Pest Management Strategic Plan
for
Pears
in
Oregon and Washington

Lead Authors: Katie Murray and Joe DeFrancesco

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Contact Person:
Joe DeFrancesco, Oregon State University, IPPC
2040 Cordley Hall
defrancj@science.oregonstate.edu
541-737-0718

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Work Group Members

Work Group Members In Attendance:

Mid-Columbia
Steve Castagnoli, Oregon State University
Craig Mallon, Duckwall-Pooley Fruit
Peter Shearer, Oregon State University
Eric Shrum, Western Ag Improvement
John Wells, Wells and Sons

Medford
Kathleen McNamara, Bear Creek Orchards
Ron Meyer, Meyer Orchards
John Neilsen, Medford Pear Orchard
David Sugar, Oregon State University

Okanogan
Ken Hemberry, Peshastin Hi-Up
Kelly McDonald, Blue Bird Orchards
Mel Schertenleib, Wilbur Ellis
Mark Stennes, Cascade Crest Organics

Wenatchee
Betsy Beers, Washington State University
Craig Christensen, Grower
Bob Gix, Blue Star Growers
Neil Johnson, Northwest Wholesale
Josh Koempel, Potentiality Orchards
Jim McFerson, Washington Tree Fruit Research Commission
Tim Smith, Washington State University
Gary Snyder, C and O Nursery

Yakima
Jeff Allen, G. S. Long
Michael Bush, Washington State University
Mike Doerr, DuPont
Mark Hanrahan, Grower  
Burt Hopper, Grower  
Chuck Peters, Grower  

**Others in Attendance:**  

Joe DeFrancesco, Oregon State University  
Jim Farrar, Western IPM Center  
Laura Grunenfelder, Northwest Horticultural Council  
Desmond Layne, Washington State University  
Katie Murray, Oregon State University  
Tim Pitz, Underwood Fruit  
Alan Reitz, Underwood Fruit  
Ray Schmitten, Schmitten Orchards  

*Special thanks to the dozens of growers, advisors, and university personnel who attended our regional mini-session meetings in each of the five regions and provided valuable input to this document.*
Summary of Most Critical Needs: Industry-Wide

(Region-specific needs follow these industry-wide needs)

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

Research:

- Develop an IPM program in each growing region for major pear pests based on regional climate differences and impacts of control on other pest populations (e.g. controlling certain pests while preserving pollinators and natural enemies that help control other pests, such as codling moth, pear psylla, and mites).
- Develop best practices for nutrient and irrigation management of pear trees by region (i.e., refine fertilizer and irrigation recommendations) to help growers manage/reduce excessive vigor and balance shoot growth and fruit production.
- Develop an irrigation strategy that is conducive to controlling for multiple pests (e.g. for pear psylla and codling moth management, the recommendation is for overhead sprinklers, while for management of storage rot the recommendation is for low-angle nozzles).
- Analyze the economic impacts of major pear pests in order to better understand what drives pest management decisions and to help establish priorities for future research.
- Determine the impacts of regional climate differences on pest populations and pear trees in general (e.g. pest overwintering, fecundity, life cycle, etc.).
- Develop a well-funded pesticide-testing program to evaluate new pesticides for efficacy and crop safety in an effort to provide unbiased information to growers and advisors.
- Secure funding for more research in both Oregon and Washington with regard to pear pest management.
- Develop regional programs for evaluation of existing cultivars and rootstocks, focusing on pest resistance and tree size/vigor reduction, which would allow for more effective pest management and harvest.
- Improve dwarfing rootstocks available to pear producers (e.g. conduct an investigation of worldwide germplasm and/or develop a breeding program for the Pacific Northwest).
- Better coordinate university and researcher priorities with grower priorities.
- Bring pear researchers together on a regular basis to share and discuss current research, challenges, and potential solutions.
• Develop comprehensive “best management practices” that maximize yield and fruit quality.
• Perform a literature review of pertinent past research on pear pests and synthesize salient points, particularly as these points relate to the stated needs of this PMSP document.
• Develop an industry-wide reader/paper/website to keep growers updated with current research.
• Develop a general economic best practices guide for major pear pests.
• Research and develop more effective sprayer technology.
• Research cropping systems and canopy management with relation to pest management, vigor, and profitability.
• Research more effective controls (e.g. products and technology) for postharvest decay for better control and resistance management.
• Research the interactions between codling moth and pear psylla (biology and control).
• Develop “softer” pesticide alternatives to rotate with granulosis virus for effective codling moth control and better resistance management.
• Identify reduced-risk pesticides, as well as new pesticide modes of action, for control of pear psylla.
• Design and conduct a pollination study for crop yield control.

Regulatory:
• Develop crop-specific, risk-based food safety regulations.
• Collaborate with the IR-4 Program to identify and expedite new registrations.
• Research the potential for increasing rates of certain products (abamectin, spinetoram, spirotetramat) to enhance efficacy.
• Expedite registration of new antibiotic products for fire blight control and promote a protocol for environmental stewardship for the sustained use of these products in orchard situations.

Education:
• Educate growers and advisors regarding additional strains of granulosis virus for codling moth control.
• Develop a Western Region Pear Pest Management Coordinating Committee (WRPPMCC) for information synthesis and dissemination.
• Develop a well-funded university extension education system.
• Educate growers on best practices for resistance management when controlling for pear psylla.
• Once research has been completed, educate growers and advisors on salient points from past research on pear pests and management.
• Secure funding for more education in both Oregon and Washington with regard to pear pest management.
Summary of Most Critical Needs: Medford

Research:
- Research and develop new methods to control shoot blight phase of fire blight.
- Research and develop “softer” pesticides and other management options for control of pear psylla.
- Research and develop non-disruptive control methods for codling moth.
- Research and develop new chemical classes (new modes of action) of pesticides for scab.
- Research and develop organic scab control methods and materials.
- Research and develop a longer lasting/faster killing virus for codling moth.
- Research and develop new materials to rotate with virus for codling moth.

Regulatory:
- Expedite registration of Kasumin (kasugamycin) for fire blight control.
- Reduce 2, 4-D buffer requirements (distance between usage point and waterway).

Education:
- Educate growers and advisors on best practices for use of softer materials for insect control to preserve pollinators and natural enemies.
- Educate growers and advisors on trapping methods and thresholds for oblique-banded leaf roller (OBLR).
Summary of Most Critical Needs: Mid-Columbia

Research:
- Develop orchard management systems that address vigor management, pest management, and profitability (including labor reduction).
- Secure funding to hire a postharvest pathologist.
- Continue research on the impacts of “soft” codling moth management and mating disruption on pear psylla in terms of biological control and hormesis.
- Continue research on effective management and controls for fire blight.
- Secure continued funding for pear pest research.

Regulatory:
- Develop risk-based, crop-specific food safety regulations.
- Request a re-assessment of risk from fumigation of orchard land based on a more realistic, infrequent need for fumigation in an effort to reduce buffer width requirements surrounding fumigated blocks.

Education:
- Increase funding for outreach to growers and advisors concerning pests and pest management.
- Continue educating growers and advisors on use of (and any new developments in) mating disruption for codling moth control.
Summary of Most Critical Needs: Okanogan

Research:
- Research and develop new effective controls (conventional and organic) for both fire blight and pear psylla.
- Research on rootstock (e.g. size/vigor control, etc.).

Regulatory:
- Expedite registration for new effective materials for fire blight control.
- Address MRL issues for various newer products that are important to the industry.

Education:
- Create one common website for disseminating research and other information to growers, advisors, and other industry professionals.
- Make various orchard tours and demonstrations available online (perhaps on the common website, once created) as “Virtual Tours” for growers and advisors at a greater geographical distance from the bulk of the industry.
Summary of Most Critical Needs: Wenatchee

Research:
- Gather/synthesize the existing knowledge and research on pear pest management for dissemination to pear industry.
- Document the use of fire blight prediction models to support use of antibiotics in an IPM program.
- Develop reduced risk techniques for pear psylla control, especially for controlling overwintering adults.
- Develop a pesticide resistance management plan for postharvest fungicides.
- Characterize the effect of regional climate on psylla and mites.
- Develop a Western Regional Coordinating Committee for pear pest management research.
- Determine best timing for control of “bull’s eye rot” postharvest disease.
- Develop a dwarfing rootstock to address excessive vigor issues.
- Work with WSU to find solutions to resolve dissatisfaction with the non-renewal of the pear entomology position.
- Develop risk-based, crop-specific food safety regulations with producer input.

Regulatory:
- Expedite solutions to MRL issues using a coalition of stakeholders (in collaboration with the Northwest Horticultural Council).
- Once identified, expedite pesticide registrations for overwintering pear psylla and stink bugs (including brown marmorated stinkbug).
- Clarify and moderate the FSMA (Food Safety Modernization Act).

Education:
- Disseminate existing knowledge on pear pest management to the pear industry.
- Continue education on identification and information on natural enemies in pear orchards and how to promote them.
- Demonstrate new technologies for pear psylla control as they become available.
- Train growers and advisors on resistance management (fungicides, insecticides, herbicides) and document its implementation.
- Educate the public on the benefits of eating pears.
- Educate the public on IPM practices used in pear production.
- Educate warehouse management personnel on importance of a postharvest pesticide-resistance management plan for postharvest fungicides.
- Facilitate communication between preharvest and postharvest fungicide managers.
Summary of Most Critical Needs: Yakima

Research:
- Research variety/rootstock susceptibility to fire blight under different cropping systems (particularly higher density plantings) and different canopy management strategies.
- Research best practices and new product development to avoid pear psylla tolerance or resistance to modes of action of the most effective insecticide(s).
- Research and develop improved sprayer technology for better canopy coverage, and research the impacts of this technology on resistance management of key pests.
- Continued development of new products and management strategies that target different life stages of codling moth (e.g., bin sanitation for pupae or new products targeting the adult moth stage).
- Research and develop pest management strategies for emerging exotic arthropods and diseases, including the brown marmorated stink bug.

Regulatory:
- Develop producer guidelines on how to diminish risks of exceeding pesticide MRLs on pears for export to counties whose tolerance is lower than the USA.
- Develop risk-based, crop-specific food safety regulations to better account for risks that are outside the control of tree fruit producers.
- Develop clarification and guidelines on how producers can minimize food safety risks associated with common orchard operations, such as harvest bin placement and overhead cooling.

Education:
- Develop a centralized website of pest management information for tree fruit producers.
- Promote the indirect impacts of area-wide programs that should, in turn, promote producer adoption of area-wide programs.
- Increase public marketing and consumer awareness of what producers are doing for public health and as environmental stewards.
- Continue to educate the public on the benefits of eating properly ripened pears.
Process for this Pest Management Strategic Plan

In a proactive effort to identify pest management priorities and lay a foundation for future strategies, pear growers, commodity group representatives, pest control advisors, regulators, university specialists, and other technical experts from Oregon and Washington formed a work group and compiled this document. Feedback on the potential content of document was first gathered from pear industry representatives throughout five identified regions in Oregon and Washington (Medford, Mid-Columbia, Okanogan, Wenatchee, and Yakima) at regional meetings in each of these areas. Members of the work group then met on November 20, 2013, in Hood River, Oregon, where they drafted this document containing critical pest management needs, general conclusions, activity timetables, and efficacy ratings of various management tools for specific pests in pear production. The work group reviewed the resulting document. The final result of these efforts, this document, is a comprehensive strategic plan that addresses many pest-specific critical needs for the pear industry in Oregon and Washington.

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

Description of the biology and life cycle of each pest are described in detail in the entry for each pest. Also included in the entry for each pest are biological controls, cultural controls (including resistant varieties), and/or chemical controls (including pre-plant pesticide treatments) being used by growers. Within each major pest grouping (insects, diseases, and weeds), individual pests are presented in alphabetical order, not in order of importance.

Note:
Trade names for certain pesticide products are used throughout this document as an aid for the reader in identifying these products. The use of trade names in this document does not imply endorsement by the work group or any of the organizations represented.
Commercial pear production in the United States is concentrated in the Northwest, with Washington and Oregon producing around 75% of the nation’s pears. There are more than 1,500 pear growers in Oregon and Washington who ship their pears through 53 packing facilities and three canneries.

Pears produced in Oregon and Washington are primarily varieties of the European pear, *Pyrus communis*. The varieties Bartlett, red Bartlett, and Starkrimson are commonly referred to as “summer pears” as they are typically harvested in the summer (mid-July to late August). The more commonly grown and later harvested “winter pear” varieties include Anjou, Comice, Bosc, and red Anjou.

In 2012, Washington ranked first in U.S. pear production, growing nearly half of the nation’s pears, with approximately 1,230 growers and 21,500 bearing acres. Farmers in Washington grew approximately 391,000 tons of pears, with winter pears totaling 210,000 tons, and summer pears totaling 181,000 tons. The crop value for Washington pears exceeded $205 million in 2012, making pears the state’s tenth most valuable agricultural commodity.

In 2012, Oregon pear growers ranked second in U.S. pear production, producing 28% of the U.S. pear crop, with approximately 280 growers and 16,000 bearing acres. Farmers in Oregon grew approximately 248,000 tons of pears in 2012, 61,000 of which were Bartletts, and 187,000 tons consisting of winter pear varieties. The crop value for pears in Oregon in 2012 exceeded $134 million, making pears the state’s eighth most valuable agricultural commodity.
The main growing regions are the Okanogan, Wenatchee, and Yakima valley areas of Washington, the Mid-Columbia area of Washington and Oregon, and the Medford area of Oregon.

Washington exports almost 35% of its fresh pears, while Oregon exports just under 40%. The main countries receiving pears from the Pacific Northwest are Mexico (over 71,000 exported tons) and Canada (over 49,000 exported tons), although Northwest pears are exported to more than 40 countries worldwide.

_Growing regions in Washington and Oregon._

![Map of the Pacific Northwest showing growing regions for pears](image)

_Main varieties grown by region in Washington and Oregon._

<table>
<thead>
<tr>
<th>Region</th>
<th>Varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medford, Oregon</td>
<td>Comice, Bosc, Bartlett</td>
</tr>
<tr>
<td>Mid-Columbia, Oregon; and Washington</td>
<td>Anjou, Red Anjou, Bosc, Comice, Bartlett</td>
</tr>
<tr>
<td>Yakima, Washington</td>
<td>Bartlett, Bosc, Anjou</td>
</tr>
<tr>
<td>Wenatchee, Washington</td>
<td>Anjou, Red Anjou, Bosc, Bartlett</td>
</tr>
<tr>
<td>Okanogan, Washington</td>
<td>Bosc, Anjou, Bartlett</td>
</tr>
</tbody>
</table>
Throughout both states, Bartlett is the most abundantly grown variety at approximately 240,000 tons, with 54% processed and 46% sold for fresh markets. Anjou is the second most abundantly grown variety at approximately 224,800 tons of production throughout both states, followed by Bosc at 61,172 tons and red Anjou at 22,418 tons. Of the entire crop produced in Oregon and Washington, the majority is sold fresh, with only 22% (primarily Bartlett) processed into canned pears, juice, and other products.

*Fresh Pear production in Oregon and Washington, 2012*.

<table>
<thead>
<tr>
<th>Variety</th>
<th>OR/WA Tons</th>
<th>% Oregon</th>
<th>% Washington</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bartlett**</td>
<td>100,770</td>
<td>35%</td>
<td>65%</td>
</tr>
<tr>
<td>Red Bartlett</td>
<td>2,278</td>
<td>3%</td>
<td>97%</td>
</tr>
<tr>
<td>Starkrimson</td>
<td>6,892</td>
<td>63%</td>
<td>37%</td>
</tr>
<tr>
<td>(Green) Anjou</td>
<td>224,800</td>
<td>39%</td>
<td>61%</td>
</tr>
<tr>
<td>Bosc</td>
<td>61,172</td>
<td>46%</td>
<td>54%</td>
</tr>
<tr>
<td>Comice</td>
<td>4,566</td>
<td>93%</td>
<td>7%</td>
</tr>
<tr>
<td>Red Anjou</td>
<td>22,418</td>
<td>57%</td>
<td>42%</td>
</tr>
<tr>
<td>Red Winter Pear</td>
<td>301</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>Concorde</td>
<td>1,714</td>
<td>7%</td>
<td>93%</td>
</tr>
<tr>
<td>Seckel</td>
<td>1,114</td>
<td>79%</td>
<td>21%</td>
</tr>
<tr>
<td>Other Winter Pear</td>
<td>2,851</td>
<td>82%</td>
<td>18%</td>
</tr>
<tr>
<td><strong>Total OR/WA Fresh Pears</strong></td>
<td><strong>428,881</strong></td>
<td><strong>41%</strong></td>
<td><strong>59%</strong></td>
</tr>
</tbody>
</table>

*Statistics listed in this table are from the Pear Bureau Northwest and represent actual packed boxes of fresh product. Statistics previously mentioned in the text are reported from the National Agricultural Statistical Service (NASS) and likely represent all fruit produced, including culls; hence the slight discrepancy.

** Processed Bartlett pears account for an additional 126,000 tons of production between the two states.

**Specifics of Pear Production**

In Pacific Northwest pear orchards, tree and row spacing can vary considerably, and consequently so can tree density per acre. Orchards can range in density from 200 to 700
trees per acre, with rows spaced anywhere from 12 to 20 feet apart. For older orchards, between-row spacing up to 20 feet and in-row spacing of 10 feet are common (approximately 218 trees per acre). Newer orchards usually have reduced between-row (16 to 18 feet) and in-row (6 to 8 feet) spacing, with tree density ranging from 302 to 454 trees per acre. Higher density pear orchards exist but are uncommon due to lack of well adapted, precocious and productive size-controlling rootstocks.

Average yield is between 15-20 tons per acre for fresh pears, and closer to 30-35 tons per acre for cannery pears, which are not as extensively culled as pears destined for the fresh market. Pear trees reach bearing age at 4–8 years and can produce pears of commercial quality for 50-75 years.

Pear trees in the Pacific Northwest require cross-pollination between compatible cultivars for optimum yield and fruit size. Thus, commercial producers generally plant 10 to 25% of each block with pear pollenizers (Anjou for Bartlett, and Bartlett for winter pear varieties) to enhance fruit set. Pear trees need regular watering and can tolerate heavy, wet soil. In winter, trees are pruned, not only to maintain shape, manage growth, and enhance fruit-productive wood, but also to remove pest habitat and improve coverage for insecticide applications. Replacement trees are also planted in winter and spring.

Harvest can begin as early as July for summer pears, and as late as October for winter pears, depending on the variety and location. Workers pick the fruit “mature-green” (mature and capable of ripening, but not yet ripe). Pears are picked by hand into thirty-pound shoulder bags, and placed into orchard bins to minimize bruising. Pears are immediately transported and rapidly cooled at packinghouses, and then transported through the packing line by water to be sorted and separated by size and grade before being hand-packed and stored in cold-storage rooms until shipment. Cannery pears are picked and placed in cold storage for a minimum of five days before they are moved to ripening rooms where they are ripened, peeled, and canned. Winter pear varieties require two to twelve weeks of cold storage to ripen to their highest quality, although conditioning (pre-ripening) in storage with ethylene is becoming a frequent practice. Fresh pears are generally marketed and sold in 44 lb. boxes, although various other box styles and bagging options are also used.
Integrated Pest Management (IPM) Strategies in Pear Production

IPM is an approach to pest control developed in the 1960s, and has been the prevailing school of thought since that time. By definition, IPM seeks to control pests (arthropod pests and diseases, weeds, nematodes, and vertebrates) using multiple, complementary tactics in an environmentally and economically sound manner. Tools such as monitoring, sampling/scouting, biological control, physical/cultural control, sanitation, host plant resistance, and chemical control are all parts of the IPM toolbox used by pear growers and advisors in the Pacific Northwest. For each crop/pest situation, the goal is to keep pests below an economic threshold with a selection of these tools, and harmonize them with the control of other pests.

The history of pear pest management in the Western U.S. dates back to the late 1800s with widespread plantings of tree fruit around European settlements of the Pacific Northwest. Pesticide options were few, and generally the same materials were available for apples and pears. Because of this, orchards could be inter-planted with both crops, without problems of label restrictions. Lead arsenate, petroleum oils, lime-sulfur, soap, Bordeaux mixture and nicotine were the mainstays of tree fruit pest management in the first half of the 20th Century. The advent of synthetic organic pesticides during and after World War II broadened the scope of pesticides dramatically, and over the decades, pesticide labels became crop specific. Within the past 10-15 years, there has been a change to grouping crops on pesticide labels, so that modern labels may now refer to ‘pome fruits’ as a group (which includes apples and pears), with exceptions by crop listed specifically.

Up until WWII, codling moth was the most serious pest of pears and apples. In 1939, pear psylla was detected in Washington State, and had spread to Medford, Oregon by the 1950s. Although technically an indirect pest (feeding on leaves and shoots rather than on fruit, as does codling moth) pear psylla soon became a very serious pear pest, eclipsing codling moth in importance in some regions. The recent advances in control of codling moth, such as mating disruption or sterile insect releases, have had a positive impact on pest management and fit well into IPM programs.

Pear cultivars vary more widely than apple cultivars in their susceptibility to codling moth, although all are vulnerable to attack. The winter pears (e.g., ‘Anjou’) are less susceptible to codling moth injury, especially during the first generation of codling moth when the immature pears are very hard. Summer pears are softer and more aromatic, and are more vulnerable to attack. While not classed as true host-plant resistance, this variation is sufficient to alter the degree of control needed in some cases.
Although codling moth is a key pest common to all U.S. pear production regions, the severity of attack in the northern states appears to decrease in a north-south gradient; conversely, pear psylla problems increase in the north, and are relatively minor in the south. While cultivar and production practices may play a role, regional climate and landscape effects may also have an impact.
Pear Export Markets and Maximum Residue Limits (MRLs)

The Pacific Northwest produces over 70% of the U.S. pear crop, 30 to 40% of which is exported annually. Top export markets for pears include Mexico, Canada, Brazil and Russia. A more extensive list is available on the Northwest Horticultural Council’s website at http://www.nwhort.org/pearfacts.com.

Pear exporters are concerned with meeting international pesticide regulatory standards for crop protection chemicals. The list of available chemicals and corresponding country-specific Maximum Residue Levels (MRLs) continues to change regularly. Difficulties arise when an MRL exists in the United States, but not for an export market (the importing country), or it does exist but at a lower value than in the U.S. These inconsistencies affect the pest management options available for growers wishing to export their fruit. Examples of these inconsistencies can be noted in the NHC’s Pear Top Markets table at http://www.nwhort.org/PearMRLs.html. When these differences occur, especially for a large number of active ingredients, and the importing country does not defer to international residue standards adopted by the Codex Alimentarius Commission (http://das.wsu.edu/nwhort/ui#codexmrl), the risk of having fruit rejected due to a pesticide residue increases. It may also mean that a grower has to use a less-optimal material in order to meet export requirements. For shippers or sales agencies, this also means that there is less flexibility for shipping, with fewer grower lots eligible for certain restrictive export markets.

Often, this can be because the newest pesticide products are not registered for use in certain export markets. This may be because the market is too small to justify registration costs, or a registration is pending, or because growers in that country do not have need for that specific product. In these cases, there is less urgency to establish a use-based MRL in that market, which can delay the adoption of effective products by U.S. growers, perhaps necessitating the establishment of an import tolerance in the foreign market. Lack of MRLs can also restrict resistance-management programs in the U.S., due to more-limited options eligible for specific export markets.

Standardization of international MRLs is an important issue for pear growers in the Pacific Northwest, and critical to maintain (and expand) export markets. Further, a program evaluating pesticide residues based on usual grower applications could help determine which products can safely be used (and when and how they should be used) in order to meet export MRLs.
Economics of Pear Pest Management

Pears have a relatively large complex of potential arthropod pests, diseases, and weeds which must be managed on an annual basis. Historically, pear growers have relied on chemical control of major pests such as codling moth and pear psylla. Costs associated with pest management can be a substantial portion of total annual production costs for pears in the Pacific Northwest. Several factors can influence pest pressure and the success of management programs, so actual costs may vary widely among individual pear orchards. Average costs of pest management programs were estimated using data from enterprise budgets prepared by OSU and WSU Extension (Table 1). Relative to apple and cherry, average costs for pear pest management are generally higher.

Significant reductions in costs of insect and mite management have been demonstrated for apple when selective management programs are implemented. Similar reductions have also been demonstrated for pear growers implementing selective programs. But, success has been more variable in pear than for apple, and consequently, so have reductions in costs. In both pear and apple, the more selective insecticide programs are generally considered to have reduced negative impacts on natural enemies of secondary pests. When these programs are successful, pest management costs are reduced because secondary pests are maintained below economic thresholds through biological control, and the need for additional pesticide inputs and associated costs are reduced.

In many pear-producing areas, pear psylla has the potential to cause significant economic damage if not controlled. Because pear growers have historically relied on disruptive chemical control of codling moth, which also disrupt potential bio-controls for pear psylla, successful biological control of pear psylla has yet to be widely demonstrated. The advent of pheromone mating disruption as a selective control for codling moth has provided a new opportunity to develop pest management programs for pear that integrate biological control of other important pests, especially pear psylla.

The availability of labor for harvest has also become a significant concern for pear producers, and impacts their decision-making process and economic success. Blocks or trees that have higher infestation of pear psylla are more problematic at harvest (harvesters do not want to pick the sticky fruit that can result from pear psylla infestations), and additional fruit losses occur at the time of packaging (post harvest).
Combined costs per acre of arthropod pest, disease, and weed management programs for pear, apple, and cherry in Oregon and Washington.

<table>
<thead>
<tr>
<th>State</th>
<th>Crop</th>
<th>Pest management costs</th>
<th>Total variable costs</th>
<th>Pest management as % of total variable costs</th>
<th>Source</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>OR</td>
<td>Bartlett</td>
<td>$ 851</td>
<td>$ 4,410</td>
<td>19%</td>
<td>OSU AEB0026</td>
<td>2012</td>
</tr>
<tr>
<td>OR</td>
<td>Anjou (with Bartlett pollenizers)</td>
<td>$ 861</td>
<td>$ 4,158</td>
<td>21%</td>
<td>OSU AEB0025</td>
<td>2012</td>
</tr>
<tr>
<td>OR</td>
<td>Apple</td>
<td>$ 932</td>
<td>$ 4,685</td>
<td>20%</td>
<td>OSU AEB0024</td>
<td>2012</td>
</tr>
<tr>
<td>OR</td>
<td>Sweet cherry</td>
<td>$ 631</td>
<td>$ 6,360</td>
<td>10%</td>
<td>OSU AEB0030</td>
<td>2012</td>
</tr>
<tr>
<td>WA</td>
<td>Bartlett</td>
<td>$ 870</td>
<td>$ 4,566</td>
<td>19%</td>
<td>WSU FS034E</td>
<td>2010</td>
</tr>
<tr>
<td>WA</td>
<td>Anjou (with Bartlett pollenizers)</td>
<td>$ 1,050</td>
<td>$ 5,344</td>
<td>20%</td>
<td>WSU FS031E</td>
<td>2010</td>
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<tr>
<td>WA</td>
<td>Gala apple</td>
<td>$ 800</td>
<td>$ 5,651</td>
<td>14%</td>
<td>WSU FS005E</td>
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<tr>
<td>WA</td>
<td>Sweet cherry</td>
<td>$ 925</td>
<td>$ 8,719</td>
<td>11%</td>
<td>WSU FS022E</td>
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Impact of Horticultural Practices on Pear Pest Management

The trends of planting new pear blocks at higher tree densities with narrower row and tree spacing, adopting new plant canopy strategies and tree architectural designs, as well as vigor-management practices, will invariably lead to new challenges in pest management. Two key pests, pear psylla and fire blight, are linked to tree vigor, and it is suspected that the management of other pests (aphids, spider mites, etc.) may be impacted by host-tree vigor and susceptibility under these newly adopted horticultural practices.

Studies have clearly demonstrated the relationship between tree vigor and pear psylla abundance. Excessive amounts of nitrogen and/or other growth-promoting practices (e.g., over-irrigation, low fruit set, etc.) lead to continual formation of new succulent shoot growth on which psylla prefer to feed and lay eggs. Plant growth regulators (PGRs) can reduce shoot growth of pear, and subsequently pear psylla abundance; however, presently none are labeled for use in pears. Recent studies using the PGR prohexadione-calcium on ‘Anjou’ pears showed a reduction in annual shoot elongation of approximately 40%. Additional studies and development of new technologies that reduce tree vigor and suppress pest abundance are needed.

Similarly, the severity and extent of symptom expression and tree death caused by fire blight disease has been linked to tree vigor. Excess nitrogen fertilization and heavy pruning will elevate a tree’s susceptibility to fire blight. Plant growth regulators that reduce terminal shoot growth of pear can also reduce progression of fire blight symptoms in pear.

Research needs:

- Develop crop sustainable nutrient and water management programs and other cultural techniques (e.g., root pruning) to minimize excessive tree vigor and maintain crop yield while, concomitantly, providing benefits in pest management.

- Investigate alternative PGR chemistries on pear growth and impacts on insect and disease pest density.

- Develop and evaluate new dwarfing and precocious rootstocks in various Pacific Northwest growing regions, and determine rootstock effects on yield, tree vigor, pear psylla and other arthropod pest abundance.

- Investigate the impact of these new dwarfing and precocious rootstocks on the incidence of fire blight and other plant pathogens.
• Develop novel training systems that maintain yield while providing benefits to pest management (better spray coverage, reduction in excessive succulent growth, etc.)

**Regulatory need:**
- Register PGRs that have vigor-management attributes and pest management benefits.

**Education need:**
- Once PGR products have been registered, educate fruit producers on the proper rates and timings to control tree vigor, and how to adjust these factors to enhance the management of insect and disease pests.

~ Intensive Pear Plantings ~
Pear Crop Stages and Pest Occurrence

**Dormancy**
*(November-February; Bud Stage 0*)
Pear psylla, weeds, rodents

**Delayed Dormancy**
*(February-March; Bud Stages 1 & 2*)
Pear psylla, grape mealybug, San Jose scale, eriophyid mites, European red mite, pear psylla, pear thrips, true bugs

**Cluster Bud - Pink**
*(March-April; Bud Stages 3, 4, & 5*)
True bugs, pear psylla, mealybug, San Jose scale, leafrollers, eriophyid and spider mites, powdery mildew, scab*, fireblight, russet, pear thrips

**Bloom through Petal Fall**
*(April-May; Bloom = Bud Stage 7*)
Fireblight, powdery mildew, pear scab**, russet, leafrollers, weeds

**Petal Fall through 2 Weeks After Petal Fall**
*(May)*
Fireblight, pear psylla, codling moth, leafrollers, grape mealybug, eriophyid mites, pear scab*, powdery mildew, storage rot, weeds

**Fruit Growth**
*(May-September)*
Codling moth, pear psylla, grape mealybug, aphids, true bugs, leafrollers San Jose scale, European red mite, spider mites, eriophyid mites, pear scab Cover sprays: codling moth, pear psylla, spider mites, weeds

**Harvest**
*(July-August for summer pears; September-October for winter pears)*
Storage rots, weeds

**Post-harvest**
*(October)*
Pear psylla, eriophyid mite, rodents, weeds

* See Bud Development Chart (courtesy Washington State University) pg. 28.
** Timing for scab control is generally based on effective predictive models.
Pear Field Activities by Crop Stage

**Dormancy**
*(November-February; Bud Stage 0)*
Dormant insecticide application, rodent control, pruning/tree training, freeze protection

**Delayed Dormancy**
*(February-March; Bud Stages 1 & 2)*
Pest scouting, insecticide application, weed management, frost protection, planting, irrigation (under tree)

**Cluster Bud - Pink**
*(March-April; Bud Stages 3, 4, & 5)*
Pest scouting, pre-bloom insecticide & miticide applications, fungicide application, frost protection

**Bloom through Petal Fall**
*(April-May; Bloom = Bud Stage 7)*
Pest scouting and monitoring, fungicide application, weed management, fireblight application, frost protection, place pheromone traps in orchard

**Petal Fall through 2 Weeks After Petal Fall**
*(May)*
Pest scouting and monitoring, insecticide & miticide applications, fungicide application, blight pruning, fruit thinning (chemical, hand), hang pheromone dispensers

**Fruit Growth**
*(May-September)*
Pest scouting and monitoring, insecticide & miticide applications, fungicide application, fireblight pruning, weed management, tree training, calcium application, fertilizer (liquid), bin placement

**Harvest**
*(July-August for summer pears; September-October for winter pears)*
Pest management assessment & fruit cull analysis, weed management
**Post-harvest**  
*(October)*  
Pest scouting, insecticide application, fungicide application, herbicide application, rodent control, fertilization (dry), pruning

*Bud Development Chart, Washington State University.*
Pear Pests and Management Options

I. Major Pests

Note: Within each pest grouping throughout the document (insects, diseases, and weeds), individual pests are presented in alphabetical order, not in order of importance.

Insects and Mites

Codling moth (*Cydia pomonella*)

This insect can be a serious pest in pears, especially in the warmer, dryer areas of the Pacific Northwest. Bartlett pears are the most susceptible to codling moth injury, especially in the early season. Most of the early-season injury on pears occurs through the calyx end of the fruit. All pears become more susceptible to codling moth injury later in the season. In areas such as Yakima, where apples are grown in close proximity to pears, codling moth pressure can be higher than in other areas. Urban growth can also exacerbate problems with codling moth, with homes coming into closer proximity to growing areas and backyard trees harboring the pest.

In many areas, codling moth is reasonably managed using mating disruption and/or chemical control. It is also managed by pear psylla controls (many codling moth programs are designed in conjunction with psylla control). However, insecticide resistance has been documented and efficacy varies based on location. Also, some of the available chemical controls can disrupt natural enemies that can suppress pear psylla, which can lead to greater pear psylla problems.

Codling moth larvae feed directly on the fruit, either by making a shallow feeding cavity (sting), or boring into it and feeding within on flesh and seeds (entry). Stings are shallow depressions where feeding occurred and stopped. Larvae that bore into the fruit leave characteristic holes filled with frass on the exterior, which protrudes from the hole.

Adult moths have a 0.5 to 0.75-inch wingspan, with alternating gray and white bands on the wings and a copper band on the wing tips. Larvae are 0.1 inch long at hatch and 0.8 inch long at maturity, and are whitish with a black head when immature and pinkish with brown heads when mature. Pupae are brown and about 0.75 inch long. The eggs are small and usually laid singly.
Codling moths overwinter as mature larvae in silken cocoons spun under loose bark, in the soil, or at the base of the tree. Pupation takes place in the spring around the time the first blossoms are showing pink, and adults emerge around bloom. Adults are active primarily at dusk, and lay eggs on leaves and occasionally on fruit. The larvae emerge, begin to feed on and bore into the fruit, where they are out of reach of contact pesticide sprays and most natural enemies. After 3 to 4 weeks they leave the fruit to seek a sheltered spot on the tree to spin cocoons. The larvae overwinter in the cocoon, but they may emerge in 2 to 3 weeks as a new flight of adults. These adults are active in July and August. In warmer areas and in seasons with hotter than normal degree days during the growing season, a third brood (whole or partial) may occur. Larvae of this brood often penetrate and damage fruit but do not complete development before harvest or winter.

**Chemical control:**

Insecticide resistance is an issue; growers and advisors avoid treatment of consecutive generations of codling moth with same material(s) or modes of action.

- **Acetamiprid (Assail):** Widely used; good efficacy when used earlier in season; not widely used in the Mid-Columbia region due to disruptiveness to pear psylla natural enemies.
- **Chlorantraniliprole (Altacor):** Very effective; used more in the Mid-Columbia area than other areas. Not effective against pear psylla so not used as widely in areas with higher pear psylla pressure, such as Wenatchee.
- **Diazinon:** Not widely used; poor efficacy; disruptive to pollinators and natural enemies.
- **Diflubenzuron (Dimilin):** Not available in the Pacific Northwest.
- **Emamectin (Proclaim):** Not used; low efficacy mid to late season.
- **Flubendiamide (Belt):** Not widely used; low to moderate efficacy.
- **Granulosis virus (Cyd-X):** A biologically-based pesticide. Requires frequent applications when pest pressure is high.
- **Horticultural oil:** Widely used.
- **Indoxacarb (Avaunt):** Not effective.
- **Mating disruption with pheromone dispensers.** A biologically-based control method. Widely used and effective.
- **Methoxyfenozide (Intrepid):** Effective but not widely used due to necessary timing of application and the availability of better choices (Rimon) that also control psylla.
- **Novaluron (Rimon):** Used early in the season to avoid phytotoxicity issues.
- **Phosmet (Imidan):** Moderately effective, but not widely used due to expense and short residual; disruptive to pollinators and natural enemies.
- **Pyriproxyfen (Esteem):** Not widely used for codling moth control; used for other insects (pear psylla, scale) at different timing.
• Spinetoram (Delegate): Very effective; also controls pear psylla. Used widely in Wenatchee area to control both insects; can be disruptive to pollinators and natural enemies; generally used late-season.
• Spinosad (Entrust): Used mainly in organic production systems with high pest pressure; expensive; toxic to pollinators and natural enemies.

Biological control:
• General predators, including bats and spiders, feed on the adult moths, and arthropod predators (spiders, ground beetles, and vertebrate predators such as birds and mice) feed on mature larvae seeking overwintering sites.

Cultural control:
• Remove brush, debris, and infested fruit from the orchard.
• Use best practices for harvest bin placement and treatment (e.g. hot water, tarping, fumigation) in the orchard to minimize codling moth infestation.

Critical Needs for Codling Moth Management in Pears:

Research:
• Continue to research, develop, and evaluate additional “soft” controls for codling moth that protect pollinators and natural enemies which, in turn, can help control mite and pear psylla populations.
• Identify and evaluate new effective chemistries for codling moth (e.g. longer lasting control and alternatives to chlorantraniliprole for resistance management).
• Continue research on development of host plant masking techniques.
• Develop a longer lasting form of granulosis virus for codling moth control (e.g. closer to 3 weeks instead of 7 days).
• Develop chemistries more compatible with mating disruption and granulosis virus to help control codling moth without increasing pear psylla problems.
• Research best practices for codling moth control to prevent increased pear psylla problems.
• Research the potential impacts of climate change on codling moth control.
• Field test and validate new codling moth phenology models.
• Establish an action threshold for codling moth control.
• Synthesize past research on codling moth and develop a comprehensive strategy for controlling codling moth and pear psylla using mating disruption and selective pesticides.
• Develop a more cost-effective mating disruption program.
• Research and develop area-wide mating disruption programs for codling moth control, especially in the Mid-Columbia area, with potential for cost-sharing for new participants.
• Research the impacts of using mating disruption for codling moth control on other pests (e.g. mites, psylla) to achieve a better understanding of why this tactic might help control other pests.

Regulatory:
• Continue to register additional “soft” controls for codling moth that protect pollinators and natural enemies that can help control mite and pear psylla populations.

Education:
• Develop an area-wide education program for growers regarding efficacy of mating disruption.
• Implement area-wide mating disruption programs for codling moth control, especially in the Mid-Columbia area, with potential for cost-sharing for new participants.
• Educate growers and advisors on standardization of codling moth trapping procedures (density and placement of traps), and how to best use traps for treatment decision-making.
• Synthesize past codling moth management research and present to growers and advisors.
• Educate growers and advisors on best practices for using mating disruption (e.g. thresholds).
• Provide better outreach and education by pest board to the public regarding codling moth control (e.g. importance of removing infested backyard trees to protect nearby commercial orchards).

Eriophyid Mites

Pear rust mite (*Epitrimerus pyri*)
Pearleaf blister mite (*Eriophyes pyri*)

Eriophyid mites can be a problem pest in all Oregon and Washington pear-growing regions. This is especially true for pears grown for export.

Feeding by pear rust mites on foliage causes bronzing of the leaves (which is not particularly damaging), while feeding on the fruit causes russetting, especially around the calyx end but can extend over most of the fruit. Non-russeted cultivars like Anjou and Bartlett are particularly susceptible. Pear rust mite can be difficult to control in organic orchards, and requires multiple applications in conventional orchards.
Pearleaf blister mite is relatively uncommon in conventional orchards, but may occur in organic or minimally sprayed orchards. Feeding on leaves causes reddish to yellowish green blisters; blisters turn brown or black as the tissue dies later in the season. Leaves may drop prematurely. Loss of foliage weakens trees, reduces shoot growth, and interferes with fruit maturation and fruit bud formation. Feeding on fruit causes irregular, russeted spots. Fruit damage by blister mites is caused by feeding injury to buds before bloom.

Adults of these eriophyid mites cannot be seen without magnification. Pearleaf blister mites are light in color, cylindrical, tapered at the posterior end, with two pairs of short legs at the front of the body. The overall appearance is that of a microscopic worm. Nymphs have the appearance of an adult, but are even smaller. Adult pear rust mites are wedge-shaped and yellowish brown with two pairs of legs near the front of the body.

Eriophyid mites overwinter as mature females under outer bud scales. As buds swell in the spring, the mites begin to disperse and infest developing leaves and fruitlets; eventually the mites move to growing terminals. Several generations per year may develop. Eriophyid mites move from tree to tree, perhaps by wind or carried on birds or insects. Scouting for pearleaf blister mite is generally not effective during the current season; by the time blisters are noticed the damage has often been done. However, in some cases it is possible to see and control this pest before damage has occurred. If damage is noted, action will be needed the following fall or spring.

Current management of Eriophyid mites is fair to good as long producers proactively manage these pests. The best control strategies target these mite species during the autumn or dormant season. Eriophyid mites may be indirectly controlled by pear psylla and spider mite control programs during the growing season.

**Chemical control:**

Pre-bloom control:
- Calcium polysulfide + oil (Sulforix and other brands): Widely used by both conventional and organic growers.
- Micronized sulfur + oil: Widely used by both conventional and organic growers.

Growing season control:
- Abamectin (Agri-Mek): widely used for psylla and spider mites and is effective on rust mite.
Carbaryl (Sevin): effective but not widely used; better choices are available that control other pests as well.

Dicofol (Kelthane): Not used; better choices available.

Fenbutatin-oxide (Vendex): not used due to label restrictions, long PHI, and better choices available.

Fenpyroximate (FujiMite): Widesy used for spider mites and effective on rust mites.

Pyridaben (Nexter, GWN-1715): Washington SLN labels (WA-090017b and WA-090017a) allow an application rate higher than the Section 3 label. Widely used for spider mites and effective on rust mites.

Spirodiclofen (Envidor): Used for psylla and effective on rust mites.

Spirotetramat (Ultor): Used primarily for psylla control but also controls rust mites.

Post-harvest control:

- Calcium polysulfide + oil (Sulforix and other brands): Widely used by both conventional and organic growers.
- Micronized sulfur + oil: Widely used by both conventional and organic growers.

Biological control:

- None.

Cultural control:

- None.

Critical Needs for Eriophyid Mite Management in Pears:

Research:

- Research and determine the best application rates for existing chemistries used to control mites.
- Develop effective alternatives to currently registered miticides (or research effective chemicals used in other parts of the world) to prevent resistance and protect pollinators and natural enemies.
- Identify and evaluate new effective organic and conventional controls (especially alternatives to formetanate hydrochloride, which was effective but is no longer registered for use in pears) for eriophyid mites.
- Research the risk for resistance among eriophyid mites.
- Research the potential for biological control for eriophyid mites.
Regulatory:
- Once identified, expedite the registration of new chemical controls (e.g. alternatives to formetanate hydrochloride, etc.).

Education:
- None at this time.

Grape Mealybug (*Pseudococcus maritimus*)

Mealybugs can be a serious pest in Pacific Northwest pears, especially in some regions such as the southern Okanogan Valley, as well as in the Wenatchee area.

Mealybug damage primarily results from the insect’s secreted honeydew, which is cast off in small drops and falls down through the canopy. When it lands on fruit it causes a coarse, black russet, which is similar to pear psylla russeting. However, mealybug russeting is scattered over the fruit surface, while honeydew from pear psylla is in patches or streaks. In addition to russeting caused by honeydew, populations of mealybug can result in infestation of the calyx and associated rot in storage.

The adult female is wingless and can be up to 0.2 inch long. It has a well-developed ring of waxy filaments around the sides of its body. The nymphs (or young crawlers) are purplish and covered with a powdery wax coating. As they get older, the coating gets thicker, and a fringe of wax filaments develops.

Grape mealybugs overwinter as eggs or first instar crawlers in egg sacs beneath bark scales and in cracks. Crawlers start emerging from egg sacs at the beginning of bud swell and begin feeding on the bases of buds. When buds open they go directly to new shoots and leaves. Once settled, the crawlers start feeding and become progressively more difficult to kill. First generation nymphs mature during late June and July in the Pacific Northwest. Adult males appear first, mate and die. Receptive females release a pheromone to attract males. Mated females migrate to sheltered areas, lay eggs and die in the egg sac. In warmer areas a second generation matures in late August and September. Nymphs of this generation sometime settle around the stem end of the fruit or in calyx end of the fruit.

Many of the pear psylla pesticides currently in use may also provide control for mealybug.
Chemical control:
- Acetamiprid (Assail): Used occasionally, less effective than other choices available.
- Azadirachtin (Neem): Used by organic growers.
- Buprofezin (Centaur): Used; effective.
- Chlorpyrifos (Lorsban): Highly effective; delayed-dormant application only.
- Diazinon: Used; effective.
- Imidacloprid (Provado): Used; effective.
- Phosmet (Imidan): Not widely used; better choices available; disruptive to pollinators and natural enemies.
- Spirotetramat (Ultor): Widely used; effective.
- Thiamethoxam (Actara): Widely used; effective.

Biological control:
- Little research has been done to date on the effectiveness of natural enemies in keeping mealybug populations at levels below economic damage, but parasitic wasps, predatory bugs and beetles, lacewings, and spiders may all help control mealybug. Ladybeetles are considered effective predators.

Cultural control:
- Remove sucker crowns (overwintering sites for the mealybug) during dormant and summer pruning.

Critical Needs for Grape Mealybug Management in Pears:

Research:
- Identify and evaluate effective controls for mealybug, including chemical and biological control.
- Research the proper balance of nutrient management to maintain fruit size while reducing tree vigor in order to resist mealybugs.
- Research resistance status of mealybugs in the field and develop a resistance management plan for grape mealybug control.
- Research the potential for a degree-day model for crawler emergence and, if indicated by research, develop a degree-day model for crawler emergence.
- Review research regarding grape mealybug management and control in grapes which may prove effective in pears.

Regulatory:
- None at this time.
Education:

- Educate growers and advisors on existing information regarding timing of control.
- Compile and transfer pertinent research from grapes to share with pear growers and advisors.

Leafroller

European or filbert leafroller (*Archips rosana*)
Fruittree leafroller (*Archips argyrospila*)
Obliquebanded leafroller (*Choristoneura rosaceana*)
Pandemis leafroller (*Pandemis pyrusana*)

There are several species of leafroller pests of pear trees. Leafrollers are the larvae of tortricid moth species that use fruit trees as hosts, as well as native plants. They all cause similar damage to the trees but differ in their appearance and, more importantly, in their life cycle. Adults of these species vary from fawn-color to dark brown. There are distinctive bands or mottling on the wings. Wingspans range from 0.5 to 1 inch. The larvae of these species are all green caterpillars with a light brown to black head, depending on the species. Pandemis larvae are green with a green or brown head. Obliquebanded leafroller larvae are similar to pandemis larvae, except the head is dark brown to black.

As the name implies, the leafroller larvae roll and tie leaves together for shelter and feeding. They thrash about when disturbed and may drop from the leaf suspended by a silken thread. Feeding on the growing points of young plants can promote undesirable branching. Leafroller feeding within the flower or young fruit clusters results in fruit abortion or deeply scarred fruit.

The principal leafroller pests of pear trees can be divided into single-generation moths, such as the fruittree leafroller and the European leafroller, and two-generation moths, such as the obliquebanded leafroller and pandemis leafroller.

The single-generation leafrollers overwinter as egg masses on twigs and branches. Eggs begin to hatch in spring as flower buds are opening and continue hatching until petal fall. The larvae feed for 4 to 6 weeks, then pupate in the rolled leaves and emerge as moths in early summer. The overwintering eggs are laid in July.

Two-generation leafrollers overwinter as immature larvae under the bark on scaffold branches of a variety of host plants. Larvae may feed during warm periods in winter but become active in spring with the onset of new growth. They feed for
several weeks and then pupate in rolled leaves. Adult moths generally emerge around May and lay eggs for the next generation. The next generation hatches in early summer and can cause considerable fruit injury as the larvae will settle and feed in fruit clusters especially where fruit are touching. Observe early spring growth for rolled leaves and feeding damage in fruit clusters and on new growth. Adults may be monitored with pheromone traps.

**Chemical control:**
Leafrollers can develop resistance to chemical controls very quickly. Growers need to be able to alternate chemistries and modes of action.

*Dormant-season control:*
- Chlorpyrifos (Lorsban) + oil: Used; effective.

*Growing-season control:*
- *Bacillus thuringiensis:* A biologically based pesticide. Widely used in organic production.
- Chlorantraniliprole (Altacor): Used; effective.
- Emamectin (Proclaim): Used; very effective.
- Flubendiamide (Belt): Widely used; effective.
- Methoxyfenozide (Intrepid): Widely used; effective.
- Novaluron (Rimon): Used early in season in some areas; widely used for pear psylla control which may provide some leafroller control as well.
- Pyriproxifen (Esteem): Used; not as effective as other products.
- Spinetoram (Delegate): Used; effective.
- Spinosad (Success, Entrust): Entrust used in organic production; Success not widely used in conventional production.

**Biological control:**
- Parasitic wasps, tachinid flies, and predators like the brown lacewing and spiders, although not “stand alone” controls, greatly reduce leafroller populations throughout the year.

**Cultural control:**
- Fruit thinning can reduce problems (e.g. thin fruit clusters to a single fruit)

**Critical Needs for Leafroller Management in Pears:**

**Research:**
- Research the resistance status of leafrollers in the field and develop a resistance management plan for leafroller control.
Regulatory:
- None at this time.

Education:
- Educate growers on the use of pheromone traps for monitoring (trapping techniques and decision-making).

**Pear psylla** (*Cacopsylla pyricola*)

Pear psylla is a critical insect pest in all regions of Pacific Northwest pear production.

Pear psylla control and pear psylla damage can have a huge economic impact on growers. The presence of sticky honeydew secreted by the pear psylla in the orchard at harvest can also result in a labor shortage at harvest due to the difficulty of finding workers willing to pick sticky pears. Pear psylla damage appears to be most severe in orchards that have closely planted trees and trees with dense, vigorous branch and leaf growth.

The adult pear psylla resembles a miniature cicada. Adults have two distinct forms, a summer and winter form, which differ in appearance. Winterform adults are 0.1 inch long, dark in appearance, with transparent wings held roof-like over the body. Summerform adults are 0.08 inch long, greenish to brown, with a similar wing appearance to the winter-form.

Pear psylla overwinters in a semi-dormant state as winterform adults on a variety of trees in and around the orchard. They return to pears and begin laying eggs at the base of buds during bud swell and in other rough places on small twigs. The eggs are shaped like grains of rice and are yellow-orange at maturity. After leaves unfold, eggs are laid along leaf midveins and petioles, and on stems and sepals of blossoms. Egg-laying by female winterforms continues as long as overwintering adults are present, up through bloom and petalfall. The nymphs hatch and feed on the opening blossoms and young leaves, forming droplets of honeydew on upper and lower leaf surfaces. The nymphs, with conspicuous red eyes, pass through five growth stages and change from creamy yellow to green then brown. During the first three stages, the nymphs are encased in a drop of honeydew. There may be three to four generations before the winterform generation appears in the fall.

Nymphs and adults suck plant juices and produce honeydew that drips onto leaves and fruit. Honeydew can russet fruit. Sooty mold often grows on psylla honeydew,
which also russets fruit. Blackening and “burning” of leaf tissue is also typical of pear psylla infestations. Large numbers of pear psylla can stunt and defoliate trees and cause fruit drop. Serious psylla infestations can also impact the next season’s crop via fruit bud formation.

**Chemical control:**
Pear psylla often develops resistance rapidly to chemical controls. Resistance to some insecticides has been documented in both Oregon and Washington. Alternating chemistries and modes of action is important for growers and advisors.

**Dormant application:**
- Esfenvalerate (Asana XL): Registered but not sold in tree fruits; more effective and less disruptive products available.
- Fenpropathrin (Danitol): Not widely used; expensive.
- Horticultural oil: Widely used to delay egg laying.
- Kaolin (Surround WP): Used to delay egg laying; more widely used in the Wenatchee and Okanogan regions.
- Lambda-cyhalothrin (Warrior) + horticultural oil: Widely used and effective.
- Permethrin (Ambush, Pounce, and others): Used; effective. Used alone or in combination with oil.

**Delayed Dormant application:** The prebloom program is very important in preventing unmanageably high populations of pear psylla later in the summer.
- Buprofezin (Centaur): Used; effective.
- Calcium polysulfide (Sulforix) + horticultural oil: Used and effective; more common in organic production.
- Diflubenzuron (Dimilin) + horticultural oil: Not sold in tree fruits; novaluron (Rimon) is preferred product.
- Esfenvalerate (Asana) + horticultural oil: Not sold in tree fruits.
- Fenpropathrin (Danitol) + horticultural oil: Not widely used; expensive.
- Horticultural oil: Widely used to delay egg-laying; regional differences in efficacy.
- Kaolin (Surround): Used and effective; more widely used in Wenatchee and Okanogan regions.
- Lambda-cyhalothrin (Warrior) + horticultural oil: Used (generally only once pre-bloom).
- Micronized sulfurs + horticultural oil: Used.
- Novaluron (Rimon) + horticultural oil: Used later in season.
- Permethrin (Pounce, Ambush) + horticultural oil: Used and effective.
- Pyriproxyfen (Esteem): Used later in season.
**Prepink/Pink applications:** Used in addition to dormant and delayed dormant sprays, if needed based on monitoring.
- Acetamiprid (Assail): Occasionally used.
- Buprofezin (Centaur): Used.
- Fenpropathrin (Danitol): Not widely used; expensive.
- Fenpyroximate (Fujimite): Not widely used at this timing.
- Lambda-cyhalothrin (Warrior): Not widely used at this timing.
- Novaluron (Rimon): Widely used and effective.
- Permethrin (Pounce, Ambush): Not widely used at this timing.
- Pyridaben (Nexter): Not widely used at this timing.
- Novaluron (Rimon): Widely used and effective.
- Pyriproxyfen (Esteem): Used; effective.
- Thiamethoxam (Actara): Not widely used.

**Petalfall + 2 weeks post petalfall application:**
- Abamectin (Agri-Mek): Widely used but not effective for all regions due to regional resistance issues.
- Buprofezin (Centaur): Used; effective.
- Fenpyroximate (Fujimite): Not generally used at this timing.
- Novaluron (Rimon): Widely used and very effective. Not used in the Medford area due to phytotoxicity issues.
- Pyridaben (Nexter): SLN labels for use in Washington (WA-090017b) and Oregon (OR-120003b) allow an application rate higher than the Section 3 label. Used; effective at higher rate.
- Spirotetramat (Ultor): Widely used and effective.

**Post-petalfall through Harvest application:**
- Azadirachtin (Neem): Used by organic growers.
- Abamectin (Agri-Mek): Not widely used; not effective at this timing.
- Acetamiprid (Assail): Widely used; short PHI.
- Buprofezin (Centaur): Used; effective.
- Clothianidin (Belay): Used; short PHI.
- Fenpyroximate (FujiMite): Used.
- Imidacloprid (Various formulations): Used; short PHI.
- Kaolin (Surround): Not widely used after petalfall.
- Pyridaben (Nexter): SLN labels for use in Washington (WA-090017b) and Oregon (OR-120003b) allow an application rate higher than the Section 3 label. Used; effective.
- Pyriproxyfen (Esteem): Used more in early season due to 45-day PHI.
• Spinetoram (Delegate): Widely used; effective.
• Spirotetramat (Ultor): More effective earlier in season.
• Thiamethoxam (Actara): Used and effective but has a long PHI.

Biological control:
• Predacious plant bugs (*Deraeocoris, Anthocoris, Campylomma*) are among the more important predators of pear psylla. Other predators include lady beetles (adults and larvae), lacewings, and earwigs. Parasitic wasps (*Trechnites* sp.) can also provide a level of population suppression. If natural enemies can be conserved within the orchard, biological control of pear psylla can be effective.

Cultural control:
• Avoid promoting unnecessary vigor.
• Remove suckers from interior of the trees, which removes psylla eggs and nymphs and increases spray coverage.
• Overhead irrigation might help control psylla pressure due to frequent rinsing and washing; but this is not common practice due to increased risk of fire blight disease, and potential for rinsing insecticide applications from trees.

**Critical Needs for Pear Psylla Management in Pears:**

Research:
• Cultivar development for pear psylla resistance:
  ➢ Establish a breeding program in the Pacific Northwest to develop dwarfing (less vigorous) and precocious rootstocks and cultivars resistant to pear psylla.
  ➢ Develop and evaluate new cultivars that yield smaller, less vigorous trees that can be planted more densely and harvested mostly from the ground (dwarfing, compacting rootstock). Less vigorous trees are less appealing to pear psylla and enable better pest management.

• Pear psylla pesticide development and evaluation:
  ➢ Develop products with a short PHI to control pear psylla damage at harvest.
  ➢ Identify and evaluate “softer” management options (particularly summer-use insecticides) to effectively manage pear psylla while protecting natural enemies.
  ➢ Identify and evaluate effective products against over-wintering adults (much needed is a pre-bloom spray other than pyrethroids).
- Investigate the most effective controls for the first pear psylla generation.
- Identify and evaluate effective alternatives to endosulfan (which was effective but is no longer registered in pears).
- Identify and evaluate effective systemic insecticides for pear psylla control, especially for targeting adult pear psylla.
- Need information/research on compatibility and effectiveness of chemicals in a tank mix to prevent leaf and fruit burn.
- Identify and evaluate new chemistries with different modes of action for resistance management.
- Research and determine the most effective coverage and concentration rates to use for commonly used, important pear insecticides.

- Research on natural enemies and biological control systems for pear psylla:
  - Identify and evaluate effective natural enemies and biological management systems for pear psylla.
  - Research best management practices for pear psylla when pears are grown adjacent to cherries (specifically in Mid-Columbia area, psylla can be a greater problem in orchards adjacent to cherries, and cherry sprays can be disruptive to pear psylla biological control efforts).
  - Continue research on the potential of using certain thrips to control pear psylla.
  - Identify other predators for pear psylla (Predatory mirids - insects in the miridae family and other true bugs).
  - Develop a predator-prey ratio for a variety of currently known natural pear psylla predators.
  - Develop economic thresholds for predator management.
  - Research on best practices for identifying, protecting, and managing natural enemies in pear orchards (including research on the relationship between nutrition/growth and pest density, and research on the relationship between predator density and life cycle and pear psylla control).

- Research on climate/weather impacts and predictions:
  - Complete a prediction model or degree-day model for pear psylla (research has been completed and published; only need remaining is a modeler to write the model).
  - Need to better understand impacts of regional climate differences on pear psylla populations and pear trees, and insect pests in general (overwintering, fecundity, cycling, and summer temperatures).
  - Research potential impacts of climate change on pear psylla control.
  - Investigate potential uses of Tolfenpyrad (Bexar) for overwintering control of pear psylla.
• Perform a literature review of past research on pear psylla and synthesize salient points.
• Develop more channels for bringing research to the fields: more on-farm demonstrations, trials and research.
• Hire a pear-specific entomologist or post-doc researcher to work more closely with the pear industry and focus on pest and registration issues.
• Research and develop regional IPM programs for using softer pesticides and predator conservation to control pear psylla.
• Investigate possibility of area-wide spray timing for pear psylla control.
• Research the proper balance of nutrient management to maintain fruit size while reducing tree vigor in order to slow the population growth rate of pear psylla.
• Research the impacts of rootstock and plant vigor on pear psylla occurrence and severity.
• Research the efficacy of using sprays of vinegar and large water volumes to help rinse the psylla honeydew and reduce the development of the black sooty mold that causes fruit injury.
• Develop better application/sprayer technology for contact insecticides to allow contact with insect pests higher up in the trees.
• Research economics of using over-tree irrigation for washing trees before sprays vs. extra sprays, including potential additional benefits (such as potential mite control by using over-tree irrigation).
• Investigate SAR (systemically acquired resistance) products and their impacts on pear psylla abundance.
• Investigate the likelihood of insecticide resistance developing in pear psylla if higher insecticide use rates were to be approved.

Regulatory:
• Once identified, expedite the registration of alternatives to endosulfan.
• Investigate the potential for increasing the rate of certain pear psylla controls (abamectin, spinetoram, and spirotetramat) for more effective control.
• Collaborate with the IR-4 Program to identify and expedite new registrations.

Education:
• Educate growers and advisors on salient points from existing pear psylla research after an extensive literature review is performed.
• Educate growers and advisors on how to identify and preserve natural enemies in their orchards that can help manage pear psylla.
• Increase distribution and awareness of the pictorial guide to natural enemies that is currently available to growers and advisors.
San Jose scale (Quadraspidiotus perniciosus)

San Jose scale was introduced to the U.S. on flowering peach in the 1870s. It is now a pest of all fruit trees and many ornamental and wild trees and shrubs throughout the U.S., particularly in hot, dry climates. In Oregon and Washington, this pest is a particular problem in the Mid-Columbia region and in organic production systems.

Scale insects are closely related to aphids, mealybugs, and whiteflies. Like these insects, they also have piercing-sucking mouthparts. San Jose scale can be differentiated from other scale insects by the scale (shell) that covers the adult females. The scale is hard, gray to black, and cone-shaped. The scale has a tiny white knob in the center with a series of grooves or rings around it.

Large populations of scale can devitalize plants and impede growth. Severe infestations by San Jose scale can kill twigs and even the whole tree. Fruit infestations by San Jose scale initially cause development of red spots around the feeding site. San Jose scale attacks both woody parts and fruit.

San Jose scale overwinters in an immature state and is black in color. In spring, the tiny winged males emerge and mate with wingless females. Females give birth to live young about a month later (no eggs are seen). The young scales, called "crawlers," are very small, flattened, and yellow, and move around on bark and foliage before settling down to feed. Young scales also can be dispersed by wind, rain, irrigation, or by the movement of people and machinery. After settling down to feed, the insects become sessile and they secrete a waxy coating over their body that can protect them from pesticides. There are two generations per year, crawlers are usually found during June and July and again in August to September.

Growers and advisors can monitor by inspecting twigs and spurs during the dormant season for scales, and inspecting fruit at harvest to determine severity of infestation. Purplish-red halos on young bark indicate infestation. The crawlers are best observed with a magnifying glass in June/July and can be monitored by wrapping black sticky tape around an infested branch, sticky side out. Male San Jose scale can be monitored with pheromone traps. Adult males emerge in spring, around the same time as codling moth.

San Jose scale is usually controlled in pears by pre-bloom oils and insecticide applications and is considered a minor pest if properly controlled for. However, if left unchecked, it can become a major pest in just a couple of years. Also, some orchards experience infestation by wind-blown scale crawlers that can cause
economic damage. Scale can also be a particular problem with pears destined for export and is a quarantine pest in some markets.

**Chemical control:**
In-season sprays are timed to match crawler emergence.

**Pre-bloom control:**
- Buprofezin (Centaur): Effective.
- Calcium polysulfide (Sulforix, others): Used with oil, especially in organic production, but resistance can be an issue.
- Horticultural oil + an organophosphate (e.g. Supracide or Lorsban): Lorsban is used and effective; Supracide is expensive and not as widely used.
- Pyriproxyfen (Esteem): Widely used; effective.

**Growing season control:** (timing is difficult during the season; most effective controls are pre-bloom)
- Acetamiprid (Assail): Used for other pests; can also suppress scale.
- Buprofezin (Centaur): Used; effective
- Diazinon: Effective but not widely used; disruptive to pollinators and natural enemies.
- Imidacloprid (Provado): Used for other pests; can also suppress scale.
- Pyriproxyfen (Esteem): Widely used; effective.
- Spirotetramat (Ultor): Also used for other pests but effective in controlling scale.

**Biological control:**
- Larvae of green lacewings and other insects are aggressive predators of scale, along with a number of parasitic wasps. However, biological control does not necessarily prevent significant scale infestations and certain chemical pesticide applications can be disruptive to effective control by natural enemies.

**Cultural control:**
- None.

**Critical Needs for Scale Management in Pears:**

**Research:**
- Investigate the impact of wind-dispersed crawlers from adjacent woodlands.

**Regulatory:**
- None at this time.
Education:
- Educate growers and advisors on export issues with regard to scale.

**Spider Mites**
Brown mite (*Bryobia rubrioculus*)
European red mite (*Panonychus ulmi*)
McDaniel mite (*Tetranychus mcdanieli*)
Twospotted spider mite (*Tetranychus urticae*)
Yellow spider mite (*Eotetranychus carpini borealis*)

Spider mites are a problem pest in pears in all regions of Oregon and Washington. Controlling for pear psylla can also lead to an increase in mite problems by decreasing populations of mite predators in the process.

Spider mites damage leaves by puncturing cells and sucking out the contents, resulting in foliar injury varying from leaf yellowing and stippling to bronzing and blackening. High populations of spider mites can cause significant defoliation. Economic damage can occur at levels below one mite per leaf in sensitive varieties such as Anjou and Bosc.

Adult mites are small, usually only about 0.02 inch long and have eight legs. The mite species infesting pears vary in appearance as follows:

- **Brown mite:** The adult female is dull reddish brown with dark orange markings, and somewhat flattened. The front legs are very long, over twice the length of the other legs, and extend forward from the body.
- **European red mite:** Adult females are globular, reddish with white hairs. Immature mites are similar in appearance, only smaller. Eggs are red, globular and have a stipe.
- **Twospotted or McDaniel mite:** Adults are yellowish-brown, about 0.02 inch long. Twospotted mites have two dark spots on the body, while McDaniel mites have a typically less distinctive pattern. Immature mites are similar in appearance, only smaller. Eggs are round and pale green, translucent to opaque.
- **Yellow spider mite:** Adult females are pale yellow to white with 2 or 3 dark, rectangular markings on each side of the abdomen. Immature mites are similar in appearance to the twospotted spider mite, but have more of a yellowish color. Eggs are clear and spherical.
Twospotted, McDaniel and yellow spider mites overwinter as fertilized females under bark or in soil debris. European red mite and brown mites overwinter as eggs in crevices of twig bark and young limbs. They move to young foliage at bud break in spring and produce many generations during spring to autumn. Females can lay up to 10 eggs per day and more than 200 during their lifetime. Egg-to-adult development can occur in 7 to 10 days during summer. They thrive under hot, dry conditions. Large colonies of mites produce webbing. Dispersal occurs mainly through wind transport via ballooning on their webbing.

**Chemical control:**
Spider mites can rapidly develop resistance to chemical controls; growers alternate chemistries and modes of action. In the Medford and Wenatchee regions, resistance to adulticides has been documented; ovicides are most effective in that growing region.

- **Abamectin (Agri-Mek) + oil:** Used and effective, but there are resistance concerns with this product.
- **Acequinocyl (Kanemite):** Not very effective.
- **Bifenazate (Acramite):** There are resistance concerns with this product.
- **Clofentezine (Apollo):** Used as an ovicide; more effective on red mite.
- **Dicofol:** There are resistance concerns with this product.
- **Etoxazole (Zeal):** Widely used; effective.
- **Fenbutatin-oxide (Vendex):** Not effective; there are resistance concerns with this product.
- **Fenpyroximate (FujiMite):** Used; effective.
- **Hexythiazox (Savey, Onager):** Controls eggs only, not adults (ovicide).
- **Horticultural oils:** Used and effective, especially when used prebloom to suffocate overwintering red mite eggs.
- **Oxamyl (Vydate):** Not used; very toxic to predatory mites.
- **Pyridaben (Nexter):** SLN label for Washington (WA-090017b) allows an application rate higher than the Section 3 label. Used.
- **Spirodiclofen (Envidor):** Used; effective.

**Biological control:**
- Predatory mites, lady beetles (Stethorus spp.) and minute pirate bugs can provide some biological control. However, due to the sensitivity of many pear varieties to spider mite feeding, the effect of natural enemies can be too slow or insufficient to prevent significant damage to foliage.

**Cultural control:**
- Avoid dry, dusty conditions, which can increase infestations.
- Cover crops can reduce dust and, subsequently, mite problems.
• Broadleaf weeds like mallow, bindweed, white clover, and knotweed enhance mite numbers, so suppression with cultivation or grass groundcover during the late spring and summer months is important.
• Irrigation management: avoid drought-stressed trees, which are more susceptible to mite infestations and damage.

**Critical Needs for Spider Mite Management in Pears:**

**Research:**
• Identify and evaluate effective miticides for spider mite management.
• Develop action thresholds and/or best timing for pear psylla control to prevent mite and aphid flare-ups.
• Develop an integrated plan for pear psylla control to protect natural enemies that control mites.
• Research the impacts of various horticultural practices (e.g. cover cropping and other cultural practices) on mite prevention and preservation of natural enemies.
• Identify and evaluate effective alternatives to formetanate hydrochloride (Carzol), which was effective but is no longer registered for use in pears.
• Research the impacts of weather and climate on spider mites (e.g. effects of high summer temperatures on mite populations and impacts on trees).
• Develop a spider mite prediction model based on temperature, pace of population development, and life cycle; include how various pear cultivars are affected.
• Research the effects of mid-summer herbicide applications on mite populations vs. applying herbicides earlier.
• Research best timing of herbicide application—not just for weed control but also to prevent mite flare-ups.
• Research the proper balance of nutrient management to maintain fruit size while reducing tree vigor in order to resist mites.
• Investigate the impact of hormoligosis (impact of low pesticide rates on insect/mite reproduction) on mite outbreaks

**Regulatory:**
• Expedite registration for alternative chemistries (e.g. alternatives to formetanate hydrochloride, etc).

**Education:**
• Educate growers and advisors on impacts of various horticultural practices (e.g. cover crops and other cultural practices) on mite prevention and preservation of natural enemies.
**True bugs**

Consperee stink bug (*Euschistus conspersus*) and other stink bug species

Western boxelder bug (*Boisea rubrolineata*)

Western tarnished plant bug (*Lygus hesperus*) and other *Lygus* spp.

True bugs are becoming problematic pests in the Pacific Northwest. As softer programs are being used, problems with true bugs are increasing.

These insects have piercing, sucking mouthparts and a triangle between the head and the wings. Their feeding on fruit causes depressions and hard corky areas. Lygus bug adults are 0.25 inch long and green to brown in color. Boxelder bugs are 0.5 inch long and black with red lines. Stink bugs are up to 0.5 inch long and fairly broad with a shield-shaped appearance. The color can vary from green to brown. Currently, the most damaging stink bug in western orchards is the consperee stink bug, the adult is pale brown and yellow underneath with red antennae.

These sucking bugs overwinter as adults and may migrate into orchards around bloom. Lygus bugs are especially a problem near alfalfa fields. Lygus and stink bugs have a wide host range and will feed on many broadleaf weeds. As broadleaf weeds in and around orchards dry up during the summer, lygus and stink bugs may migrate into the trees and feed on the fruit. Monitoring by limb tapping is necessary to detect migration. A sweepnet can be used to sample the groundcover to determine if lygus bugs are present.

**Chemical control:** Chemical controls currently available for true bugs are highly disruptive to biological control so are used judiciously.

- Flonicamid (Beleaf): Used for *Lygus* spp.
- Pyrethroids (Danitol or Warrior): When used for stink bug control during the summer months, pyrethroids will increase risk of pear psylla insecticide resistance.

**Biological control:**

- None.

**Cultural control:**

- Maintain a weed-free orchard groundcover, such as a regularly mowed sod groundcover, to deter both lygus and stink bugs.
- Removing stink bug habitat from orchard borders.
Critical Needs for True Bug Management in Pears:

Research:
- Develop effective biological controls for managing true bugs.
- Develop and implement “attract and kill” methodology.

Regulatory:
- Seek pesticide labels for use on non-crop areas (border control).
- Register replacement products for endosulfan and formetanate hydrochloride.

Education:
- None at this time.
Diseases

Fire blight

Fire blight is a very serious disease for pear growers in all Pacific Northwest regions. However, it can be difficult to predict and may be very serious some years but appear hardly at all in other years.

Fire blight is caused by *Erwinia amylovora*, a bacterium that overwinters in cankers on infected pear trees. Risk of infection increases with the number of active "holdover" cankers in an orchard, and is dependent on conditions of temperature and rainfall (growers and advisors use a disease forecasting system to predict infection risk periods). Insects, pruning tools, and splashing rains can spread this bacterium. Insect vectors of the bacterium include leafhoppers, flies, bees, and aphids. Bacteria enter healthy, main blooms from the stigma through the nectary. Flowers, which are open for up to 7 days and are the most common entry point for the bacteria, support rapid growth of the bacteria when temperatures are above average. Vigorously growing shoot tips, young leaves, and wounds also can be infection sites. Entrance into healthy-appearing leaves and shoots may be through the base of epidermal hairs.

All pear cultivars are susceptible to fire blight, Bosc especially so. Although Seckel pear and some cultivars with Seckel in their parentage are less susceptible to fire blight than most pears, they are not immune. Fire blight also severely attacks apple, cotoneaster, photinia, pyracantha, hawthorn, quince, and mountain ash. In a "fire blight year," when disease pressure is high, young trees, especially those trained to a central leader, can be severely damaged and often die.

Following warm periods during bloom, spurs, blossoms, and twigs may become infected, developing a darker, water-soaked appearance. Moisture, in the form of rain or dew, helps move bacteria to the infection sites (hypanthia) or the blossoms. Infected tissues turn brown to black and rapidly wilt and die. Infected blossoms frequently are distorted. A tan-yellow bacterial exudate ("ooze") often appears where infection occurs.

Cankers develop on trunks, limbs, and at the graft union. Cankers are at first water soaked, later brownish red, and ultimately dark brown or black. Bark covering the cankered area is sunken and more rough than the surrounding area. Severe cankers girdle and kill infected limbs. Concorde may show trunk cankers first, before symptoms are seen on flowers or shoots.
Other problems that can sometimes be confused with fire blight include Pseudomonas blossom blast, Nectria twig blight, pear dieback caused by Phomopsis sp., and twig borer beetle damage.

Pruning to rid trees of fire blight damage can result in great losses to growers, sometimes resulting in the loss of whole trees, groups of trees, or entire orchards.

**Chemical control:**

Note:

1. A forecasting system is used to help time applications during bloom.
2. Although regular bactericide sprays (copper products, streptomycin, oxytetracycline) during primary bloom have been the most effective controls, their use alone after an infection event may not adequately control fire blight.

- **Dormant sprays:** Copper fungicides applied during dormancy have been found to reduce disease intensity by about 20 percent during bloom.

- **Delayed-dormant sprays:** Copper (Bordeaux, Champ, Kocide, Cueva, others) + oil can delay and/or reduce inoculum production in cankers missed after pruning. The application of copper-based products is not always effective but is recommended if the orchard had fire blight the previous season.

- **Postharvest sprays:** In severe cases, a late season (immediately post-harvest) copper application may be warranted.

- **Biologically-based chemical controls:** (Note: No biologically-based product has been proved effective to reduce damage to the trees when applied after blight symptoms appear):
  - *Bacillus amyloliquefaciens* strain D747 (DoubleNickel 55): Not used; poor control.
  - *Bacillus subtilis* strain QST 713 (Serenade MAX): Fair to good control. Requires multiple, short interval applications during the four days leading up to an infection event (abnormally warm temperatures, followed by blossom wetting).
  - Oxytetracycline (Terramycin, Mycoshield): Apply at early bloom.

**Biological control**

- *Aureobasidium pullulans* (Blossom Protect): Good to excellent control, but may enhance russetting on some cultivars when applied during cool, wet weather from bloom to 14 days post petal fall. Use during warm weather when fire blight risk is predicted to become high over the next two to four days, then follow with other control tactics.

- *Pseudomonas fluorescens* strain A506 (BlightBan A506): Incompatible with ziram, mancozeb, fosetyl-al, and copper products but is compatible with some antibiotics. Will not control fire blight alone; must be integrated into a regular antibiotic schedule. Poor to fair control.
Cultural control:

- Remove and immediately destroy all traces of blight.
- Do not combine pruning and blight cutting (i.e. cut blight first and remove cuttings from orchard before pruning).
- Use sterilizing solution on all pruning tools during spring and early summer. This is not necessary in late fall through winter.
- Do not cut when trees are wet from rain, irrigation, or dew.
- If early bloom is severely infected, delay cutting until extent is determined. Cut out late bloom infections as soon as noticed.
- In spring and summer, cut at least 12 to 15 inches past any visible discoloration.
- In fall, immediately after harvest or during dormant season, inspect the orchard and remove all infections missed earlier. Cutting 4 to 6 inches beyond discoloration is enough at this time.
- Prevent excessive shoot and sucker growth by using moderate amounts of nitrogen fertilizer.
- Manually remove late blooms. If feasible, remove blooms before they open the first year after planting.
- In young orchards with susceptible cultivars and/or rootstocks, remove and destroy severely infected young trees. Replanting is more effective and less risky in the long run.
- Check new nursery trees for any symptoms of fire blight.
- Remove nearby landscape or fence-row trees that can be a source of the inoculum.
- Avoid overhead irrigation.
- Reducing irrigation in a vigorous orchard may slow development of blight observed on new shoots and, if reduced in spring, can help lower potential for dew formation on flowers.
- Some minor cultivars, such as Blake’s Pride, are resistant.
- Use a disease forecasting system, such as Washington State University’s “Cougarblight.”

Critical Needs for Fire Blight Management in Pears:

Research:

- Develop fire blight-resistant pear varieties.
- Research phytotoxicity and efficacy of new copper materials.
- Research possibility of plant-induced resistance products (SAR’s) for fire blight control.
• Develop alternative effective controls for fire blight, both conventional and organic, including chemical, biological, and cultural, to better control fire blight and to prevent antibiotic resistance.
• Develop organic and conventional alternatives to copper and sulfur, which can russet fruit.
• Develop new, cost-effective application technology for fire blight spray applications during bloom.
• Research best timing for fire blight treatment. (e.g. post-harvest treatment).
• Develop best practices for nutrient management of pear trees (i.e. refine fertilizer recommendations) to help growers manage/reduce excessive vigor and reduce shoot growth.
• Research timing and effects of irrigation on fire blight.
• Identify and evaluate effective plant-growth regulators to manage fruit drop, crop load, shoot hardening, and control vegetative growth without causing phytotoxicity.
• Support further research on new non-russeting copper sprays.
• Develop more effective infection diagnosis tools; continue research on potential for detecting fire blight bacteria using flower testing to increase ability to predict fire blight outbreaks.
• Add additional weather stations from Wenatchee River Valley to existing fire blight decision-making model.
• Develop an integrated pest management plan for fire blight control based on emerging horticultural systems, particularly high-density plantings where fire blight can be far more serious to closely spaced pear trees.
• Develop a better push/alert system via text and/or email regarding fire blight infection periods.

Regulatory:
• Expedite the registration of alternative controls for fire blight, such as kasugamycin (Kasumin), Previso (copper) and acibenzolar (Actigard).
• Expedite registration for newly developed, non-russeting copper sprays to control fire blight.
• Maintain current registrations of efficacious antibiotic products for controlling fire blight. Especially, retain registration of oxytetracycline products.

Education:
• Better educate consumers regarding the challenges of pear production and harvest.
• Educate consumers and address misconceptions regarding the use of antibiotics in pears to control fire blight, specifically including the results of the antibiotic residue tests.
• Educate growers and advisors on proper timing for fire blight control.
• Educate growers and advisors on using the existing fire blight decision-making model.
• Educate growers and advisors on best practices for managing fire blight effectively and proactively rather than reactively.
• Educate growers and advisors regarding timing and effects of irrigation on fire blight.
• Educate growers and advisors on best practices for cutting and sanitation (tools, etc.)

**Powdery Mildew**

Powdery mildew is caused by *Podosphaera leucotricha*, a fungus that overwinters in terminal buds of apples. Other host plants include crabapple, quince and some ornamental pear species. Pear orchards are at a higher risk of disease development if planted next to apple orchards. The disease is a problem primarily with winter pears, particularly on the cultivars Anjou and Comice where a russet-free fruit finish is highly desired. Leaf and terminal infection seldom cause economic losses except in the nursery.

Infected terminal buds of apple and sometimes pear develop into shoots covered with spores (conidia). Spore dispersal is favored by wind and warm temperatures but inhibited by leaf wetness. On pear fruit, white mycelium is visible until early June when it sloughs off, leaving a russet patch where cells have died. The russet area expands as the fruit enlarge. Infected terminal buds have an open pointed appearance.

Powdery mildew is a problem for growers in the Medford and Mid-Columbia areas, as well as in Yakima. It can be a problem in the Wenatchee area but the drier climate tends to helps prevent outbreaks.

**Chemical control** (applied from three weeks pre-bloom to three weeks post-bloom to avoid russetting):

Alternate or tank-mix different modes of action; most fungicides limited to not more than two consecutive applications to prevent resistance.

• Bicarbonate-based products (Armicarb, Kaligreen, MilStop, others): Poor to moderate control; used mainly in combination with other products to boost efficacy; especially useful in organic production. Phytotoxicity with green pear cultivars.
- Boscalid + Pyraclostrobin (Pristine): Can be effective; but more often used later in season to control postharvest decay.
- Difenconazole + Cyprodinil (Inspire Super): Not used; not very effective against powdery mildew (primarily used for scab).
- Fluxapyroxad + Pyraclostrobin (Merivon): Not widely used; MRL issues.
- Pentiopyrad (Fontelis): Widely used; very effective.
- Horticultural oils: Not effective; not used.
- Kresoxim-methyl (Sovran): Used in rotation with different modes of action. No more than two consecutive applications. Phytotoxicity issues with cherries; avoided by adjacent pear growers.
- Polyoxin-D (Ph-D WDG): Not widely used; efficacy unknown.
- Sulfur-based products: Used; but may cause fruit russet at temperatures above 80°F.
- Tebuconazole-based products (Tebucon, Tebuzol, Unicorn): Not widely used for powdery mildew; used for postharvest decay. Low efficacy, likely due to resistance. Unknown whether there is a PGR effect on fruit shape when using these products.
- Tebuconazole + Trifloxystrobin (Adament): Used for scab control; also effective against powdery mildew if timing of application is right; unknown whether there is a PGR effect on shape when using during bloom.
- Thiophanate-methyl (Topsin): Often used in combination with another fungicide.
- Trifloxystrobin (Flint): Used; effective. Rotate every other application with different modes of action.
- Triflumizole (Procure): Widely used; very effective.
- Biologically-based chemical controls:
  - *Bacillus amyloiquefaciens* strain D747 (DoubleNickel 55): Unknown efficacy.
  - *Bacillus pumilis* (Sonata): Used in organic production.
  - *Bacillus subtilis* (Serenade MAX): Unknown efficacy; Sonata is more effective and the preferred product.
  - *Reynoutria sachalinensis* (Regalia): Not widely used; used by organic growers.

**Biological control:**
- None.

**Cultural control:**
- None.
Critical Needs for Powdery Mildew Management in Pears:

Research:
- Research best timing of treatments for powdery mildew control.
- Develop a plan for resistance management.
- Develop a forecasting model for predicting powdery mildew outbreaks.
- Identify and evaluate new classes of fungicides to control powdery mildew.

Regulatory:
- None at this time.

Education:
- None at this time.

Russet

Fruit russet can be caused by various factors, including cool, wet weather, frost, pesticides, viruses, fungi and bacteria. Each cultivar is affected differently by the above factors. ‘Anjou’ and ‘Comice’ pears are both very susceptible to fruit russeting.

Russet results from the damage to epidermal cells that occur within the first 30 to 40 days after petal fall. Once damaged, a brown layer of suberized cells form in the lower epidermal region. As cork cells develop in this area, they push outward and become exposed to the surface as the fruit matures.

Cool (not necessarily freezing) weather and wet fruit, especially from pink-blossom stage until three weeks after petal fall, can cause russeting. This kind of weather may be the direct cause of russeting, or provide conditions for growth of russet-inducing bacteria.

Podosphaera leucotricha, the fungus that causes powdery mildew, can also russet fruit. Cultivars susceptible to powdery mildew can develop this type of russeting.

Several different kinds of bacteria can cause russeting, including Erwinia herbicola and Pseudomonas sp. that produce high levels of the plant hormone indole-3-acetic acid (IAA). These bacteria have been shown to increase russeting when inoculated onto pear fruit.

Russeting caused by cool weather and wet fruit is often associated with corky lenticels and tan markings shaped like rain-splashed water droplets. These
markings are more abundant at the stem end of the fruit. A band that forms either partially or completely around the fruit is usually what characterizes frost russetting. Russetting from spray materials is likely to be found where spray droplets accumulate, such as the lowest portions of the fruit. Russetting from powdery mildew is tan to gray and has a netted appearance.

Russetting is a problem in the Mid-Columbia and Medford regions but not generally a problem in the more arid areas of Washington.

**Chemical control:**
Using these products during bloom may aid in russet control.
- Dodine (Syllit): Used; May russet some cultivars if used during bloom.
- Mancozeb (Dithane, Manzate, Penncozeb): Used.

**Biological control:**
- *Pseudomonas fluorescens* strain A506 (BlightBan A506): May help reduce russetting when used for fire blight control.

**Cultural control:**
- None.

**Critical Needs for Russet Management in Pears:**

**Research:**
- Identify causal agents for russetting and identify effective russet controls.
- Develop a prediction model for russetting.
- Develop a breeding program for russet control.
- Identify best timing for most effective control of russet.
- Identify new markets for russeted pears.

**Regulatory:**
- None at this time.

**Education:**
- Consumer education regarding acceptance of russeted fruit.

**Scab**

Scab can be an issue for growers in the Medford and Mid-Columbia regions.
Pear scab is caused by *Venturia pirina*, a fungus that overwinters in infected fallen leaves and, in some areas, on pear tree twigs. Twig infection can be a problem in the Medford region and commonly west of the Cascade Mountains. Fallen leaves produce ascospores in the spring. Spores are generally released during rain over a 3 to 4 month period beginning at bud break. Infection occurs when leaves are wet for 10 to 25 hours and symptoms are seen in 2 to 3 weeks. Conidia are produced in these new scab spots and can infect healthy foliage or fruit when wet.

The cultivars Bartlett, Bosc, and Forelle are very susceptible to scab. The disease does not cause apple scab, nor can the apple scab fungus cause pear scab. Scab on Asian pear is also caused by a different species, *V. nashicola*, that has not been reported in the Pacific Northwest.

In spring, dark olive-black spots with a soft velvet look appear on young fruit, stems, calyx lobes, or flower petals. Young infected fruit frequently drop or are misshapen. Scab spots expand with growth until halted by dry weather. Old fruit infections often crack open. Cracks are surrounded by russeted, corky tissue and then an olive-color ring of active fungus growth. If fruit is infected late in the season, about two weeks before harvest, pinpoint-size scab spots often appear in storage a month or more after harvest.

On leaves, olive-black spots expand with leaf growth but often cause the leaf to twist abnormally. Infected twigs show small blister-like infections and develop a corky layer. Many twig infections are sloughed off during summer.

**Chemical control:**
For resistance management, use of fungicides is limited to not more than two consecutive applications, and various modes of action are used in rotation.

**Delayed dormant control:**
- Calcium polysulfide (BSP Lime sulfur, Tetraul, Sulforix, and other brands): Used; effective.

**Foliar applications during the growing season:** (alternate or tank-mix different modes of action; limit applications from any group to two or fewer per year; copper and sulfur products are generally not used after delayed dormant period due to risk of fruit marking)
- Boscalid + Pyraclostrobin (Pristine): Widely used; effective.
- Copper octanoate (Cueva): New product, not yet widely used; potentially low risk for fruit marking when used during this stage.
- Cyprodinil (Vangard): Used, but difenconazole + cyprodinil (Inspire Super) is preferred product; tank-mixed with another fungicide.
- Difenconazole + Cyprodinil (Inspire Super): Used and effective.
- Dodine (Syllit): Widely used and effective, may have phytotoxicity issues.
- Ferbam (Ferbam Granuflo): Not used. Not recommended for late season due to black residue on fruit. Resistance might be an issue with this product.
- Fluxapyroxad + Pyraclostrobin (Merivon): New product; not yet widely used.
- Kresoxim-methyl (Sovran): Resistance issues with this product, but it continues to be used in some areas.
- Mancozeb (Dithane, Pennoceeb, others): Used and effective.
- Pentopyrad (Fontelis): Used and effective.
- Pyrimethanil (Scala): Not widely used for scab; used for postharvest decay.
- Tebuconazole + Trifloxystrobin (Adament): Used; effective.
- Tebuconazole-based fungicides (Tebucon, Tebuzol, Unicorn): Not used. Unknown whether there is a PGR effect on fruit shape when using during bloom.
- Thiophanate-methyl (Topsin M) (most often tank-mixed with another fungicide): Used mainly preharvest to control postharvest decay; effective.
- Trifloxystrobin (Flint): Used as a protectant and not a curative. Resistance issues are known with this product.
- Triflumizole (Procure): Widely used; effective.
- Wettable Sulfur (Microthiol Disperss): Widely used; effective.
- Ziram (Ziram 76DF): Used for postharvest decay; also effective against scab when used at petal-fall or late season.
- Biologically-based chemical controls:
  o *Bacillus amyloliquefaciens* strain D747 (DoubleNickel 55): Not recommended for use; offers only suppression.

**Biological control:**
- None.

**Cultural control:**
- Apply nitrogen in fall to enhance decomposition of fallen leaves and make them more palatable to earthworms.
- Shred fallen leaves with a flail mower to help speed decomposition of infected leaves.
- Reduce irrigation sets so leaves do not stay wet for extended periods. Use sprinkler irrigation systems that do not wet the foliage of the tree (e.g. microsprinklers), or use drip irrigation.
- Use weather forecasting models to determine pear scab infection periods.
Critical Needs for Scab Management in Pears:

Research:
- Develop organic-approved alternatives to copper and sulfur, which have been known to cause phytotoxicity.
- Identify and evaluate effective (and cost-effective) chemistries to better control scab and prevent resistance.
- Research most effective rates of application of fungicides to control pear scab.

Regulatory:
- Once identified, expedite registration of new, effective chemistries to provide growers and advisors with rotational chemistries for resistance management.

Education:
- Promote an understanding of scab biology.
- Educate growers on how to use the scab prediction model and when to apply products.
- Distribute best practices guide for scab to growers.
- Research the extent to which “best practices” for this pest are economically feasible.

Postharvest Decay
Postharvest decay is a major issue for winter pears in all regions. It can have a large economic impact on the grower if not effectively controlled. While some postharvest disorder issues are caused by abiotic problems (e.g. temperature or humidity), issues of postharvest decay are caused by organisms, which are listed below.

- **Alternaria rot** (*Alternaria alternata*): Infection occurs through skin breaks or areas weakened by sunburn, bruising, senescence or scald.
- **Bull’s-eye rot** (*Neofabraea perennans* and *N. alba*): Pear tree bark is a source of infection in the field. Fruit can become infected any time between bloom and harvest, but susceptibility increases as the growing season progresses. The disease progresses more quickly when infection is through a wound. Rain or over-tree irrigation during the growing season encourages disease spread and rot development. ‘Bosc’ is highly susceptible to bull’s-eye rot. Light brown spots develop with a dark brown border and the fruit gets a firm, mealy texture. This type of rot does not spread from one fruit to another while in storage. This rot does not show up on fruit in the orchard, but on fruit after three to four months of cold storage.
- **Blue mold** (*Penicillium expansum*): Delays in cooling fruit after harvest can increase risk of this rot. The fungus can infect through wounds, lenticels, and
bruises late in storage. High nitrogen levels and tree vigor also contribute to disease development. Rot appears light brown, often with a blue, moldy growth in the center. Rotts are soft and watery.

- **Cladosporium rot** (*Cladosporium herbarum*): Dark brown, water-soaked spots; can be similar to side rot.
- **Coprinus rot** (*Coprinus psychromorbidus*): Large, depressed spots with light brown centers and a thinner, dark brown margin. A white cobweb-like growth on the surface can cause a nest or cluster of rotted fruit. Can be mistaken for bull’s-eye rot.
- **Fire blight** (*Erwinia amylovora*): Lesions resulting from pre-harvest infection are dark brown and hard.
- **Gray mold** (*Botrytis cinerea*). Spores from the orchard infect through wounds. Infection may take place through wounds, calyx, or stems (the latter especially in ‘Anjou’). Lesions on infected fruit may spread to neighboring fruit during storage, resulting in pockets or “nests” of gray mold.
- **Mucor rot** (*Mucor piriformis*). Spores come from soil or fallen fruit on the orchard floor and may be brought into the packing house on bin bottoms.
- **Phacidioptynis rot** (*Potebiamyces pyri* [asexual *Phacidioptynis piri*]) has been found in all major pear-producing areas of the Pacific Northwest. It is associated with dead bark, cankers and twig dieback of pear trees. Spores from pycnidia are the main type of inoculum in the orchard. Infection of fruit occurs in the orchard between bloom and harvest, but symptoms develop in storage. Rot may occur on the calyx or stem end or be associated with wounds. Decayed areas appear water-soaked in the early stages of rot. As the rot develops the decayed areas turn black, but the margin continues to be water-soaked. Decayed fruit eventually look like a ripe avocado. May be confused with gray mold early on but the margin of Phacidioptynis rot appears translucent while gray mold appears brown.
- **Side rot** (*Phialophora [Cadophora] malorum*). ‘Bosc’ is very susceptible. Rot typically appears as dark dime-sized spots. Maybe be indistinguishable from Cladosporium and Alternaria rot.
- **Sphaeropsis rot** (*Sphaeropsis pyripputrescens*). A postharvest fruit rot of Anjou pears. It is present in most pear-producing areas of central Washington. Infection of fruit occurs in the orchard and symptoms develop in storage. Rot develops as a firm brown rot of the calyx- or stem-end. The fungus may form pycnidia in the decayed areas as the rot advances. The internal decayed flesh appears brown. Decay develops along the vascular tissue. Symptoms are similar to gray mold except with a strong odor.
- **Sprinkler rot** (*Phytophthora cactorum*). Infection is from irrigation water on fruit in the field. Lesions are light brown and soft with a pungent, phenolic odor.
• **Storage scab** (*Venturia pirina*): Small, light brown, sunken spots resulting from pre-harvest infection when fruit are wet.

**Chemical control:**
(Limited to not more than two consecutive applications of any chemical.)

*Applied pre-harvest (1-3 weeks):*
• Boscalid + Pyraclostrobin (Pristine): Effective; widely used.
• Thiophanate-methyl (Topsin M): Effective; widely used.
• Ziram (Ziram 76DF): Used earlier; long PHI. Can cause skin irritation to harvesters.

*Postharvest application:* (Used after harvest during packing; growers and advisors must avoid using same fungicide or active ingredient twice, once preharvest and once postharvest, on same fruit):

• Calcium hypochlorite: Used in wash prior to fungicide application.
• Captan: Not widely used but important to some packers.
• Fenhexamid (Judge): Not widely used; Effective against Botrytis but not effective against most other types of decay.
• Fludioxonil (Scholar): Can be used twice, once before storage and once after. SLN OR-090021 and WA-100007 allow in-field bin application. Widely used; very effective.
• Gas ozone (O$_3$): Used for cold storage and CA room sanitation.
• Pyrimethanil (Penbotec): Widely used; very effective.
• *Pseudomonas syringae* strain ESC-11 (Bio-save): A biologically-based fungicide. Occasionally used as a line spray application at packing; moderately effective when applied to fruit promptly after harvest.
• Quaternary Ammonium Compounds (Quats): Used for cold storage and CA room sanitation.
• Sodium hypochlorite (Aghchlor 310): Used in dump tank and/or on-line prior to fungicide application.
• Sodium orthophenylphenate (Deccosol, Stop Mold, and other brands): Used by many packers to reduce inoculum build-up in dump tanks.
• Thiabendazole (Mertect and other brands): Used, but resistance issues have been noted with this chemical class.
• Fruit wraps (Copper–treated paper fruit wraps applied at packing; however not all wraps are treated): Widely used; effective.

**Biological control:**
• None.
Cultural control:

- Use low-angle sprinkler nozzles for irrigation in the field.
- Maintain good in-row weed control; mow grass between rows.
- Use foliar nutrient sprays before harvest. Calcium-based products can reduce infection by some pathogens.
- Use a minimal amount of nitrogen fertilizer.
- Harvest at proper maturity, and instruct harvesters on the proper technique for removing fruit from the tree. Delayed harvest means increased decay.
- Clean fruit bins before filling, and keep soil off the bottom. A hot water pressure wash or steaming can help clean bins. Clean storage rooms of all debris well before filling, and treat surfaces with a disinfectant.
- Harvest and cool fruit quickly. Keep harvested fruit out of sun.
- Avoid injuring fruit. This is very important. Smoothing orchard roads and driving slowly helps. Paying pickers by the hour rather than by the bin can help prevent fruit injury at harvest.
- Controlled-atmosphere storage, especially with low (1%) oxygen, reduces the incidence and severity of bull’s-eye rot.
- Do not return culls back into the orchard.

Critical Needs for Postharvest Decay Management in Pears:

Research:

- Identify effective fungicides for both pre- and post-harvest with different modes of action to prevent resistance, and that target multiple sites in the pathogen.
- Develop more effective application technology for timely application of post-harvest fungicides.
- Identify new materials that stimulate resistance to decay in the fruit (e.g. SARs).
- Develop effective biological controls to prevent postharvest decay.
- Identify and evaluate new effective controls for postharvest decay.
- Develop a prediction model for the different types of organisms that can cause postharvest decay.
- Research timing of infection susceptibility to learn best timing for control.
- Research best timing for pre-harvest control.
- Research the risks for postharvest decay, and how certain cultural and other practices might prevent and reduce postharvest decay.
- Research and develop best practices for controlling postharvest decay.
- Research pre- and postharvest applications of ethylene inhibitors (AVG and 1-MCP) for increasing resistance to decay in fruit.
• Create a research document regarding postharvest decay and its costs to the pear industry as a whole, tying together processing issues and effects of postharvest decay on growers’ profitability.
• Research impacts of climate and irrigation on tree vigor, and pests and diseases.
• Develop pear-specific packing lines and equipment to more gently handle pears at packing houses.
• Research new products and sanitation processes for controlling Mucor rot.

Regulatory:
• Seek registration for Luna Sensation (fluopyram + trifloxystrobin) for use on pears in OR and WA.
• Seek registration for pre-mix postharvest fungicides (such as fludioxonil + difenoconazole) for resistance control.

Education:
• Educate growers and advisors on the risks for postharvest decay and how certain cultural and other practices might prevent and reduce postharvest decay.
• Educate growers and advisors on importance and best practices for controlling postharvest decay.
• Educate growers and advisors on economic impacts of postharvest decay.
WEEDS

Many different types of weeds can be found in pear orchards. Below is a list of the more common ones.

**Broadleaf perennial and biennial weeds:**
- Bindweed, field (*Convolvulus arvensis*)
- Canada thistle (*Cirsium arvense*)
- Chickweed, mouseear (*Cerastium vulgatum*)
- Common mallow (*Malva neglecta*; can be a perennial, biennial or an annual)
- Dandelion (*Taraxacum officinale*)
- Mullein (*Verbascum thapsus*)
- Sow thistle (*Sonchus arvensis*)

**Note:** Field bindweed, dandelion, and common mallow can influence mite populations; mites reside in the weeds and move into the pear trees when weeds are controlled.

**Broadleaf annual:**
- Chickweed, common (*Stellaria media*)
- Clover (*Trifolium spp*)
- Common mallow (*Malva neglecta*; can be a perennial, biennial or an annual)
- Dead nettle, purple (*Lamium purpureum*)
- Filaree (*Erodium cicutarium*)
- Fleabane, hairy (*Conyza bonariensis*)
- Groundsel, common (*Senecio vulgaris*)
- Kochia (*Kochia scoparia*)
- Knotweed, prostrate (*Polygonum aviculare*)
- Lambsquarters, common (*Chenopodium album*)
- Marestail (aka horseweed) (*Conyza canadensis*)
- Mustard, wild (*Brassica kaber*, syn. *Sinapis arvensis*)
- Nightshade, black (*Solanum nigrum*)
- Nightshade, hairy (*Solanum physalifolium*)
- Pigweed, redroot (*Amaranthus retroflexus*)
- Prickly lettuce (*Lactuca serriola*)
- Puncture vine (*Tribulus terrestris*)
- Purslane, common (*Portulaca oleracea*)
- Sow thistle (*Sonchus oleraceus*)
- Russian thistle (*Salsola iberica*)
- Willowherb, fringed (*Epilobium ciliatum*)
- Willowherb, slender (*Epilobium brachycarpum*)
Annual grasses:
Barnyardgrass (*Echinochloa crus-galli*)
Green foxtail (*Setaria viridis*)
Italian ryegrass (aka. Annual ryegrass; *Lolium multiflorum*; resistant to glyphosate)
Large crabgrass (*Digitaria sanguinalis*)
Wild proso millet (*Panicum miliaceum*)

Perennial grasses:
Bermudagrass (*Cynodon dactylon*)
Johnson grass (*Sorghum halepense*)
Quackgrass (*Agropyron repens*)

Equisetum:
Horsetail, field (*Equisetum arvense*)

Woody species:
Blackberry (*Rubus spp*)
Cottonwood, black (*Populus trichocarpa*)

Nutsedge:
Yellow nutsedge (*Cyperus esculentus*)

In most orchards, row middles have permanent native or planted grass covers that are primarily managed by mowing or flailing. These grass covers reduce soil erosion on sloping sites, improve traffic conditions in wet weather, and increase water infiltration and drainage. Broadleaf weed species are sometimes controlled in the row middles with selective broadleaf herbicides containing 2,4-D. In conventional orchards, weeds in the tree rows are managed with pre- and post-emergent herbicides. In organic orchards, weeds in the tree rows are managed with mechanical cultivation, flaming, non-selective contact herbicides, and mulches to suppress weed growth.

Weeds in tree rows compete for soil moisture and nutrients in both newly planted and mature orchards and can inhibit tree growth and fruit yield. Other weeds may host pests, including insects, mites and plant viruses, and can provide competition for pollinating bees in spring. Common dandelion, for example, blooms about the same time as pears and are a preferred nectar source for bees in the spring.

Pear rootstock suckers are a problem in orchards planted with certain rootstocks that tend to produce many suckers. In orchards with prolific sucker production, these need to be controlled as part of a tree-row weed management program (summer “burn-down” with a contact, postemergence herbicide).
When using non-selective, systemic herbicides such as glyphosate, growers must be careful to avoid applications to green bark, low limbs, or suckers with buds that are beginning to open. Non-selective, systemic herbicides are more prone to enter through green bark and wounds on stems than through mature bark.

Persistent, soil-active herbicides can be applied during spring, fall, or the winter dormant season, and activated with rain or sprinkler irrigation if dry conditions persist. After establishing an effective weed control program, growers may use lower rates or split applications of some herbicides (such as simazine, diuron), in fall and early spring to improve year-round weed control and reduce possible injury to the pear trees.

Contact herbicides, such as paraquat (Gramoxone) and pyraflufen-ethyl (Venue) can be used to control existing vegetation, but they lack residual control and are nonselective. Paraquat is generally effective but is a restricted-use herbicide and requires careful handling and secure storage. Three non-selective, contact, organic herbicides are now available for use in orchard crops: Matran (contains clove and wintergreen oils), Greenmatch EX (lemongrass oil), and Weed Pharm (acetic acid). Like conventional contact herbicides, these products do not provide residual control of emerging weeds. These herbicides are most effective if weeds are less than 6 inches tall, there is bright sunlight, or air temperatures are 70°F or higher. However, the increased cost and reduced effectiveness of organic herbicides limits use by conventional growers.

Several selective postemergence herbicides are registered for use in pear production. They usually work best if applied to seedlings less than 4 inches tall. Application is timed so the maximum number of seedlings have emerged but the largest seedlings are not too big to kill. Environmental conditions not only affect the efficacy of the herbicide, but may also influence the crop’s tolerance to the herbicide. The grass herbicides Fusilade (fluazifop), Poast (sethoxydim) and Select (clethodim) are more effective when the weeds are actively growing.

Surfactants can make the difference between good and poor weed control. Crop oils or other nonphytotoxic adjuvants are required on many postemergence herbicides; in specific cases, nitrogen solutions may be required and may improve weed control. Pear growers and advisors are cognizant that the label must be read carefully for understanding this crucial information.

Repeatedly using the same or similar weed control practices can result in weed shifts to species that tolerate these practices. Examples include prostrate weeds that tolerate flailing, deep-rooted perennials that tolerate cultivation or can survive
during the summer dry season, and weeds from a natural population of susceptible biotypes that become resistant. Weeds that survive cultivation, mowing or flailing, specific herbicide treatments, or other routine cultural practices must be eliminated before the tolerant species or biotypes become established. Best practices include combining a variety of weed control practices or treatments, rotating practices and herbicides, and spot treating with a hoe or registered herbicide when the weed first appears. Also, sanitation (cleaning equipment when moving between fields) helps prevent weed spread.

Repeated use of glyphosate (Roundup and other brands) in Pacific Northwest agriculture has selected for a resistant biotype of annual rye grass. Over-reliance on herbicides with a single mode of action for orchard floor maintenance increases the risk of selecting for resistance in other weed species. It also threatens the long-term usefulness of glyphosate for weed control in pear orchards.

**Chemical control:** (Note: Many products are combined with others and used at lower rates to provide more broad spectrum control).

*Soil-active herbicides:*

- **Dichlobenil (Casoron):** Not widely used. Effective but expensive; used only for certain weeds. Good control of *Equisetum* spp.
- **Diuron (Karmex):** Widely used; effective.
- **Indaziflam (Alion):** Widely used; effective.
- **Isoxaben (Trellis):** Labeled for non-bearing only; recommended for new plantings. Not widely used; expensive.
- **Napropamide (Devrinol):** Recommended for new plantings. Not used; better products available.
- **Norflurazon (Solicam):** Widely used; effective.
- **Oryzalin (Surflan):** Recommended for new plantings. Widely used; effective.
- **Pendimethalin (Prowl):** Recommended for new plantings. Widely used; effective.
- **Pronamide (Kerb):** Recommended for new plantings. Widely used; effective.
- **Terbacil (Sinbar):** Labeled for non-bearing orchards only. Not used; this product is toxic to pears.
- **Trifluralin + isoxaben + oxyfluorfen (Showcase):** Labeled for non-bearing orchards only. Not used; efficacy unknown.
- **Simazine (Princep):** Widely used; effective.

*Soil- and foliar-active herbicides:*

- **Flumioxazin (Chateau):** Recommended for new plantings. Not used in pears due to phytoxicity issues.
- **Oxyfluorfen (Goal):** Widely used; effective.
- **Rimsulfuron (Matrix):** Widely used; effective.
Postemergence contact herbicides:

- Acetic acid (Weed Pharm): Expensive and caustic; not widely used. Sometimes used for organic production.
- Carfentrazone (Aim): Used; provides good sucker control. However, phytotoxicity from drift can be an issue with this product.
- Diquat (Reglone): Labeled for non-bearing only. Not used; better options available.
- Paraquat (Gramoxone): Widely used; effective.
- Pyraflufen (Venue): Widely used; effective.
- Saflufenacil (Treevix): Not widely used.

Translocated herbicides:

- 2,4-D (non-volatile formulation): Widely used; effective.
- Clethodim (Select Max): Labeled for non-bearing only. Seldom used; controls grass only.
- Clopyralid (Stinger): Newly registered; not yet widely used.
- Fluazifop (Fusilade DX): Labeled for non-bearing only. Seldom used; controls grass only.
- Glyphosate (Roundup and other brands): Widely used and effective, but Italian ryegrass (aka. Annual ryegrass) resistance has been observed in some areas.
- Sethoxydim (Poast): Used with Roundup resistant grasses, but Roundup is the preferred product.

Biological control:

- None known.

Cultural control:

- Mowing
- Cultivation
- Protective barriers (weed mats) (especially used in organics).
- Flaming (used in organics); limited due to air restrictions.

Critical Needs for Weed Management in Pears:

Research:

- Identify and evaluate a season-long and safe sucker burn-down material.
- Develop a rootstock breeding program that will develop a new rootstock that sends up fewer suckers.
- Research best practices for orchard floor management (to control mites, true bugs, and other pests that can come from weeds).
Identify soil-active herbicides that can be applied during spring or summer (rather than winter) with longer residual effects.

Research various chemical classes for tank mixing to prevent weed shifts and resistance.

Develop a general, systematic plan for weed control in pear orchards.

Research glyphosate resistance and best practices for resistance management.

Establish funding for more weed scientists, particularly in Oregon.

Identify and evaluate effective pre- and post-emergent controls for nutsedge.

Research best timing for controlling Canada thistle.

Identify and evaluate effective new chemistries for organic and conventional weed control.

Research impacts of dwarf trees and high-density plantings on weed control.

Identify and evaluate new pre-emergence products that are safe and can be used during the first year of new plantings.

Research potential for using green manure crop material for soil sterilization as alternatives to fumigants (e.g. cherry roots, African ryegrass, spent lavender, etc.).

Identify and evaluate effective alternatives to glyphosate, specifically systemic, non-selective herbicides that target perennial weeds.

Develop programs of rotation for weed control.

Research to gain a better understanding of weed biology (life cycles, susceptible life stages, optimal timing, resistance screening, etc.).

Research the potential for reducing PHI’s on certain herbicides currently used with longer ones (e.g. Simazine).

**Regulatory:**

- Seek registration for propargite (Omite) to mix with herbicides for controlling mite populations in the weeds. (Other effective miticides are saved for use on trees in-season; Omite is phytotoxic to pear trees but could be used on weeds).

- Need to develop/expand labels into orchards for various herbicides, and change products currently labeled as “non-bearing” to “new plantings,” and expand to bearing orchards when possible.

- Alternative regulations for fumigation in smaller plantings need to be developed. Current soil fumigation regulations make fumigation in small fields very difficult and expensive.

- Seek a reduction on buffers for 2,4D when technology can effectively mitigate drift.

**Education:**

- Educate growers and advisors regarding the overuse of glyphosate and the need for rotation to prevent further glyphosate resistance.
II. Vertebrate Pests

Rodents (Voles, gophers)

Rodents are a problem mainly when weeds aren’t well controlled and a dense mat of weeds is present. Rodents are also more of a problem on young, tender, smooth-barked vigorous pears before the bark begins to thicken and crack. In organic orchards (no available chemical controls), and in areas with long periods of snow cover, rodents (specifically voles) can be a more serious pest that can even destroy trees with overwinter feeding on crown and bark. Another rodent of concern in pear orchards is the pocket gopher, which can feed on the roots of fruit trees and on drip irrigation tape.

Management of rodents:

- Effective weed control (mowed middles and fall mowing to grind fruit and grasses) helps manage mice and vole populations by reducing habitat.
- Encouraging natural predation of coyotes and raptors can help reduce rodent population levels.
- Younger trees can be protected with various types of mouse guards (aka tree guards) on the trunks.
- Proper selection of ground cover, cover crop, and living mulches that are less attractive and palatable to voles.
- Chlorophacinone (Rozol). Used after harvest and during dormancy for voles and pocket gophers; effective.
- Zinc phosphide (Prozap Zinc Phosphide Pellets). Used after harvest and during dormancy for voles; effective.
- Barn owl nest boxes and raptor perch installations are sometimes used for rodent control.
- Gophers are managed by trapping or bait placement (aluminum phosphide or strychnine alkaloid treated baits).

Deer/Elk

Elk are an isolated but serious issue for growers when present. Raking of trees with antlers can cause serious damage to trees, even killing young trees.

Deer are of increasing concern to growers. They feed on tender growing tips, reducing tree growth and detrimentally impacting tree shape. Later in the season, deer can defoliate trees as well as damage and break branches with their antlers. Deer infestation can be a serious problem in orchards with young trees.
Management of deer/elk:
- Fencing of orchards is the most effective way of managing large vertebrate feeding, but in most cases this is not practical due to expense or the presence of streams or rivers.
- Individual wire fences can be created around young inter-planted trees.
- Some growers attempt to discourage feeding by hanging fabric softener cloths or soap on the trees, and using commercial deer deterrent sprays.
- Hazing, running herds out of blocks, and special hunts issued by State Departments of Fish and Wildlife (ODFW and WDFW) are also sometimes utilized.

Critical Needs for Vertebrate Pest Management in Pears:

Research:
- Document the economic impacts of vertebrate pests.

Regulatory:
- Improve working relationships between University Extension, ODFW, WDFW, and the pear industries of Oregon and Washington.
- Work with ODFW and WDFW to develop a wildlife management program for managing deer/elk in pear orchards.
- Seek funding for a cost-share program for deer/elk fencing in problem areas.

Education:
- Educate growers and advisors on wildlife management programs, and provide growers and advisors with awareness and access to information generated by State Departments for wildlife management programs.
- Continued education for growers and advisors on management systems that provide the best mix of natural predators and baiting/trapping to control mice and voles in pear orchards.
III. Minor Pests

Insects and Mites

**Pear sawfly (aka Pear slug) (Caliroa cerasi)**

Pear sawfly is a European insect now found in most areas of the U.S. It attacks both pear and cherry, and is also found on mountain ash, hawthorn, and ornamental Prunus species. It can be a big problem for pears in organic production, especially in the Medford region.

The adult is a glossy black wasp, about 0.2 inch long. The larva resembles a small slug due to the olive green slime that covers the body and the fact that the head is wider than the rest of the body. Mature larvae are 0.37 inch long and orange-yellow. Larvae feed on the upper surface of leaves, skeletonizing them; the fruit surface may also be scarred when populations are very high. Heavy feeding causes leaves to drop, with a reduction in vigor, yield, and return bloom, particularly on young trees.

Pear sawfly overwinters as a pupa in a cocoon 2 to 3 inches deep in the soil. Adults emerge over an extended period in late April to May. The adult female inserts eggs into leaf tissue, and eggs hatch in 10 to 15 days. Larvae immediately begin to feed on the upper surface of the leaf. After 3 to 4 weeks, they drop to the soil to pupate. Second generation adults emerge in July, and larvae from this generation feed in August and September. Most larvae from this generation drop to the ground to overwinter. Growers and advisors can monitor trees for slug-like larvae, especially in August and September when large populations can build up.

**Chemical control:**
- Usually controlled by spray programs for other insects; most insecticides are effective including spinosad (Success, Entrust), spinetoram (Delegate), carbaryl (Sevin), pyradibenz (Nexter), fenpyroximate (Fujimite), and imidacloprid (Admire).

**Biological control:**
- None.

**Cultural control:**
- None.
Critical Needs for Pear Sawfly Management in Pears:

Research:
- Alternative products are needed for rotation to avoid resistance.
- Develop effective organic-approved controls.

Regulatory:
- None at this time.

Education:
- None at this time.

Thrips

Pear thrips (*Taeniothrips inconsequens*)
Western flower thrips (*Frankliniella occidentalis*)

Pear thrips are very small (0.06 inch at maturity). Adults of these insects are dark and perceived as mere black specks when observed on foliage. Adult pear thrips have two pairs of wings, but are weak fliers. Consequently, dispersal by adults from one infested area to another may be attributed to wind currents. The larvae have red eyes and are pale cream to translucent green, which makes them difficult to observe on the foliage. Larvae sometimes congregate in groups on the foliage, which makes them more conspicuous. Adult western flower thrips range from clear lemon yellow to yellow brown to dark brown in color.

Feeding by pear thrips causes blasting of flower and leaf buds, and ragging of foliage. This pest has recently become a localized problem in the Mid-Columbia pear-growing region, especially in orchards that border habitat with native hosts such as maple and other deciduous trees. It is generally not a problem in the Wenatchee area.

Western flower thrips may damage pears grown throughout the Pacific Northwest. The primary damage is from egg punctures in newly formed fruit. Each puncture results in a slightly depressed russetted spot, between 0.125 and 0.25 inch in diameter. They also feed on the growing tips of newly planted trees, deforming tree growth.

Pear thrips are native to Europe and have been a pest in the US since the early 1900s on not only tree fruit but also an array of forest trees. This pest spends most of the winter as an adult female in the soil. Adults emerge in early spring and disperse to
a suitable host and crawl beneath a swollen bud scale to feed on immature plant tissue, which they can extensively damage. Eggs are laid soon after a suitable host is located. Following egg hatch, the larvae continue to feed while the adult thrips die off. The larvae drop to the soil in late spring and prepare to overwinter. Growers and advisors can use a beating tray during pink stage to monitor and detect immigrating pear thrips along border rows.

**Chemical control:**
- Spinetoram (Delegate): Used. Effective.
- Spinosad (Entrust, Success): Used. Effective.

**Biological control:**
- None.

**Cultural control:**
- None.

**Critical Needs for Thrips Management in Pears:**

**Research:**
- Identify and evaluate other effective chemistries (e.g. alternatives to formetanate hydrochloride, which was effective but is no longer registered for use in pears) for thrips control.
- Identify and develop products with long residual effects for thrips control.

**Regulatory:**
- None at this time.

**Education:**
- None at this time.

**Diseases**

**Phytophthora Crown and Collar Rot** (*Phytophthora cactorum*)

Phytophthora crown rot can be a problem in some areas of Washington with Bartlett and Anjou pears.

This rot appears as cankers on the trunk, between the soil line and the crown. Soil must be removed from the trunk to observe the cankers. Damage to the trees can
range from partial girdling of the tree to complete girdling and tree death if conditions remain favorable for the fungus.

This disease is not easily diagnosed from symptoms in the top of the tree. Scattered yellow leaves occur on trees in mid-season. In the fall, affected trees often develop a reddish or purple cast in the foliage, which becomes sparse. Foliar symptoms may appear only on branches directly above the canker, while the remainder of the tree appears normal and continues to bear fruit.

Crown and collar rot can be found in both young and older plantings, and can be a particular problem when replanting in old orchard sites. It is more serious in heavy, poorly drained soils than in light, well-drained soils, although it can occur in almost any soil with improper irrigation. Irrigation greatly influences the disease since the fungus is a water mold.

The fungus can be introduced into an orchard on planting stock, irrigation water, or on contaminated farm implements.

This disease can be difficult to control because it is an erratic disease and there is incomplete knowledge of the disease cycle. By the time infections are discovered, it is usually too late to eradicate the disease and save the tree.

**Chemical control:**
- After infection, remove soil from base of infected trees and spray the lower trunk with a fixed copper fungicide (50% metallic copper). Refill the area around the trunk with fresh soil in late fall.
- Fosetyl-al (Aliette): Used, efficacy unknown.
- Mefenoxam (Subdue): For non-bearing trees only.

**Biological control:**
- None known.

**Cultural control:**
- Choose resistant varieties and rootstocks. Susceptible rootstocks should not be planted where the soil is heavy or poorly drained.
- Select light soils with good drainage for orchard establishment.
- Keep irrigation periods to less than 8-hour runs.
- Plant shallow, and plant on raised beds.
- Provide tree support to young trees to prevent “rocking” in the wind, which results in an opening or well around the tree base, which collects water.
Pseudomonas Blossom Blast and Dieback

This disease is caused by *Pseudomonas syringae* pv. *syringae*, a bacterium. It can be a problem in the Medford and Mid-Columbia regions, but is generally not enough of a problem to warrant specific controls.

Rain and low temperatures, especially frost-inducing temperatures during bloom, increase incidence of blossom infection. Two common genetic traits increase the bacterium’s ability to cause disease: Most produce a powerful plant toxin, syringomycin, which destroys plant tissues as bacteria multiply in a wound, and the bacteria also produce a protein that acts as an ice nucleus, increasing frost wounds that bacteria easily colonize and expand.

Severe blossom blight can impact Packham’s Triumph, Bartlett, Eldorado, Anjou, and Bosc cultivars. Less severe blossom blight impacts Comice, Forelle, red Anjou, and red Bartlett cultivars.

Infection may cause blossom blast, leaf spots, dieback of twigs and spurs, dormant-bud death, and bark cankers. At first, bark cankers are light brown, irregular patches on limbs. Later, outer bark and some underlying tissues may wholly or partly slough away.

Blossom blast may closely resemble fire blight but is different in that blossom blast seldom extends more than 1 to 2 inches into the spur and never involves a bacterial exudate. The blossom blast may also resemble diseases caused by *Botrytis*.

**Chemical control:**
Resistance to copper has been documented. Copper applications can russet fruit. Copper-based products include:
- Champ
- Copper-Count-N
- Copper Sulfate (Cuprofix)
- Kocide
- ManKocide
- Monterey Liqui-Cop
- Nu-Cop: Approved for organic production.
- Biologically-based chemical controls:
  - Streptomycin (Agri-Mycin 17, Streptrol, and other brands)
  - Oxytetracycline (Terramycin, Mycoshield): Application at early bloom to control fire blight can also help control *Pseudomonas*. 
Biological control:
- None.

Cultural control:
- Protect from frost using a variety of methods including overhead irrigation or wind machines.
- Remove and destroy infected tissue.

Critical Needs for *Pseudomonas* Management in Pears:

Research:
- Develop an early-season alternative to copper for disease control and resistance management.
- Develop and test technology that allows fields to be sprayed in winter when soils are wet (e.g. balloon-tire tractors or tracked equipment).

Regulatory:
- None at this time.

Education:
- None at this time.

**Red Anjou Failure/Decline**

Red Anjou Failure is a disorder that affects the Columbia strain of red Anjou pears. Incidence of the disorder is reported to be higher in the Hood River Valley than in other areas, but it does occur in other Pacific Northwest pear districts.

It is characterized by sudden or slow tree decline, with reduced shoot growth, small fruit, and reddened foliage, and may result in tree death. Roots of affected trees show variable levels of decay symptoms and necrosis. The disorder has been observed on trees grafted on OHxF 97 and OHxF 87 rootstocks.

In the late 1990s, affected trees were tested for several common viruses, the pear decline phytoplasm, and other common pathogens, but no specific pathogen was determined to be associated with the disorder. Higher incidence of the disorder has been casually observed at orchard locations at higher elevations (e.g. Parkdale, OR), locations with sandy or gravelly soils, and in high traffic areas of orchards.
Analysis of root and shoot samples from Columbia Red Anjou and standard green Anjou trees showed lower carbohydrate concentrations in the Columbia Red Anjou trees. Based on that finding it was theorized that reduced carbohydrate storage might be contributing to the onset of the disorder. To date, no specific biotic or abiotic cause has been determined to cause the disorder.

Critical Needs for Red Anjou Failure/Decline Management in Pears:

Research:
- Identify causal agents in Red Anjou Failure/Decline (and impact on red Bartlett).

Regulatory:
- None at this time.

Education:
- None at this time.
IV. Emerging/Potential Pests

Brown marmorated stink bug (*Halyomorpha halys*)

The brown marmorated stink bug is an emerging pest threat that has recently been found in Mid-Columbia, Medford and Yakima. It is expanding its range yearly.

**Critical Needs for Emerging Pest Management in Pears:**

**Research:**
- Identify and evaluate a variety of biocontrols (viruses, predatory and parasitic insects, pheromones, etc.) to control brown marmorated stink bug.
- Better understand the species identification, phenology, and abundance of the types of stink bugs affecting growers in each pear-growing region.
- Conduct more research on favored hosts for brown marmorated stink bug to determine whether pear is a favored host.
- Continue support for brown marmorated stink bug research.
- Develop a control plan for brown marmorated stink bug.

**Regulatory:**
- Retain registration for chlorpyrifos (Lorsban) to control stink bug.

**Education:**
- Increase grower monitoring for stink bug.
- Educate growers and advisors about stink bug species identification and phenology, and importance of monitoring and scouting.
- Better educate growers and advisors regarding diagnosis of stink bug damage.
- Update and disseminate ID card to help with diagnosis of stink bug damage.
References


Activity Tables for Pears: Mid-Columbia Region

Notes:
- An activity may occur at any time during the designated time period but generally not continually during that time period.
- Each “x” in the table represents 1 week of the month; placement of the “x” can indicate beginning or end of a month.

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Activity Tables for Pears: Medford Region

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Activity Tables for Pears: Okanogan Region

Notes:
- An activity may occur at any time during the designated time period but generally not continually during that time period.
- Each “x” in the table represents 1 week of the month; placement of the “x” can indicate beginning or end of a month.

~ Cultural Activities ~

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86
Activity Tables for Pears: Wenatchee Region

Notes:
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~ Cultural Activities ~

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Activity Tables for Pears: Yakima Region

Notes:
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~ Pest Management Activities ~

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### Seasonal Pest Occurrence for Pears: Mid-Columbia Region

**Notes:**
- x = times when pest management strategies are applied to control these pests, not all times when pest is present.
- Each "x" in the table represents 1 week of the month; placement of the "x" can indicate beginning or end of a month.

#### Insects

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### Seasonal Pest Occurrence for Pears: Medford Region

**Notes:**
- x = times when pest management strategies are applied to control these pests, not all times when pest is present.
- Each "x" in the table represents 1 week of the month; placement of the "x" can indicate beginning or end of a month.

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# Seasonal Pest Occurrence for Pears: Okanogan Region

Notes:
- x = times when pest management strategies are applied to control these pests, not all times when pest is present.
- Each “x” in the table represents 1 week of the month; placement of the “x” can indicate beginning or end of a month.

## Insects

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91
## Seasonal Pest Occurrence for Pears: Wenatchee Region

**Notes:**
- x = times when pest management strategies are applied to control these pests, not all times when pest is present.
- Each "x" in the table represents 1 week of the month; placement of the "x" can indicate beginning or end of a month.

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92
## Seasonal Pest Occurrence for Pears: Yakima Region

**Notes:**
- x = times when pest management strategies are applied to control these pests, not all times when pest is present.
- Each “x” in the table represents 1 week of the month; placement of the “x” can indicate beginning or end of a month.

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Efficacy Ratings for INSECT and MITE Management Tools in Pears

**Rating scale:** E = excellent (90–100% control); G = good (80–90% control); F = fair (70–80% control); P = poor (< 70% control); ? = efficacy unknown in pear management system—more research needed; * = used but not a stand-alone management tool; Blank = control would not be used for this pest.

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<th>Leafroller</th>
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<td>Novaluron (Rimon) + Horticultural oil</td>
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<td>Grape mealybug</td>
<td>Leafroller</td>
<td>Pear psylla</td>
<td>San Jose scale</td>
<td>Spider mites</td>
<td>Thrips</td>
<td>True bugs</td>
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<td>Permethrin (Ambush) + Horticultural oil</td>
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<td>Spirodoclofen (Envidor)</td>
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<td>Spirotetramat (Ultor)</td>
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<td>Thiamethoxam (Actara)</td>
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</table>

| New Chemistries |              |               |                |            |             |                |              |        |            |          |
| Cyantraniliprole |              |               |                |            |             |                |              |        |            | G        |

| Biological |              |               |                |            |             |                |              |        |            |          |
| Pheromone traps | G           |               |                |            |             |                |              |        |            |          |
| Granulosis virus | F           |               |                |            |             |                |              |        |            |          |

| Natural predators | F | F | F |          |

| Cultural / Non-Chemical |              |               |                |            |             |                |              |        |            |          |
| Avoid excess nitrogen fertilizer | F* |               |                |            |             |                |              |        |            |          |
| Avoid dry, dusty conditions | F* |               |                |            |             |                |              |        |            |          |
| Best practices at harvest | F* |               |                |            |             |                |              |        |            |          |
| Cultivation |              |               |                |            |             |                |              |        |            | *        |
| Fruit thinning |              |               |                |            |             |                |              |        |            | *        |
| Irrigation management |              |               |                |            |             |                |              |        |            | *        |
| Remove brush/debris from orchard |              |               |                |            |             |                |              |        |            | *        |
| Remove suckers and sucker crowns |              |               |                |            |             |                |              |        |            | *        |
| Weed free ground covers & use of cover crops |              |               |                |            |             |                |              |        |            | *        |
Efficacy Ratings for DISEASE Management Tools in Pears

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

<table>
<thead>
<tr>
<th>MANAGEMENT TOOLS</th>
<th>Fire blight</th>
<th>Powdery mildew</th>
<th>Russetting</th>
<th>Scab</th>
<th>Postharvest decay</th>
<th>COMMENTS</th>
</tr>
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<tr>
<td>Registered Chemistries</td>
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<td>Antibiotics (oxytetracycline, streptomycin)</td>
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<td>Bicarbonate-based products (Kaligreen, Milstop)</td>
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<td>Boscalid + pyraclostrobin (Pristine)</td>
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<td>E</td>
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<tr>
<td>Calcium hypochlorite</td>
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<tr>
<td>Calcium polysulfide (BSP lime sulfur, others)</td>
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<td>Captan</td>
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<td>Copper (Kocide, Champ, others)</td>
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<td>Cypocillin (Vangard)</td>
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<td>Difenconazole + cypocillin (Inspire Super)</td>
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<td>Fenhexamid (Judge)</td>
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<td>Ferbam (Ferbam Granulfo)</td>
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<td>Fludioxonil (Scholar)</td>
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<td>Fluxapyroxad + pyraclostrobin (Merivon)</td>
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<td>Fosetyl-Al (Aliette)</td>
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<td>Fruit wraps (Burrows, Ethoxywrap)</td>
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<td>Horticultural oil</td>
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<td>Kresoxim-methyl (Sovran)</td>
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<td>Mancozeb (Dithane, Manzate)</td>
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<td>Polyoxy D (Ph-D WDG)</td>
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<td>Pyrimethanil (Scala, Penbotec)</td>
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<td>Sodium orthophenylphenate (Deccosol, Stop Mold)</td>
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<td>Sulfur</td>
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<td>Tebuconazole + Triflurostrobin (Adament)</td>
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<td>Thiabendazole (Mertect)</td>
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## MANAGEMENT TOOLS

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<th>COMMENTS</th>
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<td><strong>Unregistered / New Chemistries</strong></td>
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<td>Copper octonoate (Cueva)</td>
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<td><strong>Biological and Biologically-based</strong></td>
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<td><em>Aureobasidium pullulans</em> (Bloom Protect)</td>
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<td><em>Bacillus amyloliquefaciens</em> (DoubleNickel 55)</td>
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<td><em>Bacillus pumilis</em> (Sonata)</td>
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<td>-Other products more effective</td>
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<td><em>Pseudomonas syringae</em> (Bio-save)</td>
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<td><strong>Cultural / Non-Chemical</strong></td>
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<td>Apply dolomitic lime to increase soil pH</td>
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<tr>
<td>Avoid excessive nitrogen fertilizer</td>
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<td>Best harvest practices (harvest at proper maturity, use proper techniques, clean bins and storage rooms, cool fruit quickly, avoid injury)</td>
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<td>Foliar nutrient sprays before harvest</td>
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<td>Maintain good in-row weed control</td>
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<td>Prune infected twigs</td>
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<td>Reduce irrigation/avoid overhead irrigation</td>
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<td>Remove and bum blight</td>
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<td>Remove blooms during first year, remove late blooms in subsequent years</td>
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<td>Remove infected terminal buds</td>
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<tr>
<td>Remove sources of inoculum/infected young trees</td>
<td></td>
<td></td>
<td></td>
<td>E</td>
<td>E</td>
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<tr>
<td>Speed decomposition of fallen leaves (using shredding and/or nitrogen applications)</td>
<td></td>
<td></td>
<td></td>
<td>E</td>
<td>E</td>
<td>G</td>
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<tr>
<td>Sterilization of tools</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>E</td>
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<tr>
<td>Use best cutting practices (do not cut wet trees, cut proper distance beyond discoloration)</td>
<td></td>
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<td></td>
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<td>E</td>
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<tr>
<td>Use controlled-atmosphere storage</td>
<td></td>
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</tr>
<tr>
<td>Use disease/weather forecasting models</td>
<td></td>
<td></td>
<td></td>
<td>E</td>
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</tbody>
</table>
Efficacy Ratings for WEED Management Tools in Pears

**Rating scale:** E = excellent (90–100% control); G = good (80–90% control); F = fair (70–80% control); P = poor (<70% control); ? = efficacy unknown—more research needed* = used but not a standalone management tool; Blank = control would not be used for this pest. Note: Weed size or stage of growth is an important consideration with most post-emergence herbicides.

In “Type” column, Pre = soil-active against pre-emerged weeds; Post = foliar-active against emerged weeds. (Note: Although rated singularly, many of these products are combined with others and used at lower rates to provide more broad spectrum control).

<table>
<thead>
<tr>
<th>MANAGEMENT TOOLS</th>
<th>Type</th>
<th>Annual Broadleaves</th>
<th>Perennial Broadleaves</th>
<th>Annual Grasses</th>
<th>Perennial Grasses</th>
<th>Woody Species</th>
<th>Nutsedge</th>
<th>COMMENTS</th>
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</thead>
<tbody>
<tr>
<td>Registered Chemistries</td>
<td>Soil-active</td>
<td>F</td>
<td>P</td>
<td>F</td>
<td>F</td>
<td>P</td>
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<tr>
<td>Diuron (Karmex)</td>
<td></td>
<td>G</td>
<td>F</td>
<td>P</td>
<td>F</td>
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<td>Dichlobenil (Casoron)</td>
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<td>G</td>
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<td>Isoxaben (Trellis)</td>
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<td>P</td>
<td>P</td>
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<td>Indaziflam (Alion)</td>
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<td>P</td>
<td>G</td>
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<td>Napropamide (Devrinol)</td>
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<td>Norflurazon (Solicam)</td>
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<td>Oryzalin (Surflan)</td>
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<td>Pendimethalin (Prowl)</td>
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<td>Pronamide (Kerb)</td>
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<td>E</td>
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<td>Terbacil (Sinbar)</td>
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<td>Trifluralin + isoxaben + oxyfluorfen (Showcase)</td>
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<td>Simazine (Princep)</td>
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<td>Flumioxazin (Chateau)</td>
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<td>Not used; better products available</td>
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<td>Oxyfluorfen (Goal)</td>
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<td>Rimsulfuron (Matrix)</td>
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<td>Saflufenacil (Treevix)</td>
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<td>Acetic acid (Weed Pharm)</td>
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<td>Carfentrazone (Aim)</td>
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<td>Phytotoxicity/drift issues</td>
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<td>Diquat (Reglone)</td>
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<td>Paraquat (Gramoxone)</td>
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<td>MANAGEMENT TOOLS</td>
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<td>Annual Broadleaves</td>
<td>Perennial Broadleaves</td>
<td>Annual Grasses</td>
<td>Perennial Grasses</td>
<td>Woody Species</td>
<td>Nutedge</td>
<td>COMMENTS</td>
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<td>Clopyralid (Stinger)</td>
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<td>Fluazifop (Fusilade DX)</td>
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<td>Non-bearing trees only.</td>
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<td>Glyphosate (Roundup, others)</td>
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<td>Sethoxydim (Poast)</td>
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<td><strong>Unregistered / New Chemistries</strong></td>
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