winter to early spring, or year round in irrigated crops. In fact, burrow fumigation with aluminum phosphide* is typically the most consistently efficacious option for gopher control as long as sufficient soil moisture is present.

(7/16) Pocket Gophers

Online with photos at http://www.ipm.ucanr.edu/PMG/selectnewpest.pistachios.html
Application of aluminum phosphide* is similar to hand-baiting.
1. Use a probe to locate the main tunnel.
2. Once the tunnel has been found, wiggle the probe to enlarge the hole large enough to dispense the aluminum phosphide* tablets into the tunnel.
3. Follow label instructions on the number of tablets to place into the tunnel.
4. Cover the probe hole with a rock or dirt clod, being careful not to bury the tablets under loose dirt.
5. Treat each tunnel system twice.

When using aluminum phosphide*, be sure to carefully follow all label directions and safety instructions.

As of 1 January 2012, the use of pressurized-exhaust machines that inject carbon monoxide into burrow systems has become a legal technique for controlling burrowing mammals in California. The California Department of Pesticide Regulation is now developing regulations for use of this method of control. This approach appears to be somewhat effective at controlling pocket gophers, although early studies have not shown it to be as effective as burrow fumigation with aluminum phosphide* or trapping.

**Gas explosive device**
The use of a gas explosive device that combines propane with oxygen has been used to kill gophers through a concussive force. This device has the added benefit of destroying part or all of the gopher's tunnel system, potentially slowing reinvasion rates. Exercise caution when using these devices because of the potential for unintended damage to property, injury to users and bystanders, potential for starting fires in dry environments, and destruction of turf. Additionally, these devices can be quite loud, making them unsuitable in residential areas. Studies on the efficacy of this device have not been positive. Alternative options such as burrow fumigation, trapping, and baiting appear to be more effective.

**Repellents**
No scientific data has been reported to show that chemical repellents effectively keep gophers from inhabiting fields, orchards, or vineyards. A new repellent for use in subsurface drip tape has been developed that may offer some promise although it has yet to be sufficiently tested to verify efficacy.

**Frightening devices**
Frightening gophers with sound or vibrations also does not appear to be effective.

* User must be a certified applicator or be under the supervision of someone who is. Some products also require a permit from the county agricultural commissioner for purchase or use.
RABBITS (7/16)

Scientific Names: Black-tailed Jackrabbit: *Lepus californicus*  
Cottontail and Brush Rabbits: *Sylvilagus* spp.

DESCRIPTION OF THE PEST

Although jackrabbits are the most common of the rabbit-type pests, they are technically classified as a hare. Jackrabbits:
- About the size of a large house cat
- Very long ears
- Short front legs
- Long hind legs

Jackrabbits live in open areas of the Central Valley, coastal valleys, and foothills and are active all year from early evening to early morning. They are seldom found in dense brush or woodlands. A good sign that jackrabbits are present is their coarse, circular fecal droppings or pellets found scattered over an area.

They make a depression underneath bushes or other vegetation where they remain secluded during the day. Jackrabbits breed from early spring to late summer.

Females may produce more than one litter a year, especially where irrigated crops are available. The average litter contains four pups, which are born fully haired, open eyed, and become active within a few hours.

Cottontail and brush rabbits are smaller than jackrabbits and have shorter ears. They nest where thick shrubs, woods, or rocks and debris provide dense cover. Their young are born naked and blind and stay in the nest for several weeks.

Rabbits are active all year. Jackrabbits frequently damage crops bordering open areas, such as grassy fields and rangeland. Cottontail and brush rabbits prefer crops near brushy habitats, ravines, riparian areas, and woodlands favored by these species.

What rabbits eat is variable depending on location and the availability of appropriate plants. They prefer succulent green vegetation; grasses and herbaceous plants typically make up the bulk of their diet. Feeding usually begins during the evening hours and continues throughout the night into the early morning. Rabbits do not need to drink water.

If food and other necessary resources are found in one place, rabbits will stay in the area. If food and areas for shelter are separated, they will move between these areas in the morning and evening. Daily travel by jackrabbits of 1 to 2 miles round trip between these areas can occur. These travels are habitually made on the same trails every day, producing noticeable paths through herbaceous vegetation.

DAMAGE

Jackrabbits, cottontails, and brush rabbits may damage young trees and vines. Rabbits may chew and remove bark and clip off branches within their reach to eat buds and young foliage. Trunk girdling is usually higher on the trunk than damage caused by meadow voles. The damage appears as vertical lines or grooves in the bark. Rabbits usually do not present a serious problem for older trees and vines. Rabbits may also gnaw on drip irrigation lines. They often live outside of orchards, vineyards, and crop fields, moving in to feed from early evening to early morning. They damage plants primarily in winter and early spring, when other sources of food are limited.

Jackrabbits can carry tularemia, otherwise known as rabbit fever. This disease is relatively rare in humans but can be contracted by handling an infected rabbit with bare hands or by eating insufficiently cooked rabbit meat. Do not handle rabbits with bare hands.

Online with photos at http://www.ipm.ucanr.edu/PMG/selectnewpest.pistachios.html
MANAGEMENT
Rabbits are active all year but damage trees and vines primarily in winter and early spring when other sources of food are limited. Manage rabbits before severe damage occurs. Common control methods for rabbits include fencing, trunk guards, repellants, baiting, trapping, and shooting depending on the species and crop. Unfortunately, habitat control and trapping are not typically effective for jackrabbits given their ability to cover great distances between forage and shelter locations. The choice of control method should depend on the urgency of the problem and the situation.

Biological Control
Predators such as coyotes and hawks are usually not sufficient to effectively control rabbits. Although these predators consume a number of rabbits, it is usually not adequate to keep populations low enough to eliminate the need for additional control measures.

Cultural Control
Fencing
Rabbit-proof fencing prevents damage to young fields, orchards, or vineyards.
1. Make the fence at least 3 feet tall using woven wire or poultry netting with a mesh diameter of 1 inch or less.
2. Bend the bottom 6 inches of mesh at a 90-degree angle and bury it 6 inches deep, facing away from the area to be protected, to keep rabbits from digging under the fence.
If you are building a fence to exclude deer, and rabbits are a potential problem, it is a good idea to add rabbit-proof fencing along the bottom. Unless you are already building a deer fence, the cost of a rabbit fence may be prohibitive for a large orchard or vineyard when you are only going to need it for a few years. Individual tree guards are a good alternative, particularly if damage to vines and trees is focused on the perimeters of orchards and vineyards.

Tree Guards
Tree guards are useful when planting new orchards or vineyards or replanting trees or vines in established areas. Cylinders made from wire mesh or some hard plastics provide the best protection against rabbits. Cardboard or heavy paper can also be used, but rabbits may chew through these.
1. Make the cylinders at least 2.5 feet tall to keep jackrabbits from reaching foliage and limbs by standing on their hind legs.
2. Secure the tree guards with stakes or wooden spreaders.
Use smaller-mesh wire and bury the bottom few inches of the cylinder if you also need protection against voles.

Habitat modification
Rabbits often invade from adjacent fields, but unless the land is under the grower’s direct management, habitat modification of the outlying habitat is usually impractical. The removal of preferred foods such as cover crops and weeds may reduce the number of rabbits that visit the crop and make them easier to detect. However, removal of vegetative cover may temporarily increase damage as the desired crop would be the only food source left for rabbits. Therefore, except for removal of old prunings and brush piles, habitat modification to reduce damage is rarely practical.

Monitoring and Treatment Decisions
Rabbits often breed, bear young, and live outside fields, orchards, and vineyards. They move in to feed at night so you may not see them during daylight hours. Therefore, monitor in the early morning, late evening, or at night (using a spotlight):

- Inspect young trees and vines periodically for feeding on bark to catch a problem early.
- Look for clipping of small, low branches and leaves as tree breaks dormancy.
If you find damage:

- Look for droppings and tracks that indicate rabbits may be the cause. Voles also chew the bark from the trunk, but the bark damage caused by rabbits extends higher on the tree and the tooth marks are distinctly larger.
- Monitor the perimeters in early morning or late evening to see where rabbits are entering and to get an idea of how many are involved.
- Estimate the number of jackrabbits at night by using a spotlight and looking for "eye shine."

**Baiting**

Poison baits may be practical for controlling large numbers of rabbits in large areas. Before baiting, consult the county agricultural commissioner for restrictions related to endangered species. Follow label directions carefully.

Only multiple-dose anticoagulant baits (i.e., chlorophacinone and diphacinone) are registered for use against rabbits. These baits are available from many county agricultural commissioners’ offices. All field-use anticoagulant baits are now restricted use materials; you will need to be certified to use these baits for rabbit control. They come in grain formulations that may be used along field edges, but not within the field itself.

Multiple-dose baits for rabbit control must be placed in bait stations specifically designed for rabbits.

1. Place bait stations containing bait near trails and secure them so they cannot easily be tipped over.
2. Use as many stations as necessary to ensure that all rabbits have easy access to bait, spacing them 50 to 200 feet apart along the perimeter where rabbits are entering the field.
3. Inspect the bait stations every morning for the first several days to keep bait supplies replenished; it may take this long before the rabbits become accustomed to feeding at the stations. Increase either the amount of bait in the stations or the number of stations if all the bait is consumed in a single night.
4. Replace any bait that becomes wet or moldy.
5. Continue baiting until feeding ceases and you no longer observe any rabbits.

It usually takes 2 to 4 weeks or more before results are seen with multiple-dose baits.

Bait should be covered or removed during daylight hours to prevent consumption by diurnal seed-eating birds. Make sure to take precautions to prevent domestic animals and wildlife from having access to the bait. Dispose of unused bait properly at the end of the baiting program. When baiting for rabbits, you should remove all aboveground carcasses by burying them underground, or by bagging and disposing them in the trash. This will reduce potential secondary poisoning hazards.

**Shooting**

Shooting, applying repellents, and trapping may provide effective control for low numbers of rabbits or may be used to temporarily reduce damage until other measures such as fences or tree guards are installed.

- When low numbers of rabbits are present and causing damage, shooting can be an effective control if shooting is allowed in your area. If only a small number is involved, shooting may be all that is necessary to prevent significant damage while crops are susceptible. For best results, patrol systematically in the early morning or at dusk.
- Keep in mind that lead ammunition is being phased out across the state. Additional information on this lead ban can be found at Department of Fish and Game website https://www.wildlife.ca.gov/hunting/nonlead-ammunition.
Repellents
Repellents are occasionally effective at deterring rabbit damage to some crops, particularly orchard and vine crops. However, no effective rabbit repellents are available for use in most vegetable and forage crops. To apply repellents in orchard and vineyard crops, spray or brush the repellent on trunks during the dormant season or on foliage or trunks during the growing season. Labels specify the proper application method, rate, and timing. Repeat applications as needed to protect new growth and to replenish any repellent that is washed off by rain or sprinkler irrigation. Effectiveness of repellents often is dependent on availability of alternative food sources. If additional food sources are abundant, repellents sprayed on target plants may be effective. If additional food sources are scarce, repellents may have little effect.

Trapping
Trapping generally is ineffective against jackrabbits because they do not readily enter traps. Box-type traps, especially the Critter Getter DK-3 baited with apple slices or dried apricots, can provide effective control of cottontails or brush rabbits when populations are small. Pre-baiting with a small amount of bait has been found to improve results.

* User must be a certified applicator or be under the supervision of someone who is. Some products also require a permit from the county agricultural commissioner for purchase or use.
VOLES (MEADOW VOLE, MEADOW MICE)  
Scientific Name: *Microtus* spp.

DESCRIPTION OF THE PEST

Voles are also called meadow mice. Adults:

- Larger than house mice but smaller than rats
- Blunt-nosed stocky rodents
- Full grown length is 4 to 6 inches
- Small ears and eyes
- Short legs
- Short tails
- Coarse fur is usually dark gray or grayish brown

Compared to deer mice, voles have a more robust body, less obvious ears, and a relatively shorter tail. Vole ears are at least partly obscured by the hair in front of them and their tails are about one-half to one-quarter the length of their head and body combined. Deer mice have relatively large and prominent, fleshy ears, white belly and feet, and their tail is bi-colored and more than 70% the length of their head and body.

Voles live in colonies and are active both day and night, all year round. Females bear 5 to 10 litters per year, with peaks of reproduction in spring and fall. Because voles mature rapidly and bear multiple litters yearly, numbers can increase quickly reaching as high as hundreds of voles per acre. In many areas, populations peak every 4 to 8 years, and then decline fairly rapidly. Voles live in areas such as irrigated pastures, fencerows, or weedy ditchbanks, where the soil is suitable for burrowing and where vegetation provides cover. Grasses and other dense ground cover provide food and shelter that favor the buildup of vole populations. They usually avoid sandy soils. The soil of the Tulelake Basin of Northern California is a location that is highly favorable for voles.

You can recognize vole activity by the narrow runways in grass or other ground cover, connecting numerous shallow burrows with openings about 1-1/2 inches in diameter. Voles seldom travel far from their burrows and runways, usually less than 10 feet (3 m) from the nest. Droppings are about 0.18 inch (4.5 mm) long and greenish when fresh, turning brown or gray with exposure to the environment. Sometimes fresh leaves or other cuttings are found in these trails.

Five species of voles, genus *Microtus*, occur in California. The most widespread species in the state is the California vole (*Microtus californicus*), which occurs in the Central Valley and throughout the length of the coast range. In potatoes, most damage occurs in the Klamath Basin, where the montane vole (*M. montanus*) is found.

DAMAGE

In orchards and vineyards

Voles can cause severe damage in orchards and vineyards by feeding on bark. Characteristic damage is complete or partial girdling of trunks from just below the soil line to usually no more than 5 inches high. In rare situations, voles climb higher on young trees or vines.

In addition to bark, voles also feed around the root crown, and sometimes chew holes in irrigation lines. Young trees or vines are more readily fed upon and most susceptible to being completely girdled and killed by voles. Large trees or vines can be damaged, but this is uncommon and rarely ends in death. For instance, after severe pruning, sufficient light penetrates the canopy for vegetation to grow near trunks, providing cover and food for voles. Voles live in areas where grass or other permanent vegetative cover remains year-round. Orchards or vineyards that have cover crops or those in which grass and herbaceous plants are left to grow next to trunks are most susceptible to damage.

MANAGEMENT

The best management programs for voles keep numbers at low levels; once vole numbers reach high levels, control becomes much more difficult and costly. Vegetation management and the proper use of exclusion keep damage to a minimum. Poisonous bait (either multiple-dose anticoagulants* or zinc phosphide*) can control voles that reach harmful numbers. All field-use rodenticides for voles are restricted use materials that require the
applicator to be a private or commercial certified applicator or to be under the supervision of a certified applicator. Some require a permit from the county agricultural commissioner for purchase or use.

**Biological Control**

Predators such as coyotes, foxes, badgers, weasels, owls, and hawks feed on meadow voles; however, predation is rarely, if ever, a major factor in controlling a rapidly increasing vole population.

**Cultural Control**

**Habitat Management**

Cultural practices can significantly affect meadow vole numbers. Because voles travel only a few feet from their burrows to obtain food, any destruction of vegetation will make the area less favorable to them and results in burrow abandonment and/or mortality. Physically removing vegetation, using herbicides or other methods to keep an area about 3 feet out from the trunks free of vegetation, has been proven to reduce damage. If you maintain ground cover or resident weeds in the row middles, keep it mowed fairly short (< 2 inches) to be less attractive to voles.

Maintaining weed-free fencerows, roadsides, and ditch banks is also an important preventive measure. A vegetation-free zone 30 to 40 feet wide between a field and adjacent areas helps reduce the potential for invasion by voles, but such a wide area is rarely practical; bare soil borders may be undesirable where off-site movement of contaminated soil and water must be prevented with a vegetative border to filter runoff.

**Exclusion**

Cylindrical wire or plastic trunk guards to protect young trees or vines from voles are widely used. An effective guard can be a 24-inch-tall cylinder made of ¼ - or ½-inch mesh hardware cloth that is of sufficient diameter to allow several years' growth without crowding the tree or vine. Bury the guards' bottom edge at least 6 inches below the soil surface, but note that voles may dig beneath them.

Plastic, heavy cardboard, or other fiber materials, such as milk cartons, can also be used to make trunk guards. These materials are less expensive, also provide sunburn protection, and are more convenient to use; however, they provide less protection against vole damage since the voles can chew through them and sometimes use them as a harborage.

Regularly check beneath tree guards for evidence that voles are burrowing underneath them to gnaw on the tree trunk, looking also for the presence of other pests such as snails. If voles take up residence inside the cover, the damage is often greater than if the covers were not used. Good weed control around trunks improves the effectiveness of trunk guards.

Exclusionary fencing consisting of aluminum flashing can be used along field borders. The fencing should be buried at least 6 inches below ground and should extend 12 inches above ground. Drive rebar or wooden stakes into the ground every 15 feet to provide support for the fencing. The efficacy of such fencing is greatly increased if bare soil is present around the base of the fence. Be aware that equipment must frequently move in and out of fields, thereby limiting sites where fencing is practical. Fencing is expensive, so significant damage should be expected to justify the cost of installation.

**Flood irrigation**

Where still feasible, flood irrigation can help control vole populations. When a field is flooded, the voles must come to the surface or drown. When at the surface, they can be picked off by a number of predators; growers and their dogs can also actively seek out voles at this time to further reduce population size.

**Monitoring and Treatment Decisions**

It is important to monitor for voles carefully. Otherwise, you may not notice damage until it is too late to prevent significant injury.

Make sure to check ditch banks, fencerows, roadsides, and other areas where permanent vegetation favors the buildup of voles. Dense grass is their preferred habitat.

Starting in midwinter, monitor monthly in cover crops, weedy areas, and alfalfa fields looking for:
• Active runways: 1- to 2-inch wide surface paths that lead to silver dollar-sized burrow openings.
• Place snap traps in runways to detect pests. Scatter around the field to identify active areas needing baiting. Use expanded trigger traps to avoid having to use bait.
• Fresh vole droppings and short pieces of clipped vegetation, especially grass stems, in runways.
• Burrow openings around the bases of orchard trees or vines. Burrows frequently have numerous openings to the surface. They are relatively shallow and contain food and nesting chambers.

If you find burrows in orchard or vine crops, remove the soil from around the base of the tree or vine and look for bark damage. Voles usually start chewing on bark about 2 inches below the soil line and then move upward to about 5 inches aboveground.

**Baiting**
If you find damaging infestations or numbers increasing within orchard, vineyard, or vegetable crops, poison baits can be used during the dormant season to greatly reduce vole numbers. Baiting can also reduce voles in adjacent areas before they have a chance to invade. Single- and multiple-dose baits are available, but there may be baiting restrictions in some areas to protect endangered species. It is imperative that you understand and follow the label directions for use. In particular, please note that poison baits cannot be applied within orchard, vineyard, or vegetable crops from green up (spring) until after harvest occurs.

For small infestations, scatter the bait in or near active vole runways and burrows according to the label directions. For larger areas and where the label permits, you can make broadcast applications using a belly grinder-type seeder or a vehicle with a tailgate seeder. Broadcast application rates vary, depending upon estimated numbers of voles and type of toxicant. Both single-dose (e.g., zinc phosphide*) and multiple-dose (e.g., first-generation anticoagulants, chlorphacinone* and diphacinone*) poisons are used for meadow vole control in orchard, vineyard, and vegetable crops. These are restricted-use pesticides that require a permit from the county agricultural commissioner for purchase or use.

In ditchbanks and other non-cropland sites, bait should be applied in fall or spring before the voles' reproduction peaks to slow or prevent populations from expanding into the crop. However, application within an orchard, vineyard, or vegetable field is restricted to the nonbearing season, so timing is key to prevent a population explosion during the growing season. Bait acceptance will depend on the amount and kind of other food available. When baiting for voles with anticoagulants, you should remove all aboveground carcasses by burying them underground, or by bagging and disposing them in the trash. This will reduce potential secondary poisoning hazards.

**Trapping**
Trapping is not typically practical as voles often number in the thousands over even relatively small areas.

**Fumigants**
Fumigation is not typically effective because of the shallow, open nature of vole burrow systems and the large number of voles. However, it is occasionally used in artichokes given the deeper structure of vole burrow systems in the crop.

**Repellents**
Repellents are not effective in preventing damage.

* User must be a certified applicator or be under the supervision of someone who is. Some products also require a permit from the county agricultural commissioner for purchase or use.
Precautions for Using Pesticides

Pesticides are poisonous and must be used with caution. READ THE LABEL BEFORE OPENING A PESTICIDE CONTAINER. Follow all label precautions and directions, including requirements for protective equipment. Apply pesticides only on the crops or in the situations listed on the label. Apply pesticides at the rates specified on the label or at lower rates if suggested in this publication. In California, all agricultural uses of pesticides must be reported. Contact your county agricultural commissioner for further details. Laws, regulations, and information concerning pesticides change frequently. This publication reflects legal restrictions current on the date next to each pest’s name.

Legal responsibility

The user is legally responsible for any damage due to misuse of pesticides. Responsibility extends to effects caused by drift, runoff, or residues.

Transportation

Do not ship or carry pesticides together with food or feed in a way that allows contamination of the edible items. Never transport pesticides in a closed passenger vehicle or in a closed cab.

Storage

Keep pesticides in original containers until used. Store them in a locked cabinet, building, or fenced area where they are not accessible to children, unauthorized persons, pets, or livestock. DO NOT store pesticides with foods, feed, fertilizers, or other materials that may become contaminated by the pesticides.

Container disposal

Dispose of empty containers carefully. Never reuse them. Make sure empty containers are not accessible to children or animals. Never dispose of containers where they may contaminate water supplies or natural waterways. Consult your county agricultural commissioner for correct procedures for handling and disposal of large quantities of empty containers.

Protection of nonpest animals and plants

Many pesticides are toxic to useful or desirable animals, including honey bees, natural enemies, fish, domestic animals, and birds. Crops and other plants may also be damaged by misapplied pesticides. Take precautions to protect nonpest species from direct exposure to pesticides and from contamination due to drift, runoff, or residues. Certain rodenticides may pose a special hazard to animals that eat poisoned rodents.

Posting treated fields

For some materials, restricted entry intervals are established to protect field workers. Keep workers out of the field for the required time after application and, when required by regulations, post the treated areas with signs indicating the safe re-entry date. Check with your county agricultural commissioner for latest restricted entry interval.

Preharvest intervals

Some materials or rates cannot be used in certain crops within a specified time before harvest. Follow pesticide label instructions and allow the required time between application and harvest.

Permit requirements

Many pesticides require a permit from the county agricultural commissioner before possession or use. When such materials are recommended, they are marked with an asterisk (*) in the treatment tables or chemical sections of this publication.

Maximum residue levels

Before applying pesticides to crops destined for export, check maximum residue levels (MRLs) of importing country at http://www.mrldatabase.com.

Processed crops

Some processors will not accept a crop treated with certain chemicals. If your crop is going to a processor, be sure to check with the processor before applying a pesticide.

Crop injury

Certain chemicals may cause injury to crops (phytotoxicity) under certain conditions. Always consult the label for limitations. Before applying any pesticide, take into account the stage of plant development, the soil type and condition, the temperature, moisture, and wind. Injury may also result from the use of incompatible materials.

Personal safety

Follow label directions carefully. Avoid splashing, spilling, leaks, spray drift, and contamination of clothing. NEVER eat, smoke, drink, or chew while using pesticides. Provide for emergency medical care IN ADVANCE as required by regulation.