OREGON STATE UNIVERSITY EXTENSION SERVICE

Integrated Pest Management Strategic Plan

for Oregon and Washington Pears

Summary of a workshop held on March 5, 2020 in Hood River, Oregon

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Process for this integrated pest management strategic plan

In a proactive effort to identify pest management priorities and lay a foundation for future strategies and increased use of integrated pest management in pear production in the Pacific Northwest, growers, commodity-group representatives, pest control advisors, processors, university specialists and other technical experts from the pear industry in Oregon and Washington formed a workgroup and assembled this plan. Members of the group met for a day in March 2020, in Hood River, Oregon, where they discussed and reached a consensus about this plan. It outlines major pests, current management practices, critical needs, activity timetables and efficacy ratings of various management tools for specific pests in pear production. The result is a strategic plan that addresses many IPM and pest-specific critical needs for the pear industry.

A list of top-priority critical needs was created based on a group voting process at the workgroup meeting. The list was drawn from an assessment of all the needs that appear throughout the document, which were compiled based on input from workgroup members. A list of broader IPM needs was also compiled, based on identified needs related to specific topics. Crop-stage-specific critical needs are also included, listed and discussed throughout this publication.

This strategic plan begins with an overview of pear production. The overview is followed by discussion of critical production aspects of this crop, including the basics of IPM in pear production in Oregon and Washington. Each pest is described briefly, with links provided for more information about the pest's biology and life cycle. Within each major pest grouping (insects, diseases and weeds), **individual pests are presented in alphabetical order, not in order of importance**. The remainder of the document is an analysis of management practices and challenges organized by crop life stage in an effort to assist the reader in understanding whole-season management practices and constraints. Current management practices are presented using a "Prevention, Avoidance, Monitoring, and Suppression" framework to place practices within a simple IPM classification and to demonstrate areas where additional tools or practices may be needed. For more information, see Appendix "Using PAMS Terminology" (page 79).

Trade names for certain pesticides are used throughout this document as an aid for the reader. The use of trade names in this document does not imply endorsement by the workgroup or any of the organizations represented.

Work group members

In attendance

Chris Adams, Oregon State University

Achour Amiri, Washington State University

Todd Campbell, Bear Creek Orchards

Rodney Cooper, USDA Agricultural Research Service

Tianna DuPont, Washington State University

Bob Gix, Blue Star Growers; Pear Research Subcommittee

Rick Hilton, Oregon State University

Achala KC, Oregon State University

Bruce Kiyokawa, Chamberlin Distributing

Craig Mallon, Duckwall Fruit, Oregon

Kathleen McNamara, Bear Creek Orchards

John Neilsen, Medford Welfare Farm, Oregon

Louis Nottingham, Washington State University

Sam Parker, Parker Orchards, WA

Chris Peters, Legacy Fruit, WA

Rebecca Schmidt-Jeffris, USDA Agricultural Research Service

Tory Schmidt, Washington Tree Fruit Research Commission/Dalen Fruit

Chris Strohm, Washington State University

Ashley Thompson, Oregon State University

Others in attendance

Chris Hedstrom, Oregon State University

Katie Murray, Oregon State University

Paul Jepson, Oregon State University

Contributing work group members not in attendance at workshop

Dave Epstein, Northwest Horticultural Council

Review of 2014 summary of most critical needs in pear pest management

A pest management strategic plan was last developed for Oregon/Washington pears in 2014. The following needs were identified by the 2014 workgroup as "most critical." An update on current progress follows each item.

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 (for example, controlling certain pests while preserving pollinators and natural enemies that help control other pests, such as codling moth, pear psylla and mites).
  - ❏ This work is in progress.
- Develop best practices for nutrient and irrigation management of pear trees by region (that is, refine fertilizer and irrigation recommendations) to help growers manage/reduce excessive vigor and balance shoot growth and fruit production.
  - ❏ This work has been ongoing; progress will be longer-term.
- Develop an irrigation strategy that is conducive to controlling for multiple pests (for example, the recommendation is for overhead sprinklers for pear psylla and codling moth management, while for management of storage rot the recommendation is for low-angle nozzles).
  - ❏ This work is in progress but is a long-term project. The impacts of conflicting irrigation recommendations for insect pest and disease control remain an important area across research and extension.
- Analyze the economic impacts of major pear pests and the implementation of control measures in order to better understand what drives pest management decisions and to help establish priorities for future research.
  - ❏ Some work is underway in this area, but this is a continuing need. More research is needed, including input from economists and agricultural business sectors.
- Determine the impacts of regional climate differences on pest populations and pear trees in general (for example, pest overwintering, fecundity, life cycle, etc.).
  - ❏ This is an important area and a continuing need. Some work is being done on non-crop pest habitats and natural enemy population variations between regions.
- 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.
  - ❏ This remains a critical need, with resistance and nontarget effects included in evaluation. Some work is ongoing for fungicides.
- Secure funding for more research in both Oregon and Washington with regard to pear pest management.
  - ❏ This is an ongoing need.
- 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.
  - ❏ This is a continuing need. Consumer acceptance also needs to be evaluated across existing cultivars and rootstocks.
- Improve dwarfing rootstocks available to pear producers (for example, investigate worldwide germplasm and/or develop a breeding program for the Pacific Northwest).
  - ❏ This is a critical and ongoing need. There is a rootstock breeding program in its third year, but results are long-term (10–20 years).

- Better coordinate university and researcher priorities with grower priorities.
  - ❏ This is an ongoing critical need, although progress has been made including these and other strategic plans.
- Bring pear researchers together on a regular basis to share and discuss current research, challenges and potential solutions.
  - ❏ This is an ongoing need.
- Develop comprehensive best management practices that maximize yield and fruit quality.
  - ❏ This is an ongoing need.
- 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.
  - ❏ The industry is engaged in a process to develop a white paper review of what is known regarding pear psylla. This needs dissemination and emphasis on other insects and diseases.
- Develop an industrywide reader/paper/website to keep growers updated with current research.
  - ❏ There are multiple websites serving the region but improvements could be made.
- Develop a general economic best-practice guide for major pear pests.
  - ❏ This is an ongoing need.
- Research and develop more effective sprayer technology.
  - ❏ This is a continuing need with slow progress, particularly with technology that focuses on pears.
- Research cropping systems and canopy management with relation to pest management, vigor and profitability.
  - ❏ This is an ongoing, important topic. Some progress has been made but this is a long-term project.
- Research more effective controls (for example, products and technology) for postharvest decay for better control and resistance management.
  - ❏ This remains a challenge. More understanding is needed about post-harvest control variables (including the impacts of pre-harvest control) and practical measures for sanitation, including the barriers to implementation of known best practices.
- Research the interactions between codling moth and pear psylla (biology and control).
  - ❏ This is an ongoing need that could be expanded to include mites and natural enemies — how does management impact these various pests?
- Develop "softer" pesticide alternatives to rotate with granulosis virus for effective codling moth control and better resistance management.
  - ❏ This is an ongoing need.
- Identify reduced-risk pesticides, as well as new pesticide modes of action, for control of pear psylla.
  - ❏ This is a continuing critical need. Testing is ongoing.
- Design and conduct a pollination study for crop yield control.
  - ❏ This is an ongoing need to help ensure consistent and large yields. Many current pollinizers are inadequate for the varieties grown, which has negative impacts. Pollinizers with a better mix of alleles would increase the potential for crop set.

Regulatory

- Develop crop-specific, risk-based food safety regulations.
  - ❏ This is an ongoing need. Work completed for the apple industry could be modified for pear.
- Collaborate with the IR-4 Program to identify and expedite new registrations.

- ❏ This is an ongoing need, and includes collaborations with pesticide companies.

- ■ Research the potential for increasing rates of certain products (abamectin, spinetoram, spirotetramat) to enhance efficacy.
  - ❏ This has been addressed in recent research (rate trials have influenced labels), but there is an ongoing need for this with organic-approved products.
- ■ 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.
  - ❏ New products have been registered. There is an ongoing need for additional, nonantibiotic products, including resistant plants.

Education

- ■ Educate growers and advisors regarding additional strains of granulosis virus for codling moth control.
  - ❏ Education is needed regarding the importance of concurrent multiple strategies to achieve control. This can be achieved through mating disruption and other strategies, including granulosis virus.
- ■ Develop a Western Region Pear Pest Management Coordinating Committee for information synthesis and dissemination.
  - ❏ This is an ongoing need.
- ■ Develop a well-funded university Extension education system.
  - ❏ Multiple new hires have taken place across Oregon and Washington; much more support is needed.
- ■ Educate growers on best practices for resistance management when controlling for pear psylla.
  - ❏ This is a continuing need, for psylla as well as other pests and pathogens including post-harvest decay resistance management.
- ■ Once research has been completed, educate growers and advisors on salient points from past research on pear pests and management.
  - ❏ This is an ongoing need.
- ■ Secure funding for more education in both Oregon and Washington with regard to pear pest management.
  - ❏ This is an ongoing need. Integrated research and Extension projects can ensure education follows research results.

2020 top-priority critical needs

The following critical needs were voted as the top-priority needs by the work group members in March. Crop-stage-specific aspects of these needs, as well as additional needs, are listed and discussed throughout the body of the document. The order of appearance within these lists does not reflect an order of importance.

Research topics

- ■ Develop phenology-based management programs for pear psylla.
- ■ Develop an areawide program for psylla management.
- ■ Evaluate the impacts — positive and negative — of mixing particle films with insecticides.
- ■ Research overwintering biology, phenology and local movement patterns (for example, alternate hosts) for psylla and other insects, including scales and mites.
- ■ Determine the impacts of various pest management practices, including pesticides, on pear pests' natural enemies.
- ■ Explore the potential for acoustic disruption of psylla mating.

- Quantify the levels of inoculum of postharvest diseases that lead to negative outcomes in the packing house to improve in-season monitoring.
- Research the impacts of multiple oil sprays to trees on general outcomes, such as tree health and impacts on other nontarget pests.
- Investigate the potential for biological control by evaluating various species effectiveness for pest control, application timing and release rate for nonendemic natural enemy species

Regulatory actions

- It is critical that growers have access to the workers they need to grow and harvest their crops. Support agricultural workforce reform that provides certainty for the workforce and addresses future needs.
- Registration of new, organic-approved materials, including herbicides, miticides and insecticides (pear psylla would be a priority target pest).
- Develop priority lists for product maximum residue limits (MRLs) in specific export markets; work with the Northwest Horticultural Council to obtain maximum residue limits in key export markets for preferred pesticides where maximum residue limits are currently not supported by registrants.
- Work with registrants to request label changes from EPA allowing more flexible use of nutrient particle films and oils, including products such as Microna (calcium carbonate) and Diamond K Gypsum (soluble gypsum) that provide psylla control.
- Develop a priority list of products for which the industry could request that EPA ease label restrictions on application methods (for example, aerial), which limit pest management options due to difficulty of getting sprayers into orchards at certain timings.
- Registration for new, high-efficacy products for fire blight management.
- Request label modifications for fire blight products to extend use beyond bloom and include petal fall, or allow shorter preharvest intervals to accommodate midseason use.

Education

- Educate pest managers and applicators on proper sprayer calibration and maintenance.
- Educate pest managers regarding beneficial insect identification (seasonlong).
- Educate pest managers on ideal timing, products and systems for honeydew washing.
- Establish an insect-scouting network that includes shared information and resources about phenology and management.
- Education to clarify the regulatory definition of GMO in light of new breeding technologies.
- Educate pest managers about the use of proper pollinizer varieties.
- Educate pest managers about pesticide risks (including human health risks to handlers and applicators and risks to natural enemies).

Pear production overview

Crop statistics[1]

Commercial pear production in the United States is concentrated in the Northwest, with Washington and Oregon producing over 80% of the nation's crop. There are more than 800 pear growers in Oregon and Washington who ship their pears through 31 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) and generally ripen on their own. The later harvested "winter pear" varieties include 'Anjou', 'Comice', 'Bosc' and 'Red Anjou'. These typically require a period of chilling in cold storage before they will ripen properly.

In 2019, Washington ranked first in U.S. pear production, with over 600 growers and 20,400 bearing acres. Farmers in Washington grew approximately 330,000 tons of pears. The crop value for Washington pears exceeded $145 million in 2019, placing pears among the state's top agricultural commodities.

In 2019, Oregon pear growers ranked second in U.S. pear production, with over 200 growers and 15,000 bearing acres. Farmers in Oregon grew approximately 236,000 tons of pears in 2019. The crop value for pears in Oregon in 2019 exceeded $109 million, with pears among the state's top agricultural commodities.

The main growing regions throughout Washington and Oregon are the Okanogan, Wenatchee and Yakima valley areas of Washington, the Mid-Columbia area of Washington and Oregon, and the Medford area of Oregon.

For the 2018 crop year (the latest complete season), Washington exported 31% of its fresh pears, while Oregon exported just over 36%. The main countries receiving pears from the Pacific Northwest are Mexico (82,322 exported

Pear growing regions and main varieties by region in Washington and Oregon.

[1] Crop statistics provided by Pear Bureau Northwest, 2020

tons) and Canada (32,413 exported tons), although Northwest pears are exported to more than 44 countries worldwide.

Throughout both states, 'Anjou' was the most abundantly grown variety followed by 'Bartlett' and 'Bosc'. Of the entire crop produced in Oregon and Washington, the majority is sold fresh (with the two states accounting for 88% of U.S. fresh pear production), with a smaller percent processed into canned pears, juice and other products.

Fresh pear production in Oregon and Washington, 2019*

Variety		OR/WA tons	% Oregon	% Washington
Summer pears	'Bartlett'**	85,402	42.14%	57.86%
	'Red Bartlett'	1,050	3.43%	96.57%
	'Starkrimson'	5,689	62.82%	37.18%
Winter pears	(Green) Anjou	194,420	51.59%	48.41%
	'Bosc'	44,707	62.57%	37.43%
	'Comice'	3,170	98.83%	1.17%
	'Red Anjou'	23,475	61.21%	38.79%
	'Forelle'	1,084	100%	0%
	'Concorde'	664	0%	100%
	'Seckel'	556	85.07%	14.93%
	Other winter pear	823	82.50%	17.50%
Total OR/WA Fresh Pears		361,040	51.97%	48.03%

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

** Processed 'Bartlett' pears are not included in this table but are included in overall production statistics earlier in this section.

Specifics of pear production

In Pacific Northwest pear orchards, tree and row spacing and tree density per acre can vary considerably. Orchards range 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 are uncommon due to a lack of well adapted, precocious and productive, size-controlling rootstocks.

Average yield is between 15–20 tons per acre for fresh pears and 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 four to eight 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. Commercial producers generally plant 10% to 25% of each block with pear pollinizers ('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 begins 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 30-pound shoulder bags and placed into orchard bins to minimize bruising. The pears are immediately transported and rapidly cooled at packinghouses, 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 2–12 weeks of cold storage to ripen to their highest quality, although conditioning (preripening) in storage with ethylene is becoming a frequent practice. Fresh pears are sometimes marketed and sold in 44-pound boxes, although other box styles and bagging options include special buyer boxes, bags and pouch packages.

Integrated pest management strategies in pear production

Integrated pest management is an approach to pest control developed in the 1960s and has been the prevailing school of thought since. 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, predictive models, 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. 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 interplanted 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 serious pear pest, eclipsing codling moth in importance in some regions. Recent advances codling moth control, such as mating disruption, have had a positive impact on pest management and fit well into IPM programs. Sterile insect release is a promising tactic under development.

Pear cultivars vary more widely than apple cultivars in their susceptibility to codling moth, although all are vulnerable to attack. The winter pears (for example,, ‘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, making them 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 are decades-old in the north, but are now beginning to develop in the south. While summer pears are more resistant to pear psylla, winter pears are more sensitive, particularly the ‘Anjou’ variety.

While cultivar and production practices may play a role, regional climate and landscape effects may also have an impact. Areas with colder, drier winters have greater pear psylla pressure than warmer moister winters. A combination of solutions will be needed to address these issues, including breeding and genetics.

Photo: © Oregon State University

Rick Hilton of SOREC checking pheromone trap for codling moth.

Pear export markets and maximum residue limits

The Pacific Northwest produces over 80% of the U.S. pear crop, around a quarter of which is exported annually. Top export markets for pears include Mexico, Canada, Israel and Colombia. A more extensive list is available on the Northwest Horticultural Council's website at https://nwhort.org/industry-facts/pear-fact-sheet/.

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 continues to change regularly. Difficulties arise when a residue tolerance for a pesticide set by the EPA in the United States differs from pesticide maximum residue limit in a foreign market. 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 https://nwhort.org/export-manual/comparisonmrls/pear-mrls/.

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, foreign countries typically use a level of detection value of 0.01 ppm for the pesticide in question, resulting in increased risk of having fruit rejected due to a pesticide residue. 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 is because the newest pesticide products are not registered for use in certain export markets. This may be because the market is too small for a pesticide registrant to justify maximum residue limit establishment costs, or an establishment of a maximum residue limit is pending (typically takes two to three years), or because a country of interest does not allow use of that specific product. In these cases, there is less urgency to establish a use-based maximum residue limit in that market, which can delay the adoption of effective products by U.S. growers. Lack of maximum residue limits in foreign markets can also restrict resistance-management programs in the U.S. by limiting options of pesticides with differing modes of action in seasonlong pesticide rotations designed to manage against resistance to more-limited pesticide options eligible for specific export markets.

Standardization of international maximum residue limits 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 grower applications that differ from labeled use could help determine application timing by which products can safely be used (rate by application timing prior to harvest) in order to meet export maximum residue limits.

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 or other growth-promoting practices (for example,, 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 can reduce shoot growth of pear, and subsequently pear psylla abundance; however, 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.

Yet, narrower canopies have demonstrated enhanced insect and disease control in apples, as well as better light penetration through the canopy, which improves fruit quality and reduces disease. Improved rootstock genetics offer improved economics and easier control of some of the critical pests currently being faced. Improved scion genetics will have the potential to increase insect, heat, and stress resistance, and potentially offer a more consistent consumer experience.

IPM critical needs

The following list of broad IPM needs was compiled based on input from workgroup members. Participants were asked to identify specific needs related to each of the headings in bold.

Decision and knowledge support

- Develop phenology models for key pear pests and diseases and increase usage and accessibility of these; also develop phenology models for natural enemies.
- Develop economic thresholds that account for both pests and natural enemies.
- Improve fire blight models.
- Develop inexpensive fruit growth monitoring systems.
- Develop decision-support tools for multipest, multicrop and areawide management.
- Increase the number of weather stations and coverage of predictive models.
- Reduce fees or subsidize access to Washington State University's Decision Aid System).
- Develop resistance monitoring and testing programs that are localized and frequent.
- Develop a decision-support tool that focuses on preharvest management for postharvest diseases.
- Assist growers in transitioning to organic certification.
- Design and test economic decision-making tools that prioritize management options.

Reduced reliance on and development of alternatives to agrochemicals

- Increase focus on breeding for pest and diseases resistant varieties.
- Explore the genetic potential of *Pyrus* spp.
- Provide funding and incentives to support innovation and on-farm trials with alternative methods.
- Explore canopy manipulation and training systems.
- Advance knowledge about protecting and sustaining natural enemy populations.
- Evaluate the most effective species, timing and rates for natural enemy release and develop recommendations for release that optimize survival.
- Investigate the impacts of exclusion nets and shade cloth on insects and pear horticulture.
- Determine the impacts of pesticides on key natural enemies.
- Develop and educate about best practices for promoting and creating and maintaining habitat for natural enemies.
- Investigate the impacts of weed management on pests and natural enemies.
- Invest in the development and evaluation of cultural (nonchemical) controls for key pear pests.
- Identify effective nonantibiotic alternatives for fire blight control.

Pollinator protection

- Examine the role of species other than the European honeybee (*Apis mellifera*) in increasing pear yields.
- Investigate the impact of pollinator protection on other aspects of IPM.
- Investigate impacts of fire blight sprays on pollinators.
- Enhance public and consumer awareness regarding the various threats to pollinators, including those unrelated to agriculture.
- Research and educate on pesticide interactions to pollinators.

Water quality

- Communicate with pesticide applicators regarding found residues and mitigations.
- Incentivize changes to sprayer technology to improve accuracy and efficacy.
- Reduce or eliminate open ditches.
- Improve piping for all irrigation delivery systems.
- Educate pest managers on pesticide risks to aquatic systems and mitigations.
- Increase water quality testing.

Human health and worker protection

- Increase worker safety materials and trainings available in Spanish.
- Identify strategies to decrease the need for workers to be on ladders.
- Re-evaluate PPE requirements for workers, including an assessment of thermal stress, and increase outreach with results.

List of major pear pests

(listed alphabetically)

Insects and mites

Codling moth

Grape mealybug

Leafrollers

Pear psylla

Pear rust mite

Pearleaf blister mite

San Jose scale

Sawflies (including California pear sawfly, dock sawfly and pear slug) (mainly a pest in organic orchards)

Spider mites

Stink bugs

Thrips

Western boxelder bug

Pathogens, nematodes and disorders

Canker diseases

Cork spot

Crown gall

Fire blight

Nematodes

Pear decline viruses and phytoplasmas

Postharvest decay

Powdery mildew

Phytophthora root and crown rot

Replant complex (*Phytopthora, Pythium, Rhizoctonia, Ilyonectria, Pratylenchus nematode*)

Russet

Pacific Coast pear rust

Scab

*Sprinkler rot (*Phytophthora)

Weeds

Problem weeds include field bindweed, yellow nutsedge, barnyard grass, poison hemlock, blackberries, prickly lettuce, puncturevine and nightshades

Invasive and emerging pests

Brown marmorated stink bug

Spotted lanternfly

Post-harvest diseases from imported fruit

Vertebrate pests

Deer/elk

Ground squirrels

Marmots

Pocket gophers

Rodents (voles, moles, orchard mice)

Turkeys

Pear pest management timing by crop stage

Dormancy

(*November-February; Bud Stage 0**)

Pear psylla, fire blight, weeds, rodents

Delayed dormancy

(*February-March; Bud Stages 1 and 2**)

Pear psylla, grape mealybug, San Jose scale, eriophyid mites, pear psylla, true bugs

Cluster bud through popcorn

(*March-April; Bud Stages 3, 4 and 5**)

True bugs, pear psylla, mealybug, San Jose scale, leafrollers, eriophyid and spider mites, powdery mildew, scab*, fire blight, russet

Bloom

(*April-May; Bloom = Bud Stage 7**)

Fire blight, powdery mildew, pear scab**, russet, leafrollers, weeds

Petal fall to early summer

(*May*)

Fire blight, pear psylla, codling moth, leafrollers, grape mealybug, eriophyid mites, pear scab*, powdery mildew, storage rot, weeds

Summer

(*May-September*)

Codling moth, pear psylla, grape mealybug, true bugs, leafrollers

San Jose scale, European red mite, spider mites, eriophyid mites, pear scab

Cover sprays: codling moth, pear psylla, spider mites, weeds

Preharvest through harvest

(*July-August for summer pears; September-October for winter pears*)

Storage rots, weeds

Pear psylla, eriophyid mite, rodents, weeds

After harvest

* See Bud development chart (courtesy Washington State University), page 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-April; Bud Stages 1 and 2**)

Pest scouting, insecticide application, weed management, frost protection, planting

Cluster bud through popcorn

(*March-April; Bud Stages 3, 4, and 5**)

Pest scouting, pre-bloom insecticide and miticide applications, fungicide application, frost protection

Bloom

(*April-May; Bloom = Bud Stage 7**)

Pest scouting and monitoring, fungicide application, weed management, fire blight application, frost protection, place pheromone traps in orchard

Petal fall through early summer

(May)

Pest scouting and monitoring, insecticide and miticide applications, fungicide application, fire blight pruning, fruit thinning (chemical, hand), hang pheromone dispensers

Summer

(*May-September*)

Pest scouting and monitoring, insecticide and miticide applications, fungicide application, fire blight pruning, weed management, tree training, calcium application, fertilizer (liquid), bin placement

Preharvest through harvest

(*July-August for summer pears; September-October for winter pears*)

Pest management assessment and fruit cull analysis, weed management

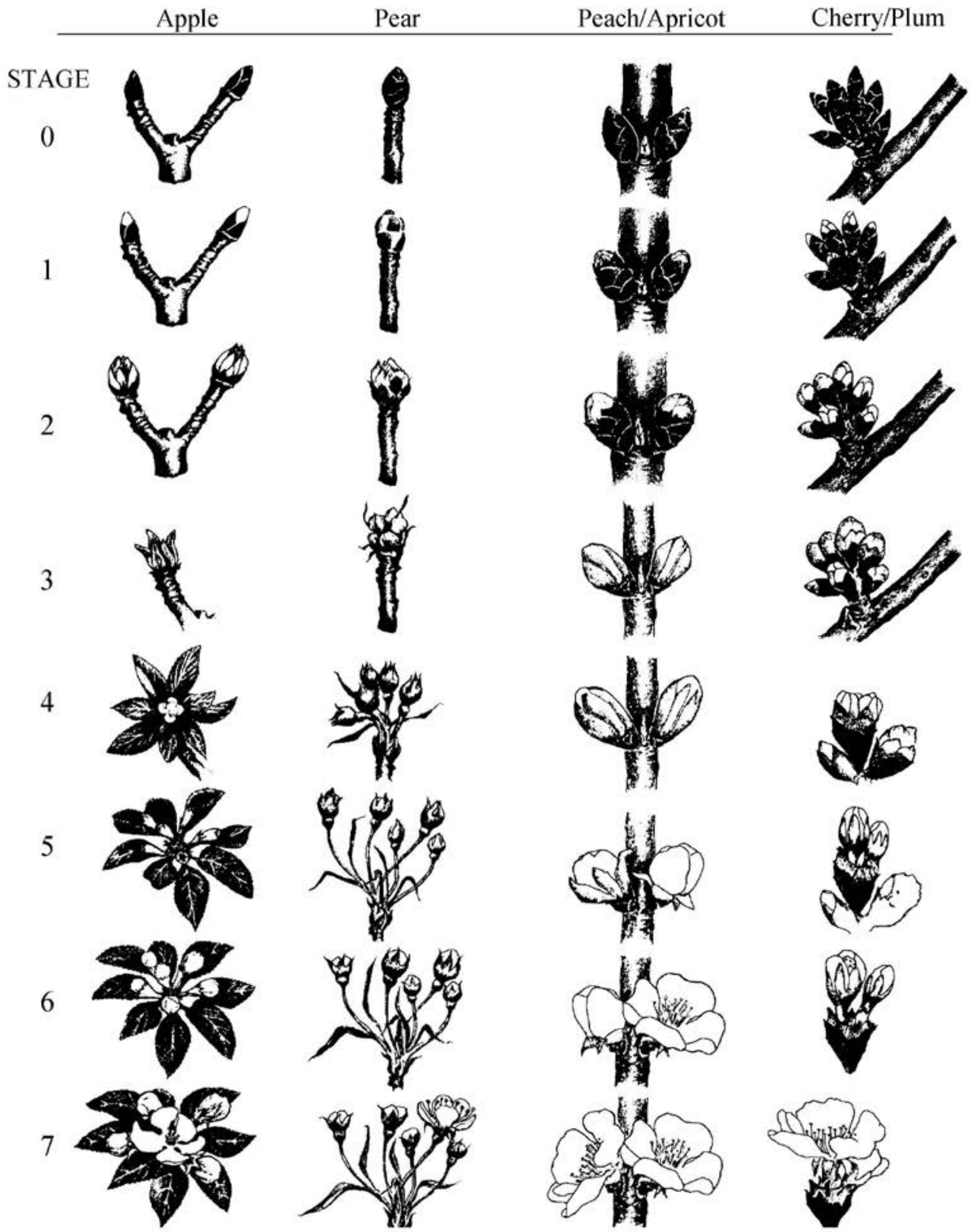
After harvest

(*October*)

Pest scouting, insecticide application, fungicide application, herbicide application, rodent control, fertilization (dry), pruning

Tree Fruit Bud Development Chart

(see keys on following page)



Source: Washington State University Extension Service.

Major pear pest descriptions

Insects and mites

Codling moth (*Cydia pomonella*)

For more information see: https://pnwhandbooks.org/insect/tree-fruit/pear/pear-codling-moth

This insect can be a serious pest in pears, especially in the warmer, drier 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 mainly 'Bartletts are grown, and 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 managed using mating disruption 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 and spider mite problems.

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

Eriophyid mites

Pear rust mite (*Epitrimerus pyri*)

Pearleaf blister mite *(Eriophyes pyri)*

For more information see: https://pnwhandbooks.org/insect/tree-fruit/pear/pear-eriophyid-mite or http://treefruit.wsu.edu/crop-protection/opm/pear-rust-mite/ or http://treefruit.wsu.edu/crop-protection/opm/blister-mites/

Eriophyid mites can be a problem pest in all Oregon and Washington pear-growing regions. This is especially true for pears grown for export. Nonrusseted cultivars like 'Anjou' and 'Bartlett' are particularly susceptible.

Pear rust mite can be difficult to control in organic orchards and requires multiple treatments in conventional orchards. Feeding by pear rust mites on foliage causes bronzing of the leaves (which is not particularly damaging), while feeding on the fruit causes russeting, especially around the calyx end but can extend over most of the fruit.

Pearleaf blister mite is 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.

Eriophyid mites cannot be seen without magnification. They 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.

Eriophyid mites may be indirectly controlled by pear psylla and spider mite control programs during the growing season.

Grape Mealybug (*Pseudococcus maritimus*)

For more information see: https://pnwhandbooks.org/insect/tree-fruit/pear/pear-grape-mealybug

Mealybugs can be a serious pest in Pacific Northwest pears, especially in some regions such as the southern Okanogan Valley and the Wenatchee areas of Washington.

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, creating a shot-gun pattern, 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.

Grape mealybugs overwinter as eggs or first instar crawlers in egg sacs beneath bark scales and in cracks. Once emerged and settled on new shoots and leaves, the crawlers start feeding and become progressively more difficult to kill. Adult males appear first, mate and die. 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.

Many of the pear psylla pesticides currently in use may also provide control for mealybug.

Leafroller

European or filbert leafroller (*Archips rosana*)

Fruittree leafroller (*Archips argyrospila*)

Obliquebanded leafroller (*Choristoneura rosaceana*)

Pandemis leafroller (*Pandemis pyrusana*)

For more information see: https://pnwhandbooks.org/insect/tree-fruit/pear/pear-leafroller and http://treefruit.wsu.edu/crop-protection/opm/leafrollers/

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. The larvae of these species are green-bodied caterpillars with light brown to black heads, depending on the species. The principal leafroller pests of pear trees can be divided into single-generation moths, such as the fruit-tree leafroller and the European leafroller, and two-generation moths, such as the oblique-banded leafroller and pandemis leafroller.

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.

Adult moths may be monitored with pheromone traps.

Pear psylla *(Cacopsylla pyricola)*

For more information see: https://pnwhandbooks.org/insect/tree-fruit/pear/pear-pear-psylla and http://treefruit.wsu.edu/crop-protection/opm/pear-psylla/

Pear psylla is a critical insect pest in all regions of Pacific Northwest commercial 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 and behavior. 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 semidormant 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. As buds separate into flowers, egg-lay moves onto fresh tissue of pedicels, sepals and petals. 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 petal fall. 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 molts (instars) and change from creamy yellow to green then brown. 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.

Sawflies

Pear slug (*Caliroa cerasi*)

California pear sawfly (*Pristophora abbreviate*)

Dock sawfly (*Ametastegia glabrata*)

For more information see: https://pnwhandbooks.org/insect/tree-fruit/pear/pear-pear-sawfly-pear-slug and http://treefruit.wsu.edu/crop-protection/opm/dock-sawfly/

Pear sawfly is a European insect now found in most areas of the U.S. It attacks both pear and cherry, and also is found on mountain ash, hawthorn and ornamental *Prunus* spp.

The larva initially 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. 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 leaf drop with reduction in vigor, yield and return bloom, particularly on young trees.

This pest is usually controlled by regular spray programs, but high populations can sometimes occur, particularly in organic pear orchards.

The larvae of the California pear sawfly look like caterpillars. They are bright green and about 0.5-inch long. The larvae eat round holes in leaves, and with extensive feeding only the midribs will remain. Although they do not directly attack fruit, they can defoliate a tree, or an orchard, in a matter of weeks. They are considered to be a minor pest of pear.

Dock sawfly lives on weeds found in orchards, and can damage fruit when it tunnels into flesh looking for hibernation sites. Fruit damage caused by the larva looks similar to that of the codling moth larva from the outside, except the characteristic frass is missing. Damage is usually minor and sporadic, although substantial injury has occurred in the past.

San Jose scale (*Quadraspidiotus perniciosus*)

For more information see: https://pnwhandbooks.org/insect/tree-fruit/pear/pear-scale

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.

San Jose scale is usually controlled in pears by prebloom 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.

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*)

For more information see: https://pnwhandbooks.org/insect/tree-fruit/pear/pear-spider-mite and http://treefruit.wsu.edu/crop-protection/opm/spider-mites/

Spider mites are a problem pest in pears in all regions of Oregon and Washington. By far, the most common spider mite pest in pear is the twospotted spider mite. Chemical control for pear psylla can lead to an increase in mite problems by decreasing populations of mite predators.

Twospotted spider mite overwinters as diapausing adult females, which are orange-red in color. Females lay semi-opaque spherical eggs, which hatch into six-legged larvae that develop into eight-legged nymphs. Nondiapausing adults are whiteish with two dark spots that may merge to give the mite the appearance of having a solid black body. Larger stages can be seen as small black dots with the naked eye, but magnification is required to see smaller stages. Many generations are produced per year, with generation times as short as one week at warm summer temperatures.

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, and economic damage can occur.

Mites thrive under hot, dry conditions. Large colonies of some species of spider mites (*Tetranychus* spp.) produce webbing. Dispersal occurs mainly through wind transport via ballooning on their webbing.

Stink bug

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

Brown marmorated stink bug (*Halyomorpha halys*)

For more information see: https://pnwhandbooks.org/insect/tree-fruit/pear/pear-stink-bug

Stink bugs are piercing-sucking insects with a triangle between the head and the wings. Their feeding on fruit causes depressions and corky areas. Stink bugs are up to an inch long and fairly broad with a shield-shaped appearance. The most damaging stink bug in western orchards is the consperse stink bug. Brown marmorated stink bug is an emerging threat, causing economic injury in some PNW pear orchards.

Thrips

Pear thrips (*Taeniothrips inconsequens*)

Western flower thrips (*Frankliniella occidentalis*)

For more information see: https://pnwhandbooks.org/insect/tree-fruit/pear/pear-thrips

Adults of these insects are dark and very small, and often perceived as mere black specks when observed on foliage. Larvae sometimes congregate in groups on the foliage which makes them more conspicuous.

Western flower thrips are usually not a problem in pear. However, they will enter blossoms at the full pink stage to feed on pollen, nectar and flower parts. Eggs are laid in the flower parts, causing oviposition scars. Feeding by pear thrips causes blasting of buds and ragging of foliage. This pest has recently become a localized problem in the mid-Columbia fruit-growing area, especially in orchards that border habitat with native hosts such as maple and other deciduous trees.

Western boxelder bug (*Boisea rubrolineata)*

For more information, see: https://pnwhandbooks.org/insect/tree-fruit/pear/pear-western-boxelder-bug

This insect is a minor pest in pears, but damage can occur in orchards located near riparian areas or where maple and boxelder trees are present, which are preferred hosts. Insects with piercing, sucking mouthparts feed on fruit, which causes depressions. Boxelder bug adults are oval shaped, half an inch long, and black with red lines. Bugs overwinter as adults and may migrate into orchards early in the season.

Diseases and nematodes

Canker diseases

For more information see: https://pnwhandbooks.org/plantdisease/host-disease/apple-malus-spp-nectria-canker-european-canker

European canker in pear is caused by a fungus, *Neonectria ditissima* (formerly *Nectria galligena)*. The disease is found primarily in high-rainfall areas along the coast, and rarely in central or eastern regions of Oregon and Washington. The canker is perennial. Cankers can also be associated with various wounds such as from pruning.

Apple cultivars are particularly susceptible to European canker, and pear is susceptible when conditions are favorable for disease development. It has been suggested that the disease is a problem in locations where it rains more than 30% of the days of the month and there are at least eight hours of temperatures between 52°F to 60°F.

The fungus can also infect fruit, causing the disease known as eye rot on the calyx end and bull's-eye rot at the lenticels similar to anthracnose and perennial canker.

Cork spot

For more information see: https://pnwhandbooks.org/plantdisease/host-disease/pear-pyrus-spp-cork-spot

Cork spot is a disorder of pears caused by a boron or calcium deficiency. Brown marmorated stink bug damage can also cause similar damage. The depth and shape of the spots will provide clues as to the cause.

The fruit surface is bumpy, and affected areas are usually more yellow than the rest of the skin. The flesh has brown or grayish corky lesions.

Crown gall

For more information see: https://pnwhandbooks.org/plantdisease/host-disease/cherry-prunus-spp-crown-gall

Crown gall is caused by *Rhizobium radiobacter* (formerly *Agrobacterium tumefaciens*), a bacterium that lives for several years in soil, often spreading from diseased nursery stock. It also may be moved by irrigation water or cultivation equipment.

The bacterium enters plants through wounds, either natural or caused by pruning, grafting, mechanical injury from cultivation, heaving of frozen soils, chewing insects or the emergence of lateral roots. After the bacterium enters a wound, a small piece of its DNA is transferred into the plant's DNA. The foreign DNA transforms normal plant cells in the wounded area into tumor cells. Once transformed, tumor cells proliferate automatically. The result is a gall — a disorganized mass of hyperplastic and hypertrophic tissue. If galls completely encircle the trunk of a young tree, it may be girdled and die.

Fire blight

For more information see: https://pnwhandbooks.org/plantdisease/host-disease/pear-pyrus-spp-fire-blight and http://treefruit.wsu.edu/crop-protection/disease-management/fire-blight/

Fire blight is a 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 (or apple) trees. Risk of infection increases with the number of 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 and wind-blown rains can spread this bacterium. Insects such as ants and flies are attracted to bacterial ooze from cankers and can move it to flowers, where it is moved from flower to flower primarily by bees.

Bacteria enter healthy, main blooms from the stigma through the nectary. Flowers are open for up to seven days and are the most common entry point for the bacteria. Pathogen cells multiply quickly on nutrient-rich floral stigmas when temperatures are warm (70–80 degrees F is optimal for the pathogen). Bacterial colonies can then be washed down the style into the floral cup by water (usually from rain or heavy dew), where they can invade flowers through the nectaries. Vigorously growing shoot tips and young leaves can be infected through wounds (for example, caused by wind, hail or insects.)

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. 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.

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.

Nematodes

Dagger, root-lesion

For more information see: https://pnwhandbooks.org/plantdisease/host-disease/pear-pyrus-spp-nematodes or http://treefruit.wsu.edu/crop-protection/nematodes-2/

There are many nematode problems in the Pacific Northwest, including dagger and root lesion nematodes. However, there has not been any published or concentrated effort to document nematode problems in pear orchards in Washington or Oregon. Few samples from pear orchards have come into the OSU Nematode Laboratory. It is suspected that nematodes are a problem on pear that simply has not been investigated. Planting and replanting can be severely impacted by nematode presence.

Pear decline viruses and phytoplasms

For more information see: https://pnwhandbooks.org/plantdisease/host-disease/pear-pyrus-spp-decline

Pear decline is caused by *Candidatus* Phytoplasma pyri, transmitted by pear psylla or by grafting infected stock to healthy trees. The pear psylla acquires the phytoplasma after a few hours of feeding, and remains infective for the rest of its life. Grafting and budding can also transmit this phytoplasma. Decline varies based on rootstock.

The pathogen survives from season to season in the roots of infected trees, and can also overwinter in pear psylla (between 30% and 60% of pear psylla can carry the phytoplasma, including the overwintered population). The phytoplasma population in the aboveground portions of the tree fluctuates through the year. The pathogen does not survive in aboveground phloem elements in late fall and winter but rebounds from root reservoirs once new phloem tissue is made in the spring.

Pear decline is characterized by two phases. Quick decline is where trees wilt, scorch and die in a few weeks. It is often preceded by slow decline and reddening. This quick decline occurs on very susceptible rootstocks such as *P. ussuriensis* and *P. pyricola*. Slow decline is where trees lose vigor over several seasons during which foliage gets sparse with little or no terminal growth and leaf size is reduced. Fruit set and size also decline. Slow decline occurs on more common rootstocks such as *P. communis*, *P. calleryana*, *P. pyrifolia*, *P. betulaefolia* and *Cydonia oblonga*. Some rootstocks are tolerant or resistant to pear decline, including 'Old Home', 'Farmingdale', and 'Winter Nelis'.

Graft incompatibility, root rots and winter injury can be mistaken for pear decline.

Postharvest decay/storage rots

For more information see: https://pnwhandbooks.org/plantdisease/host-disease/pear-pyrus-spp-storage-rots, http://treefruit.wsu.edu/crop-protection/disease-management/blue-mold/ and http://treefruit.wsu.edu/crop-protection/disease-management/gray-mold/

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 (for example, temperature or humidity), issues of postharvest decay are caused by organisms, many of 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. Rots 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.

- **Phacidiopycnis rot** (*Potebiamyces pyri* [asexual *Phacidiopycnis 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 Phacidiopycnis rot appears translucent while gray mold appears brown.
- **Side rot** (*Phialophora* [Cadophora] malorum). 'Bosc' is susceptible. Rot typically appears as dark dime-sized spots. May be be indistinguishable from *Cladosporium* and *Alternaria* rot.
- **Sphaeropsis rot** (*Sphaeropsis pyriputrescens*). 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.

Powdery mildew

For more information see: https://pnwhandbooks.org/plantdisease/host-disease/pear-pyrus-spp-powdery-mildew

Powdery mildew is caused by *Podosphaera leucotricha*, a fungus that overwinters in terminal buds of apples. 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 helps prevent outbreaks.

Replant complex (phytopthora root and crown rot)

For more information see: https://pnwhandbooks.org/plantdisease/host-disease/apple-malus-spp-replant-disease or http://treefruit.wsu.edu/crop-protection/disease-management/apple-replant-disease/

A complex of fungi, oomycetes and nematodes are the biological factors contributing to replant complex. In addition, nonbiological factors including poor soil structure, moisture stress, low or high pH, insufficient available phosphorus, herbicide residual and cold stress, have been implicated in the complex.

Tree growth is suppressed the first year and for the life of the orchard, and with severe disease pressure, tree death may occur. Compared to healthy trees, yields can be reduced by 20% to 50% and fruit quality is also lowered.

Russet

For more information see: https://pnwhandbooks.org/plantdisease/host-disease/apple-malus-spp-fruit-russeting

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 30–40 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. 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 russeting. Russeting from spray materials is likely to be found where spray droplets accumulate, such as the lowest portions of the fruit. Russeting from powdery mildew is tan to gray and has a netted appearance.

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

Pacific Coast pear rust

For more information see: https://pnwhandbooks.org/plantdisease/host-disease/pear-pyrus-spp-pacific-coast-pear-rust

Pear rust is cause by a fungus, *Gymnosporangium libocedri*. The rust fungi in this genus alternate between a conifer and roseacous host. The alternate host is the incense cedar (*Calocedrus decurrens*). The disease has been reported commonly from the Willamette Valley of Oregon, but outbreaks are only economically significant to orchardists every few years. Oriental and European cultivars are susceptible. 'Winter Nelis' is severely affected while under the same conditions 'Bartlett' is less affected. Some years 'Bartlett' can be severely affected but other pears show even greater symptoms under the same conditions.

Pear fruit are malformed while young and drop from the tree. Bright-yellowish to orangish spots with numerous cup-shape pustules (aecia) develop over the fruit surface. Spots fade and darken as the fruit matures or falls off the tree. Green shoots and leaves also are attacked but not as frequently. Symptoms are most obvious after flowering but before July.

Scab

For more information see: https://pnwhandbooks.org/plantdisease/host-disease/pear-pyrus-spp-scab

Scab can be an issue for growers in the Medford and Mid-Columbia regions.

Pear scab is caused by *Venturia pyrina*, 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 3–4-months beginning at bud break. Infection occurs when leaves are wet for 10–25 hours and symptoms are seen in two to three 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.

Sprinkler rot

For more information see: https://pnwhandbooks.org/plantdisease/host-disease/pear-pyrus-spp-sprinkler-rot-phytophthora-fruit-rot

This rot is caused by *Phytophthora* spp., a soilborne, fungus-like microorganism frequently carried in irrigation water. There were nine different distinct taxa of *Phytophthora* pathogenic to pear found in irrigation water canals in north central Washington. This rot has caused significant loss of fruit where irrigation water wetted fruit, usually on lower branches or from overhead irrigation for summer fruit cooling. As little as one hour of fruit wetting is enough time for infection.

Firm, tan-colored, rotted spots develop on the fruit, and can be more than 1 inch in diameter. Older infections can cause the whole fruit to rot on the tree. This rot can be confused with fire blight on immature pears but is lighter in color and soft to the touch. Some years, disease also may spread to fruit pedicels and first-year wood, causing a dieback that resembles fire blight.

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*)

Wild carrot (*Daucus carrota*)

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 (annual ryegrass; *Lolium multiflorum*; resistant to glyphosate, group 1 [ACCase inhibitors] and group 2 herbicides [ALS inhibitors])

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, nonselective 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 is 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 nonselective, 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. Nonselective, 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 nonselective, 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 ryegrass. 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.

Vertebrate pests

Rodents (voles, gophers)

Rodents are a problem mainly when weeds are not 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 winter 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.

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.

Turkeys

Populations of wild turkeys have been growing in recent years along the eastern slopes of the Cascade Mountains and often find favorable habitat in commercial pear orchards. While turkeys do not generally present a major threat of injury to pear trees or fruit, they can become a significant risk for food safety. These large birds produce significant amounts of fecal waste which can be picked up and transferred by orchard workers and equipment like ladders and tractors. Further, wild turkeys sometimes roost in, on, or around fruit bins, sometimes defecating directly onto wooden or plastic surfaces that will be in direct contact with fruit during harvest and postharvest storage in the warehouse.

Mice

If left unmanaged, orchard mice can girdle and kill young pear trees, especially under snow cover or in poorly managed weed strips that provide abundant cover for mice. Control of mice in organic orchards can be a challenge, particularly in areas with long, snow-covered winters.

Pear pest management activities by crop stage

Dormancy

Dormancy begins with leaf fall, which usually takes place in November, and ends with scale separation (budbreak - opening of a dormant leaf bud) in March.

Field activities and pest management decisions that occur during dormancy

Tree pruning
Sanitation for fire blight/canker
Ground fertilizers (for example, lime)
Boron application
Mowing
Rodent control
Psylla and mite control

PAMS practice[1]	Dormancy pest management activities	Target pest(s)
Prevention	Sanitation/sterilization of pruning equipment	Fire blight, canker, decay
	Pruning	General insect and disease management
	Orchard floor management (mowing, flailing, raking, clean-up)	Post-harvest rot prevention
Avoidance		
Monitoring	Insect and disease monitoring	Psylla, canker
	Evaluate results from last harvest as fruit is packed	General pest management
	Use of weather-based pest models	Multiple insects/diseases
Suppression	Kaolin (Surround)	Pear psylla
	Weed strip management – fall/early spring herbicides such as: ▪ Diuron (Karmex) ▪ Glyphosate (Roundup) ▪ Indaziflam (Alion) ▪ Oryzalin (Surflan) ▪ Oxyfluorfen (Goal) ▪ Paraquat (Gramoxone) ▪ Pendimethalin (Prowl)	Weeds, voles, mites, true bugs; Promotes irrigation uniformity
	Horticultural oils	Pear psylla, scale
	Lime sulfur	Pear rust mite, blister mite, spider mites, powdery mildew, pear psylla
	Mouse/gopher baits	Mice, gopher, etc
	Pyrethroids (for example, zeta-cypermethrin [Mustang Maxx])	Pear psylla, true bugs
	Malathion	Pear psylla
	Chlorpyrifos (Lorsban) (used either in dormancy or “delayed dormancy” [see next section])	Pear psylla, mealybug
	Lambda-cyhalothrin (Warrior)	Pear psylla

Critical needs for pest management during dormancy

Research topics

- Research and register effective adulticides for pear psylla control (especially organic).
- Research effective, areawide strategies for reducing overwintering populations of pear psylla scale, mites, other insect pests and pathogens.
- Research overwintering biology of pear psylla and how to disrupt the overwintering cycle (for example, where and how pear psylla are overwintering; whether/how they leave and re-enter orchards); determine the lethal overwintering temperatures; better understand yearly population fluctuations
- Research overwintering of various pear pathogens to better disrupt their life cycle.
- Research the impacts of pesticide use during dormancy on natural enemies.
- Continued research on the potential for acoustic mating disruption for pear psylla.
- Investigate the potential for improved plant genetics to improve pest resistance and reduce reliance on traditional control measures.
- Investigate the level of insect and disease resistance among alternative pear varieties, and their ability to meet market demand.
- Investigate ways to narrow the production canopy for ease of management.
- Research strategies for increasing tree production potential earlier in the tree life stage, to speed returns on replanting investments.
- Research the survival of early psylla eggs laid on woody areas (up to a month before green tissue forms on buds) to determine whether early treatments are necessary.
- Investigate pruning techniques that may reduce vegetative vigor and help manage psylla.
- Research crop tolerance to new preemergence herbicides for strip management.

Regulatory actions

- Develop regulatory assistance programs (federal and/or state) to help subsidize labor costs related to orchard sanitation (such as labor costs for canker removal).

[1] See Appendix "Using PAMS Terminology."

- It is critical that growers have access to the workers they need to grow and harvest their crops. Support agricultural workforce reform that both provides certainty for the current workforce and fully addresses future needs.
- Ease aerial application restrictions during dormancy due to difficulty of operating ground rigs in orchards in unsafe conditions (such as snow or mud) or near harvest when drive rows may be blocked by low-hanging, fruit-laden limbs.
- Clarify regulatory definition of the start/end of pear-growing season, particularly with the use of products during postharvest and dormancy that limit the number of uses per season (for example, tolfenpyrad [Bexar]).
- Clarify differences in label requirements between tree fruits. Diazinon requires closed cab in pears but not in apples.
- Improve rootstock screening and clean plant protocols.

Education

- Educate pest managers on basic cutting techniques for efficient fire blight management.
- Educate pest managers on overwintering behavior of various pathogens.
- Continue and expand trainings on sprayer calibration and maintenance.
- Educate broadly on the benefits of improved genetics and why this is an important long-term option for consideration.
- Educate pest managers regarding the effects of pruning on vigor control and thus psylla suppression.
- Educate pest managers on importance of developing season-long calcium usage plans based on new research (Kalcsits) to reduce cork.

Delayed dormancy

Delayed dormancy is the period from the resumption of growth, indicated by bud swell. This stage takes place from early March through “first green” of the bud cluster.

Field activities and pest management decisions that may occur during delayed dormancy

Pruning

PAMS practice	Delayed dormancy pest management activities	Target pest(s)
Prevention	Spring pruning	
Avoidance	Orchard cleanup including raking brush (prunings) and burning	Prevents re-inoculation of pathogens
Monitoring	Monitor buds for psylla egg lay activity	Pear psylla
	Monitor buds for mite activity	Spider and rust mite
Suppression	Copper	Fire blight
	Horticultural oil	Pear psylla, mealybug, scale
	Kaolin (Surround)	Pear psylla
	Lime sulfur, sulfur	Mites, psylla, fungal pathogens, fire blight; important tool for organic production
	Pyriproxifen (Esteem)	Pear psylla, scale
	Organophosphates: Malathion Chlorpyrifos (Lorsban)	Pear psylla, mealybug, scale, mites
	Tolfenpyrad (Bexar)	Pear psylla, pear rust mites
	Cinnerate	Pear psylla, mites
	AzaDirect	Pear psylla
	Lambda Cy and other pyrethroids	Pear psylla

Critical needs for pest management during delayed dormancy

Research topics

- Research the use of dormant versus summer oils in the dormant/delayed dormant season from the perspectives of entomology, horticulture and economics.
- Research the efficacy and proper timing of the use of particle films: kaolin, diatomaceous earth, nutrient (calcium carbonate, soluble gypsum) and sun protectant films for suppression of pear psylla.
- Research the use of plant-based oils during dormancy/delayed dormancy for suppression of pear psylla.
- Research the use of lime sulfur and plant-based oils for pathogen sanitation
- Research the use of reflective ground covers for psylla repellency and other horticultural benefits (such as fruit size and weed prevention).
- Research effective use of phenology models for pear psylla and other insects to support best timing for insecticide treatments.
- Research best timing for insecticide treatments during dormancy and delayed dormancy.
- Research the impact of various tree architecture types on pesticide coverage, including the effects of various sprayers on various tree architecture (tower, electrostatic, conventional airblast, etc.).
- Develop ways to better evaluate the impacts/efficacy of pesticide treatments under typical field conditions.
- Research to improve understanding of potential impacts to natural enemies from pesticide use at early timings when natural enemies are less present or active.
- Research to determine whether pear psylla treatments are better timed to psylla phenology or tree development.

Regulatory actions

- Pursue labeling changes to expand allowable particle films.

Education

- Educate pest managers on best timing for insecticide treatments during dormancy and delayed dormancy.
- Take advantage of dormancy and delayed dormancy as critical times for delivery of education and outreach, training and certification.
- Educate pest managers on the importance of spray timing for pesticide efficacy.
- Educate pest managers on best methods to evaluate the impacts/efficacy of pesticide treatments deployed, post application.

Cluster bud through popcorn

Cluster bud through pink occurs from tight cluster to first bloom, from as early as late march through as late as early May.

Field activities and pest management decisions that may occur during cluster bud through popcorn

Fungicide and insecticide applications
Orchard frost protection (irrigation or wind machines; orchard heating)
Mating disruption
Biological monitoring

PAMS practice	Cluster bud through popcorn pest management activities	Target pest(s)
Prevention		
Avoidance	Mating disruption	Codling moth, leafroller
	Orchard cleanup including raking brush (prunings) and burning	Prevents re-inoculation of pathogens
Monitoring	Ongoing monitoring	Mites, mealybug, psylla
	Use of disease prediction models	Scab
	Insect trapping	Codling moth, brown marmorated stink bug, scale
Suppression	Preventative fungicide sprays: (FRAC code rotations to avoid resistance) Mancozeb, Penthiopyrad (Fontelis), triflumizole (Procure), boscalid + pyraclostrobin (Pristine) Biological bactericide (blossom protect)	 Scab Powdery mildew Fire blight
	Bt	Pandemis leafroller
	Pyrethroids: e.g. lambda-cyhalothrin (Warrior)	True bugs (including BMSB, box elder), thrips
	Acetamiprid (Assail) Buprofezin (Centaur) Diazinon Diflubenzuron (Dimilin) Esfenvalerate (Asana) Pyradiben (Nexter) Pyriproxifen (Esteem) Spinetoram (Delegate) Thiamethoxam (Actara) Tolfenpyrad (Bexar)	Pear psylla, mealybug
	Horticultural oils	Pear psylla, mites, scale
	Miticides: abamectin (Agrimek); fenbutatin-oxide (Vendex)	Overwintering mites, pyslla
	Malathion pyriproxifen (Esteem)	Pear psylla
	Kaolin (Surround), diatomaceous earth	Pear psylla

Critical needs for pest management during cluster bud through popcorn

Research topics

- Research the use of prohexadine calcium, and other alternative chemistries, for fire blight control (including best timing of application relative to bloom).
- Develop and register new and alternative insecticides that are "softer" on natural enemies and safer for workers.
- Prioritize identification and delivery of new "softer" pesticides through IR-4 program.
- Conduct needed research to improve disease prediction models for scab, fire blight, powdery mildew.
- Develop a management recommendation structure based on pear psylla phenology model.
- Develop action thresholds for major pear pests including pear psylla that consider natural enemy populations as well as regional variations in climate.
- Research the physiological impacts to trees of multiple horticultural oil applications.
- Determine the efficacy/efficiency of insecticides when mixed with kaolin particle films.
- Research the impacts of nutrition, fertilization and irrigation on pest levels
- Research the efficacy of the use of particle films such as Microna (micronized calcium plus gypsum) on pear psylla.

Regulatory actions

- Develop stringent testing and screening protocols for new trees coming into orchards for fire blight and other economically important diseases.

Education

- Educate pest managers on the importance of drying time following pesticide applications to avoid fruit marking.
- Educate pest managers on the importance of starting with a soft insecticide program in order to build natural enemies for later in the season.

Bloom

Bloom takes place from April through May in most areas.

Field activities and pest management decisions that may occur during bloom

Planting
Pollination
Fire blight management
Frost control
Grafting
Chemical thinning
Plant growth regulation
Mating disruption
Insect and disease management
Pollen spreading to enhance pollination
Honey bee pheromone attractants (Beescent)
Biological monitoring

PAMS practice	Bloom pest management activities	Target pest(s)
Prevention		
Avoidance	Avoid irrigation during bloom	Reduce fire blight infection and spread of other pathogens
	Cutting	Canker
	Fencing orchards, caging plants, repellants	Deer
Monitoring	Use of fire blight prediction models	Fire blight
	Monitoring	Canker
Suppression	Antibiotics and biologicals: Blossom Protect Bacillus products Botanicals Soluble coppers (Cueva, Previsto)	Fire blight
	Fungicide sprays: Mancozeb, penthiopyrad (Fontelis), triflumizole (Procure), boscalid + pyraclostrobin (Pristine)	Scab, botrytis
	Insecticides: none	

Critical needs for pest management during bloom

Research topics

- Evaluate the use of bee attractant products.
- Research on “S Alleles” to support information regarding the best pollinizer pear varieties to improve pollination.
- Investigate ways to make pear blooms more attractive to bees and other natural pollinators.
- Improve fire blight control efficacy, including for organic programs, new products, SAR’s (systemic-acquired resistant products), and optimizing antibiotic use; prioritize through IR-4.
- Determine the optimal timing(s) for biologicals and botanicals for fire blight management.
- Update fire blight models to include information on lower temperature, humidity, growth.
- Research the role of flowers in contamination with pathogens including postharvest decay.
- Research the potential for the use of pollinators other than European honey bees.
- Better understanding of flower biology of main pear varieties, including flower viability, stigmatic surface pollen acceptance, pollen tube growth and fertilization optimization.
- Research on whether insecticides or particle films sprayed before bloom impact pollination.
- *Identify safe insecticides or strategic application methods that can be performed during bloom to manage psylla without harm to pollinators.*

Regulatory actions

- Register new high-efficacy products for fire blight control; prioritize through IR-4.

Education

- Educate pest managers on proper pollinizer varieties to promote consistent fruit set and higher yields.
- Develop areawide scouting and information-sharing networks for pear psylla and other insects that include insect phenology, biological monitoring reports by region, etc.
- Educate pest managers on how to use disease models like the Decision Aid System’s fire blight model.

Petal fall

Petal fall occurs during late spring, usually between late April and early May

Field activities and pest management decisions that may occur during bloom to petal fall

Fire blight cutting/management
Insecticide applications for psylla and other insects
Fungicide and herbicide applications
Fruit thinning (hand thinning, post-bloom chemical thinners)
Plant growth regulation
First irrigation, tree planting
Biological monitoring

PAMS practice	Petal fall pest management activities	Target pest(s)
Prevention	Pruning infected limbs to prevent future spread	Fire blight
	Removal and disposal of prunings (burning)	Fire blight
Avoidance	Suckering (removing suckers that grow from the base of the root stock; removed by hand)	Suckers (weeds), keeps psylla populations down by removing habitat
	Application of mating disruption products	Codling moth
Monitoring	Scouting/trapping	Codling moth, pear psylla, mealybug, mites, diseases
	Use of insect and disease models	Insects, diseases
	Leaf sampling; counting eggs and nymphs	Psylla, mites
Suppression	Insecticides: ▪ Cinnamon oil (Cinnerate) ▪ Novaluron (Rimon) ▪ Pyriproxyfen (Esteem) ▪ Spinetoram (Delegate) Note: insecticides often tank-mixed with horticultural oils, particle films and surfactants	Codling moth, psylla, mites, leafroller
	▪ Abamectin (Agri-Mek)	Psylla, mites
	▪ Buprofezin (Centaur)	Psylla, mealybug
	▪ Chlorantraniliprole (Altacor) ▪ Methoxyfenozide (Intrepid) ▪ Horticultural oil	Codling moth
	▪ Neem oils used in organic production (cannot be used on 'Comice') ▪ Spirotetramat (Ultor) ▪ Tolfenpyrad (Bexar) ▪ Acetamiprid (Assail)	Psylla
	Methoxyfenozide (Intrepid)	Codling moth
	Herbicides: ▪ 2,4 -D ▪ Carfentrazone (Aim) ▪ Diuron (Karmex) ▪ Glufosinate (Rely) ▪ Glyphosate (Roundup) ▪ Indaziflam (Alion) ▪ Paraquat (Gramoxone) ▪ Simazine	Weed management
	Fungicides: ▪ Boscalid + pyraclostrobin (Pristine) ▪ Difenoconazole + cyprodinil (Inspire Super) ▪ Mancozeb ▪ Penthiopyriad (Fontelis) ▪ Triflumizole (Procure)	Scab, powdery mildew, fruit finish
	▪ Ziram	Bull's-eye rot

Critical needs for pest management during petal fall

Research topics

- Research additional alternative methods for management of codling moth, including sterile insect release, mass trapping, etc.
- Research best types of lures for monitoring/trapping codling moth, particularly lures that can attract from greater distances, and how to implement these.
- Research the use of automated traps for codling moth that do not require physical inspection for insect counts.
- Research the efficacy of tank-mixing products with particle films.
- Research weed management impacts on pests and beneficial insects.
- Research the use of particle films and reflective mulch, and impacts to pests as well as natural enemies. What is the best timing for use (how late in season can these be effectively used)? What differences are noted between pear varieties?
- Research on psylla degree-day spray timings to determine how the phenology model can be used to optimize a spray program.
- Investigate pesticide effects on natural enemies.
- Research and deliver monitoring methods for post-harvest decay pathogens.
- Research to evaluate management of weeds like field bindweed and nutsedge.
- Research weed management to manage herbicide resistant weeds.

Regulatory topics

- Extend preharvest interval (PHI) for fire blight products (Actigard, others) that require use beyond petal fall for effective control; 60-day PHI limits use during this timeframe but spot spraying can do a lot to minimize the spread of fire blight.
- Pursue a special label for mancozeb/manzate to extend use further into the season. This is a critical product for fruit finish but label restrictions prevent use at this timing.
- Amend fungicide labels to include additional pathogens causing postharvest rots.
- Ask USDA FAS to prioritize TASC funding toward establishment of pesticides critical to pear pest management in key markets; maximum residue limits for key export markets are needed for certain chemistries including Tolfenpyrad (Bexar).

Education topics

- Educate pest managers on the proper application of preharvest fungicides to prevent postharvest resistance.
- Educate pest managers on the best timing for application of preharvest fungicides to achieve effective postharvest pathogen control.
- Educate pest managers regarding the limits on mass pest trapping with organic certification.

Summer

This stage includes fruit growth, usually from June through July.

Field activities and pest management decisions that may occur during summer

Irrigation
Mowing
Sucker removal (hand pulling)
Blight cutting
Fruit thinning
Monitoring
Insecticide and herbicide applications
Fertilizing
Honeydew washing (overhead/ground)
Propping
Biological monitoring

PAMS practice	Summer pest management activities	Target pest(s)
Prevention		
Avoidance	Sucker removal (hand pulling)	Suckers (weeds), pear psylla
	Honeydew washing (usually mid-June or later to avoid fire blight)	Pear psylla honeydew removal
Monitoring	Monitoring traps	Codling moth
	Leaf samples	Pear psylla, mites
	Monitoring for fire blight; use of predictive weather models	Fire blight
Suppression	Tilling devices/cultivation	Weeds
	Mowing	Weeds
	Insecticides/miticides (note product PHIs determine specific use at this timing): ▪ Abamectin (Agri-Mek) ▪ Cinnamon oil (Cinnerate) ▪ Fenpyroximate (FujiMite) ▪ Hexythiazox (Savey) ▪ Horticultural oil + calcium chloride ▪ Neem oils ▪ Neonicotinoids (for psylla control; low efficacy on mites): Acetamiprid (Assail); Clothianidin (Belay); imidacloprid (various products); Thiamethoxam (Actara) ▪ Pyridaben (Nexter) ▪ Spinetoram (Delegate)	Mites, Pear psylla
	Bifenazate (Acramite) Cyflumetofen (Nealta) Etoxazole (Zeal)	Mites
	Chlorantraniliprole (Altacor) *Cydia pomonella* granulovirus (Cyd-X)	Codling moth
	▪ Herbicides: ▪ 2,4D ▪ Glufosinate ▪ Glyphosate (Roundup) ▪ Caprylic acid (Suppress) organic-approved herbicide	Weeds

Critical needs for pest management during summer

Research topics

- Identify the most effective products and systems for insect honeydew removal/washing, including best surfactants, ratios of water to surfactant, best timing and impacts on postharvest pathogens.
- Determine whether removing honeydew before pesticide application increases product efficacy; determine whether honeydew washing removes pesticide residues.
- Investigate the impacts of the presence of honeydew on pests (mites) and beneficials.
- Conduct a cost/benefit analysis of the economics of differing methods of honeydew washing.
- Research the impacts of overhead washing for honeydew on other pests such as codling moth, based on disrupted efficacy of pesticides and pheromones applied for codling moth control.
- Determine the latest possible timing for particle films with respect to cleaning of the films from harvested fruit of different varieties (some varieties are more difficult to clean).
- Evaluate the benefits of natural enemy release and determine which species are most beneficial, best practices and timings for release, and effective rates and timing.
- Identify and register/prioritize through IR-4 effective organic-approved insecticides and miticides for psylla/mite control and determine best timing and rates for highest efficacy.
- Research interactions between insecticide applications for spotted-wing drosophila and collateral control of additional pear pests including psylla.
- Develop psylla treatment model based on psylla phenology and natural enemy safety.
- Research to evaluate postemergence herbicides to manage weeds yellow nutsedge and grasses.
- Evaluate alternative to hand removal of suckers.
- Research new cost-effective options for weed control in organic systems.

Regulatory actions

- Maximum residue limits are a challenge at this stage, particularly with the use of tolfenpyrad (Bexar), which is widely used by industry due to its efficacy against psylla, but does not have **maximum residue limits** posted in several important export markets.
- Work with IR4 to prioritize the identification and registration of effective organic insecticides and miticides for pear pests.

Education

- Educate pest managers on optimal timing, products and systems for honeydew washing and most effective duration of washing.
- Educate pest managers on the importance of conservation spray programs to promote natural enemies.
- Educate pest managers on the importance of scouting for psylla, mites and natural enemies to determine whether pesticide treatments are necessary.

Preharvest through harvest

The pre-harvest period begins in late July and extends through harvest, which usually ends in September

Field activities and pest management decisions that may occur during pre-harvest and harvest

Mowing before bin placement
Bin placement
Irrigation
Fungicide and insecticide applications
Changing equipment from mowing/spraying to harvest/loading
Plant growth regulator applications
Nitrogen application
Leaf sampling for nutrient analysis
Harvest sampling
Honeydew washing
Hiring/training harvest crews
Harvesting
Food safety audits
GAP program/food safety
Biological monitoring

PAMS practice	Preharvest through harvest pest management activities	Target pest(s)
Prevention	Setting up clean, flat loading areas for harvested fruit	Reducing decay + other contaminants
	Cleaning bins and picking bags for harvest (or using bin liners)	Reducing decay + other contaminants
	Cleaning and maintenance of harvesting equipment	Reducing decay + other contaminants
	Packinghouse line cleaning and room sanitation	Reducing decay + other contaminants
	Food safety training	Reducing decay + other contaminants; meeting FSMA mandates
	Prevent fruit injury	Postharvest decay
	Timely harvest (late harvested fruit presents more pest management challenges)	Postharvest decay
	Pressure testing pears to determine optimum harvest time	Postharvest decay
	Apply plant growth regulators	Postharvest decay
Avoidance	Honeydew washing	Remove psylla honeydew
	Avoid extended irrigation	Storage pathogen management
Monitoring		
Suppression	Preharvest fungicide as preventative for post-harvest disease occurrence: ▪ Boscalid + pyraclostrobin (Pristine) ▪ Fluxapyroxad + pyraclastrobin (Merivon) ▪ Thiophanate methyl (Topsin)	Postharvest fruit decay
	Insecticides (with short PHIs): ▪ Acetamiprid (Assail) ▪ Azadirachtin (Azadirect, Neemix) ▪ Burkholderia spp (Venerate) ▪ Cyflumetofen (Nealta) (mites) ▪ Horticultural oil ▪ Imidacloprid ▪ Spinetoram (Delegate)	Psylla, scale, mites, mealybug, codling moth
	Honeydew wash: Regulaid, M-pede,	Honeydew causes russet on pears, promotes mold growth, injures leaves, and impacts ability to secure labor.

Critical needs for pest management during harvest

Research topics

- Identify best practices for preharvest orchard and bin sanitation.
- Identify best practices for final honeydew wash including most efficacious products, timing, system.
- Develop a decision tool to assist with cost/benefit analyses related to pear pest management, and pesticide applications in particular (for example, which applications are improving returns, and which are not?).
- Research the evolution of pesticide resistance among pear pathogens and insects.
- Develop dwarfing rootstocks to lower canopy architecture to enable easier pesticide applications, pruning and harvesting.
- Develop rootstocks for the management of pear decline phytoplasma.

Regulatory actions

- Expand options for aerial pesticide application based on difficulty operating spray equipment in orchards at this timing.
- Identify a list of priority fungicides for which to request a shorter PHI to allow use pre-harvest.

Education

- Educate pest managers on PHIs vs. REIs, and why these two intervals might not match.
- Educate pest managers on the importance of connecting preharvest and post-harvest decay management programs including better communication between growers and packers.
- Hold demonstrations at packing houses for growers to observe the rots that develop after harvest and to learn best practices for avoiding them.
- Educate the industry regarding recent clarifications by USDA on what extent of work with genetics/genomics qualifies as a GMO.

After harvest

This timeframe includes the period immediately following harvest, and before dormancy, usually October through November.

Field activities and pest management decisions that may occur after harvest

Orchard clean up: removal of unproductive trees or blocks; fire blight cutting
Fertilizer applications
Mole/vole/vertebrate management
Deer control
Psylla clean up sprays
Winterization and repairs to irrigation system
Urea/nitrogen applications for scab management
Fall herbicide treatments
Lime sulfur applications
Post-harvest fungicide application (warehouse)
Plant growth regulator application (warehouse)

PAMS practice	After harvest pest management activities	Target pest(s)
Prevention	Fall pruning	General pest management
Avoidance	Warehouse management including: fruit segregation, cleaning packing lines, avoiding spore contamination, monitoring floatation water contamination levels; packing line cleaning, sanitizers, cold chain management	Storage rots
Monitoring		
Suppression	Lime sulfur Sulfur + horticultural oil	Psylla, mites
	Warehouse fungicide sprays: ▪ Difenoconazole (Academy) (as a drench) ▪ Fludioxinil (Scholar) ▪ Pyrimethanil (Penbotec) ▪ Thiabendizole (TBZ)	
	Herbicides: ▪ Diuron (Karmex) ▪ Glyphosate (Roundup) ▪ Indaziflam (Alion) ▪ Oxyfluorfen (Goal) ▪ Simazine (Princep)	

Critical needs for pest management after harvest

Research topics

- Continued research to identify best practices for fall pruning, and difference between fall pruning versus winter and summer pruning.
- Evaluate the efficacy of postharvest applications of kaolin (Surround) and/or other insecticides with the potential to reduce overwintering pest populations (especially psylla), and most effective post-harvest timing.
- Investigate factors affecting psylla dispersal from orchard and how this affects the population in the following season.
- Research the use of insect growth regulators to prevent or disrupt psylla reproduction.
- Identify effective control measures before leaf fall to suppress psylla populations.
- Determine the impacts of horticultural oil use on tree productivity.
- Evaluate the efficacy of refugia plantings to help build and maintain natural enemy populations.
- Identify effective strategies for management of storage decay including new chemistries and more efficient sanitation.
- Evaluate the efficacy of different technologies used to apply fungicides after harvest.
- Identify organic control measures for postharvest decay (including ozone for room sanitation, ultra-low oxygens and dynamic atmospheres).
- Identify best practices for humidity management in storage.
- Identify best practices for bin cleaning using high-pressure washers.
- Explore possibilities for areawide suppression of pear psylla after harvest, and effective ways to engage growers and develop recommendations.

Regulatory actions

- Evaluate potential new pathogen/disease species for quarantine.

Education

- Continuing education on how to avoid known pre- and postharvest practices that negatively impact food quality and decay.

Invasive and emerging pests

Insects and mites

None identified at this time

Weeds

None identified at this time

Critical needs for invasive and emerging pests

None identified at this time

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Appendices

Seasonal activity tables for pear

REGION: Mid-Columbia

Field activities (other than pest management)

Activity	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Frost protection			X	X	X							
Harvest								X	X	X		
Irrigation					X	X	X	X	X			
Mow/chop brush	X	X		X	X	X	X			X		
Planting				X	X							
Pruning	X	X	X									X
Thinning					X	X	X					
Tree removal										X	X	X

Pest management activities

Activity	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Trap monitoring				X	X	X	X	X	X			
Herbicide applications	X	X	X		X	X				X	X	X
Fungicide applications				X	X	X		X				
Insecticide applications		X	X	X	X	X	X	X	X	X		
Rodenticide applications	X	X	X	X						X	X	X
Fire blight cutting					X	X	X		X	X		
Plant growth regulator applications					X			X	X			
Use of pest and disease models				X	X	X						

Seasonal pest management activities for pears

REGION: Mid-Columbia

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

Insects	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Codling moth			X*	X*	X	X	X	X				
Eriophyid mites		X	X	X	X							
Grape mealybug	Not actively managed											
Leafroller				X*	X	X						
Pear psylla		X	X	X	X	X	X	X	X	X		
Scale			X			X	X					
Spider mites				X		X	X	X				
True bugs (BMSB)					X	X	X	X				
* controlled with mating disruption at this timing												
Pathogens	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Fire blight			X	X	X	X						
Powdery mildew				X	X	X						
Russet				X	X							
Scab				X	X	X						
Postharvest decay				X		X		X	X			
Weeds	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Annual grasses	X	X	X							X	X	X
Perennial grasses	X	X	X							X	X	X
Annual broadleaves	X	X	X	X	X	X				X	X	X
Perennial broadleaves	X	X	X	X	X	X				X	X	X
Woody species (rare)			X							X		

Seasonal activity tables for pear

REGION: Southern Oregon

Field activities (other than pest management)

Activity	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Fertilization				X			X		X			
Frost protection			X	X	X							
Harvest bin management							X	X	X	X		
Irrigation					X	X	X	X	X			
Mowing			X	X	X	X	X	X	X	X	X	
Pruning	X	X	X							X	X	X
Road maintenance							X	X				

Pest management activities

Activity	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Fire blight cutting					X	X	X	X		X	X	
Fungicide application			X	X	X	X	X	X	X	X		
Herbicide application		X	X	X	X	X	X	X		X	X	
Insecticide application		X	X	X	X	X	X	X	X	X		
Leaf samples				X	X	X	X	X				
Mating disruption			X	X	X	X	X	X	X			
Trapping				X	X	X	X	X		X		
Tray tap		X	X									
Vertebrate pest management	X	X	X	X	X	X	X	X		X	X	X

Seasonal pest management activities for pears

REGION: Southern Oregon

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

Insects	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Codling moth			X	X	X	X	X	X				
Eriophyid mites		X	X	X	X				X			
Grape mealybug	Not actively managed											
Leafroller			X	X								
Pear psylla		X	X	X	X	X	X	X	X	X		
Scale		X	X	X		X						
Spider mites							X	X				
True bugs			X	X	X	X	X					
Pathogens	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Fire blight			X	X	X	X	X			X		
Powdery mildew			X	X	X							
Russet			X	X	X							
Scab			X	X	X	X	X					
Postharvest decay								X	X	X		
Weeds	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Annual Grasses		X	X	X	X	X	X	X		X	X	
Perennial Grasses		X	X	X	X	X	X	X		X	X	
Annual Broadleaves		X	X	X	X	X	X	X		X	X	
Perennial Broadleaves		X	X	X	X	X	X	X		X	X	
Woody species											X	

Seasonal activity tables for pear

REGION: Wenatchee

Field activities (other than pest management)

Activity	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Banking/budgeting	X	X								X	X	X
Bees/pollination				X	X							
Brush cleanup			X	X	X							
Equipment maintenance	X	X	X	X	X	X	X	X	X	X	X	X
Fall cleanup										X	X	
Foliar fertilizer				X	X	X	X	X				
Ground fertilizer			X	X	X	X	X	X	X	X	X	
Harvest							X	X	X	X		
Insurance	X	X									X	X
Irrigation					X	X	X	X	X			
Mowing				X	X	X	X	X	X	X	X	
Planting				X	X							
Saw work	X	X	X								X	X
Summer pruning						X	X	X				
Thinning					X	X	X					
Tree training	X	X	X	X	X	X	X	X	X	X	X	X
Tying (spring)/propping (summer)				X	X		X	X				
Winter pruning	X	X	X	X						X	X	X

Pest management activities

Activity	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Fire blight management (bactericide)				X	X	X						
Fungicide application				X	X	X	X	X	X			
Herbicide application				X	X	X	X	X	X	X		
Insecticide application			X	X	X	X	X	X	X			
Maintaining clean lines (warehouse)	X	X	X	X				X	X	X	X	X
Mating disruption				X	X	X	X	X	X			
Post-harvest fogging (warehouse)								X	X	X		
Pre-harvest sanitation (warehouse)							X	X				
Scouting			X	X	X	X	X	X	X	X		
Suckering (removing tree suckers from root stock)						X	X					
Trapping (codling moth)					X	X	X	X	X			
Tree washing (honeydew)							X	X	X			
Vertebrate pest management	X	X	X	X	X	X	X	X	X	X	X	X

Seasonal pest management activities for pear

REGION: Wenatchee

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

Insects	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Codling moth				X	X	X	X	X	X			
Eriophyid mites			X	X	X	X	X	X	X			
Grape mealybug				X	X	X	X					
Leafroller				X	X	X	X					
Pear psylla		X	X	X	X	X	X	X	X	X		
Scale			X	X	X	X	X					
Spider mites			X	X	X	X	X	X				
True bugs			X	X	X	X	X	X	X			
Pathogens	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Canker	X	X	X	X							X	X
Fire blight	X	X	X	X	X	X	X	X	X	X	X	X
Powdery mildew				X	X							
Russet			X	X	X							
Postharvest decay								X	X			
Postharvest disease (warehouse)	X	X	X	X	X	X	X	X	X	X	X	X
Replant (fumigation)			X	X						X	X	
Weeds	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Annual grasses				X	X	X	X	X	X	X		
Perennial grasses				X	X	X	X	X	X	X		
Annual broadleaves				X	X	X	X	X	X	X		
Perennial broadleaves				X	X	X	X	X	X	X		
Woody species				X	X	X	X	X	X	X		

Seasonal activity tables for pear

REGION: Yakima

Field activities (other than pest management)

Activity	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Fertilizer			X	X	X	X	X			X		
Fire blight cutting				X	X	X	X					
Frost control			X	X	X							
Grafting				X								
Irrigation			X	X	X	X	X	X	X	X		
Measuring fruit growth				X	X	X	X	X				
Mowing				X	X	X	X	X		X	X	
Orchard removal	X	X								X	X	X
Picking							X	X	X			
Plant growth regulation				X			X	X	X			
Planting			X	X								
Pollenization				X								
Pruning	X	X								X	X	X
Thinning				X	X							

Pest management activities

Activity	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Fungicide application				X			X	X	X			
Herbicide application				X	X	X				X	X	
Insecticide application		X	X	X	X	X	X	X	X			
Nutrient application			X	X	X	X	X	X	X	X		

Seasonal pest management activities for pear

REGION: Yakima

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

Insects	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Codling moth				X	X	X	X	X	X			
Eriophyid mites		X	X	X	X	X	X	X				
Grape mealybug				X	X	X	X	X				
Leafroller				X	X	X	X	X				
Pear psylla		X	X	X	X	X	X	X	X			
Scale		X	X	X	X	X	X	X				
Spider mites		X	X	X	X	X	X	X				
True bugs					X	X	X	X				
Pathogens	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Fire blight	X			X	X	X	X	X	X		X	X
Powdery mildew				X	X	X	X	X				
Russet				X	X	X	X	X				
Postharvest decay				X				X	X			
Weeds	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Annual grasses				X	X	X				X	X	
Perennial grasses				X	X	X				X	X	
Annual broadleaves				X	X	X				X	X	
Perennial broadleaves				X	X	X				X	X	
Woody species				X	X	X				X	X	

Pear pesticide risk management

The letters below represent four categories of nontarget risk potentially affected by pesticide use. If a letter is used, it indicates that mitigation is needed at commonly used application rates in order to reduce risk. Risks were calculated using the risk assessment tool IPM PRiME. This table does not substitute for any mitigations required by the product label. For more information see Appendix X, “Pesticide Risk Classification.”

A= Risks to aquatics: invertebrates and fish

T= Risks to terrestrial wildlife: birds and mammals

P= Risks to pollinators: risk of hive loss

B= Risks to bystanders: for example, a child standing at the edge of the field

“ND” means no data is available for this product.

“–” means that risks are not anticipated for this product based on the categories of risk analyzed

HHP = Any product highlighted in yellow is classified as a “highly hazardous pesticide” by the World Health Organization and the Food and Agriculture Organization of the United Nations. These products may pose significant risks to human health and/or the environment, and risk reduction measures may not be effective in mitigating risks.

Pesticides	**Risks requiring mitigation**	**Dormancy**	**Delayed dormancy**	**Cluster bud through pink**	**Bloom to petal fall**	**Petal fall**	**Summer**	**Preharvest - harvest**	**After harvest**	**Target pest(s)**	**Comments**
		Average number of applications per crop stage, if used (does not imply usage takes place at every stage reported)									
Insecticides											
Abamectin (Agri-Mek)	**A, P**			1		1	1			Rust mite control; Psylla/mite suppression	Once per season
Acequinocyl (Kanemite)	**A**										
Acetamiprid (Assail, Intruder)	**A**			1		1	1.5			Psylla, codling moth	Twice per season
Acetamiprid + Novaluron (Cormoran)	**A**			1		1	1			Psylla, codling moth	Cheaper mixed than separate
Azadirachtin (Neem)	-			1		1	3	1			Multiples applications best
Bacillus thuringiensis (Dipel, Javelin)	-									Leafroller, codling moth	
Bifenazate (Acramite)	-			1			1			Once per season	Efficacy decreasing
Bifenthrin (Brigade)	**A, P**										

Pesticides	Risks requiring mitigation	Dormancy	Delayed dormancy	Cluster bud through pink	Bloom to petal fall	Petal fall	Summer	Preharvest - harvest	After harvest	Target pest(s)	Comments
		Average number of applications per crop stage, if used (does not imply usage takes place at every stage reported)									
Buprofezin (Centaur)	**-**			1		1	1.5			Mealy bug/ psylla	May need 2 applications
Burkholderia spp (Venerate)	**ND**										
Calcium polysulfide (Sulforix)	**ND**										
Chlorantraniliprole (Altacor)	**-**						2			Codling moth	Very efficacious
Chlorpyrifos (Lorsban)	**A, T, P, B**		1	1							Not critical
Chromobacterium subtsugae (Grandevo)	**ND**										
Clofentezine (Apollo)	**-**									Mites	Resistance issues
Cyantraniliprole (Exirel)	**ND**									Psylla	Suppression; expensive
Cyflumetofen (Nealta)	**ND**						1.5			Mites	Short PHI; useful at end of season
Cyfluthrin (Tombstone)	**HHP**										
Gamma cyhalothrin (Declare)	**A**										
Deltamethrin (Delta Gold)	**A, P**										
Diazinon	**A, T, P, B**			1							Long PHI; difficult to use
Diflubenzuron (Dimilin)	**A, T**										
Dimethoate	**A, T, P, B**									Stink bug	Long PHI
Esfenvalerate (Asana)	**A, P**										
Etoxazole (Zeal)	**A**									Mites	Resistance issues
Fenbutatin oxide (Vendex)	**A, T**										Will work once per season

Pesticides	Risks requiring mitigation	Dormancy	Delayed dormancy	Cluster bud through pink	Bloom to petal fall	Petal fall	Summer	Preharvest - harvest	After harvest	Target pest(s)	Comments
		Average number of applications per crop stage, if used (does not imply usage takes place at every stage reported)									
Fenpropathrin (Danitol)	**A, T, P**										
Fenpyroximate (FujiMite)	**A, T**						1.5				Used once per year; efficacy depends on coverage
Flubendiamide (Belt)	**-**										
Flupyradifurone (Sivanto)	**ND**						2				
Hexythiazox (Onager)	**-**						1				Resistance issues
Imidacloprid	**HHP**						1.5			Psylla	Inexpensive; late season use will take out early instars
Indoxacarb (Avaunt)	**P**										
Kaolin (Surround)	**-**	1	1	1		1	1.5		1	Psylla	Best hope for reducing overwintering egg lay
Lambda-cyhalothrin (Warrior)	**A, P**	1	1								Inexpensive; limited efficacy
Malathion	**P**	1	1	1						Psylla	Might be used 2 times pre-bloom
Methoxyfenozide (Intrepid)	**-**					1				Codling moth	
Mineral oils (JMS Stylet)	**A**	1	1	1		1	4	2	1	Psylla, mite, codling moth	
Novaluron (Rimon)	**A**			1		1				Psylla	Very efficacious
Permethrin	**A, T, P**										
Phosmet (Imidan)	**A, T, P**										Not used anymore

Pesticides	Risks requiring mitigation	Dormancy	Delayed dormancy	Cluster bud through pink	Bloom to petal fall	Petal fall	Summer	Preharvest - harvest	After harvest	Target pest(s)	Comments
		Average number of applications per crop stage, if used (does not imply usage takes place at every stage reported)									
Pyrethrins (Pyganic)	**P**										Disruptive and not effective
Pyridaben (Nexter)	**A, P**						1			Mite, psylla	One of the tools used in rotation
Pyriproxifen (Esteem)	**-**		1	1						Great on scale, weak on psylla	Weakest of the three insect growth regulators
Spinetoram (Delegate)	**P**		1	1			2			Psylla, codling moth	Coverage difficult later in season; still a viable tool
Spinosad (Delegate)	**P**										Organic -approved
Spirodiclofen (Envidor)	**HHP**										
Spirotetramat (Ultor)	**-**					1	1				
Tebufenozide (Confirm)	**-**										
Thiamethoxam (Actara)	**HHP**					1	1.5				Inexpensive; effective
Tolfenpyrad (Bexar)	**A**		1	1		1	1				MRL issues limit use later in season; efficacy dependent on coverage
Zeta-cypermethrin (Mustang)	**HHP**										
Fungicides and nematicides											
Acibenzolar-S-methyl (Actigard)	-			1	1					Fire blight	
Antibiotics (oxytetracycline, streptomycin)	-				0-4					Fire blight	
Aureobasidium pullulans, strain DSM 14940 (Blossom protect)	ND			2-3	0-1					Fire blight	Early bloom

Pesticides	Risks requiring mitigation	Dormancy	Delayed dormancy	Cluster bud through pink	Bloom to petal fall	Petal fall	Summer	Preharvest - harvest	After harvest	Target pest(s)	Comments
		Average number of applications per crop stage, if used (does not imply usage takes place at every stage reported)									
Bacillus amyloliquefaciens, strain D747 (Double nickel)	ND			1	1	1				Mildew/fire blight	
Bacillus pumilus (Sonata)	-			1	1	1				Mildew/ fire blight	
Bacillus subtilis (Serenade)	-			1	1	1		1-2		Mildew, storage rots	
Bacteriophage of fire blight	ND				0					fire blight	
Bicarbonate-based products (Kaligreen, Milstop)	-			1		1				Mildew	
Boscalid + pyraclostrobin (Pristine)	A			0-1		0-1		1		Scab/ mildew/ storage rots	
Calcium hypochlorite	ND										
Calcium polysulfide (lime sulfur, others)	ND										
Captan	P						1	1		Bull's eye rot	
Cerevisane (Romeo)	-										
Copper products (Kocide, Champ, others)	A, T, P (risks vary)		1							Fire blight	
Cyflufenamid (Torino)	-										
Cyprodinil (Vangard)	-						1			Scab/ mildew	Not common
Cyprodinil + difenoconazole (Inspire super)	-					1	1			Mildew/ storage rots	
Difenoconazole + fludioxinil (Academy)	-								1	Storage rots	Warehouse
Dodine (Syllit)	A, T, P										
Fenhexamid (Elevate)	-							1		Storage rots	
Fludioxinil (Scholar)	-								1	Storage rots	Warehouse

Pesticides	Risks requiring mitigation	Dormancy	Delayed dormancy	Cluster bud through pink	Bloom to petal fall	Petal fall	Summer	Preharvest - harvest	After harvest	Target pest(s)	Comments
		Average number of applications per crop stage, if used (does not imply usage takes place at every stage reported)									
Fluopyram (Luna Privilege, Velum Prime)	T				1	1	1			Scab/ mildew/ storage rots	
Fluopyram + pyrimethanil (Luna tranquility)	T				1	1	1			Scab/ mildew/ storage rots	
Fluopyram + trifloxystrobin (Luna Sensation)	A, T			0-1	1	1	1			Scab/ Mildew/ storage rots	
Flutriafol (Topguard)	ND			1		1	1			Scab/ Mildew	
Fluxapyroxad + pyraclastrobin (Merivon)	A			0-1		0-1		1		Storage rots	
Fosetyl-al (Aliette)	-						0-1	0-1		Phytophthora	Unusual young trees
Horticultural oils (JMS Stylet, Biocover)	A					1	0-3				
Mancozeb (Manzate)	T			0-1		1	0-2			Scab	
Metalaxyl (Metastar)	T										
Metam sodium (nematicide)	A, T	0-1	0-1								Fumigation
Myclobutanil	T				1	1	1			Mildew/ scab	
Oxamyl (Vydate) (as nematicide)	HHP						0-1	0-1		Nematodes	Not common
Oxytetracycline (Mycoshield)											
Penthiopyrad (Fontelis)	-			0-1		0-1	0-2			Mildew/ Storage rots/scab	Application on scab depends on weather conditions
Polyoxin D zinc salt (Ph-D)	-					1		1		Mildew/ storage rots	
Propiconazole (Bumper)	HHP										
Pyrimethanil (Scala)	-								1	Storage rots	Warehouse

Pesticides	Risks requiring mitigation	Dormancy	Delayed dormancy	Cluster bud through pink	Bloom to petal fall	Petal fall	Summer	Preharvest - harvest	After harvest	Target pest(s)	Comments
		Average number of applications per crop stage, if used (does not imply usage takes place at every stage reported)									
Reynoutria Sachalinensis (Regalia)	-				0-1	0-1				Mildew/fire blight	Not common
Thiophanate methyl (Topsin)	T							0-1		Storage rots	
Trifloxystrobin (Flint)	A			0-1	0-1	0-1	0-1			Scab/ mildew	
Triflumizone (Procure)	HHP			0-1	0-1	0-1	0-2			Scab/ mildew	
Wettable sulfur (Microthiol Disperss)	-		1	1						Mildew	
Ziram	A, T, P					0-1	0-1	1		Bull's eye rot	14 DPH
Herbicides											
2,4D (Weedar, Saber)	A					1	1			Broadleaves	Used once/ year
Acetic acid (Vinagreen)	-										
Carfentrazone-ethyl (Aim)	-									Broadleaves	
Clethodim (Selext Max)	-					1	1			Grasses	Used once/ year
Clopyralid (Stinger)	-					1	1			Broadleaves	Used once/ year
Dichlobenil (Casoron)	T	1	1						1	All weeds	Used once/ year
Diuron (Karmex)	T					1	1		1	Broadleaves	Used once/ year; widely used
Fluazifop-P-Butyl (Fusilade)	HHP									Grasses	Nonbearing only
Glufosinate ammonium (Rely)	HHP					1	1		1	All weeds	Used once/ year
Glyphosate (Roundup)	-			1		1	1		1	All weeds	Used ~2 times/year; widely used
Halosulfuron-methyl (Sandea)	-						1			Sedges, broadleaves	Used once/ year

Pesticides	Risks requiring mitigation	Dormancy	Delayed dormancy	Cluster bud through pink	Bloom to petal fall	Petal fall	Summer	Preharvest - harvest	After harvest	Target pest(s)	Comments
		Average number of applications per crop stage, if used (does not imply usage takes place at every stage reported)									
Isoxaben (Trellis)	T	1	1	1						Broadleaves, some grasses	Used once/ year
Indaziflam (Alion)	-	1	1			1	1		1	Broadleaves, grasses	Widely used; once/year
Norflurazon (Solicam)	A, T								1	Grasses	Used once/ year
Oryzalin (Surflan)	A, T	1	1	1					1	Grasses	Used once/ year
Oxyfluorfen (Goal)	A, T	1							1	Broadleaves, grasses	Used once/ year
Oxyfluorfen + penoxsulam (Pindar)	A, T	1	1						1	Broadleaves, grasses	Used once/ year
Paraquat (Gramoxone)	HHP					1	1			Broadleaves, grasses	Used 2-3 times/year
Pendimethalin (Prowl)	T	1	1	1		1			1	Grasses	Used once/ year
Pronamide (Kerb)	-	1	1							Grasses	Used once/ year
Pyraflufen-ethyl (Venue)	-			1		1	1			Broadleaves, suckers	Used once/ year
Rimsulfuron (Matrix)	-	1	1						1	Broadleaves, grasses	Used once/ year
Sethoxydim (Poast)	-					1	1			Grasses	Used once/ year
Simazine (Princep)	T	1	1			1	1		1	Broadleaves	Used once/ year; widely used

Efficacy ratings for pathogen and nematode management tools in pear

Rating scale: E = excellent (90–100% control); **G** = good (80–90% control); **F** = fair (70–80% control); **P** = poor (< 70% control); **?** = efficacy unknown in management system—more research needed

Management tools	Fire blight	Powdery mildew	Russet	Scab	Postharvest decay	Nematodes	Replant disease		Comments
Fungicides/nematicides									
Acibenzolar-S-methyl (Actigard)	G								
Antibiotics (oxytetracycline, streptomycin)	G-E								
Aureobasidium pullulans, strain DSM 14940 (Blossom protect)	G								
Bacillus amyloliquefaciens, strain D747 (Double nickel)	P-F								
Bacillus pumilus (Sonata)		F							
Bacillus subtilis (Serenade)	F	F			P				
Bacteriophage of fire blight	P								
Bicarbonate-based products (Kaligreen, Milstop)		G							
Boscalid + pyraclostrobin (Pristine)		E		E	E				Resistance issues
Calcium hypochlorite	?								
Calcium polysulfide (lime sulfur, others)		F							
Captan					P				
Cerevisane (Romeo)		?							
Copper products (Kocide, Champ, others)	F-G								Fixed copper (delayed dormant only)
Cyflufenamid (Torino)		G-E							
Cyprodinil (Vangard)		E			G				
Cyprodinil + difenoconazole (Inspire super)		E		G	G				
Difenoconazole + fludioxinil (Academy)					G-E				
Dodine (Syllit)				E					

Management tools	Fire blight	Powdery mildew	Russet	Scab	Postharvest decay	Nematodes	Replant disease		Comments
Fenhexamid (Elevate)					G-E				Used for gray mold control; MRL issues
Fludioxinil (Scholar)					G-E				
Fluopyram (Luna Privilege, Velum Prime)		G-E			G				
Fluopyram + pyrimethanil (Luna tranquility)		E			E				
Fluopyram + trifloxystrobin (Luna Sensation)		E		E	E				Resistance issues
Flutriafol (Topguard)		E		E	F				Resistance issues
Fluxapyroxad + pyraclastrobin (Merivon)		E		E	E				Resistance issues
Horticultural oils (JMS Stylet, Biocover)		P							
Mancozeb (Manzate)		F		G					
Metam sodium (nematicide)							E		Fumigant
Myclobutanil		E							
Oxamyl (Vydate) (as nematicide)						G			
Oxytetracycline (Mycoshield)	G								
Penthiopyrad (Fontelis)		G-E		G	G				
Polyoxin D zinc salt (Ph-D)		G			G-E				G for gray mold
Propiconazole (Bumper)		G-E							
Pyrimethanil (Scala)		E							
Reynoutria Sachalinensis (Regalia)	P	P							
Tebuconazole (Tebucon)		E		G					
Thiophanate methyl (Topsin)		G		F	G-E				Resistance issues
Trifloxystrobin (Flint)		E		G	G				
Triflumizone (Procure)		E		G	P				
Ziram				F	P				
Cultural/nonchemical									
Removing infected limbs	G								Longer-term efficacy

Efficacy ratings for insect management tools in pear

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

Management tools	Codling moth	Eriophyid mite	Grape mealybug	Leafroller	Pear psylla	Scale	Spider mite	True bugs			Comments
Insecticides											
Abamectin (Agri-Mek)		E			P		P				Resistance issues
Acequinocyl (Kanemite)							F				Not commonly used
Acetamiprid (Assail, Intruder)	E				G-F	F		P			
Acetamiprid + Novaluron (Cormoran)											
Azadirachtin (Neem)					F						
Bacillus thuringiensis (Dipel, Javelin)	P			G							
Beta-cyfluthrin (Baythroid)					P			F			
Bifenazate (Acramite)							E-P				Resistance issues
Bifenthrin (Brigade)					P			F			
Buprofezin (Centaur)			E		P						
Burkholderia spp (Venerate)					F-G						
Calcium polysulfide (Sulforix)					F						
Chlorantraniliprole (Altacor)	E			E							
Chlorpyrifos (Lorsban)			E		G-F	E					
Chromobacterium subtsugae (Grandevo)					P		P				
Clofentezine (Apollo)							G				
Clothianidin (Belay/Clutch)					G-P			F			
Cyantraniliprole (Exirel)	E			E	F-P						
Cyflumetofen (Nealta)							E				
Cyfluthrin (Tombstone)	G				P			F			

Management tools	Codling moth	Eriophyid mite	Grape mealybug	Leafroller	Pear psylla	Scale	Spider mite	True bugs			Comments
Deltamethrin (Delta Gold)	G				P			F			
Diazinon	P		G			G					
Diflubenzuron (Dimilin)	P				E						
Esfenvalerate (Asana)					P			F			
Etoxazole (Zeal)							E-P				Resistance issues
Fenbutatin oxide (Vendex)		G					F				
Fenpropathrin (Danitol)	G				P			F			Resistance issues
Fenpyroximate (Fujimite)					P		P				
Flubendiamide (Belt)	G			G							
Flupyradifurone (Sivanto)					G						
Hexythiazox (Onager)							G-P				Resistance issues
Imidacloprid					F-P	G-P	G				
Indoxacarb (Avaunt)	F										
Kaolin (Surround)		G			E-G						
Lambda-cyhalothrin (Warrior)	G				F-P			F			
Lambda-cyhalothrin + thiamethoxam (Endigo)											
Malathion					G						
Methoxyfenozide (Intrepid)	F			G							
Mineral oils (JMS Stylet)	F				F						
Novaluron (Rimon)	G				G						
Permethrin	G				P			F			
Phosmet (Imidan)	F-G		F								
Pyrethrins (Pyganic)					P						
Pyridaben (Nexter)		F			P		F				
Pyriproxifen (Esteem)					G-F						
Spinetoram (Delegate)	E			E	F-G						Expensive

Management tools	Codling moth	Eriophyid mite	Grape mealybug	Leafroller	Pear psylla	Scale	Spider mite	True bugs			Comments
Spinosad (Success/Entrust)	F			G	P						
Spirodiclofen (Envidor)							E				
Spirotetramat (Ultor)		G			G-F		P				
Tebufenozide (Confirm)	P			F-G							
Thiamethoxam (Actara)			G		G-F	G					
Tolfenpyrad (Bexar)		G			E-G						
Zeta-cypermethrin (Mustang)					P			F			
Unregistered/new chemistries											
Cinnerate					G-p						
Fenazine (Magister)					?		G				
Cultural/nonchemical											
Summer pruning			P-F		G-F						Expensive. Mechanically removes psylla and improves spray coverage
Tree washing					G-F						Short-lived, very effective if properly timed

Efficacy ratings for weed management tools in pear

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

Note**:** Weed size or stage of growth is an important consideration with most postemergence herbicides.

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

Management tools	Pre/ post	Rating	Target weed/comments
Herbicides			
2,4D (Weedar, Saber)	Post	F-G	Broadleaves, used for dandelion control
Acetic acid (Vinagreen)	Post	P	Not used
Caprylic acid (Suppress)	Post	P	Expensive, short-lived, not used
Carfentrazone-ethyl (Aim)	Post	F-G	Broadleaves
Clethodim (Select Max)	Post	F	Grasses, cases of resistance in Italian ryegrass
Clopyralid (Stinger)	Post	F	Broadleaves, Canada thistle; expensive
Dichlobenil (Casoron)	Pre	E	Equisetum; expensive; moisture-dependent
Diquat Bromide (Reglone)	Post	F	Nonbearing only, expensive
Diuron (Karmex)	Pre	G	Broadleaves; inexpensive; commonly tank-mixed; widely used
Fluazifop-P-Butyl (Fusilade)	Post	G	Grasses, nonbearing only
Glufosinate ammonium (Rely)	Post	F	Broadleaves and grasses; expensive
Glyphosate (Roundup)	Post	G	Broadleaves and grasses; commonly used
Halosulfuron-methyl (Sandea)	Pre/post	G	Broadleaves; expensive; used post-emergence for yellow nutsedge
Isoxaben (Trellis)	Pre	G	Annual; short-lived; expensive
Indaziflam (Alion)	Pre	E	Annuals; P for little mallow; long-lasting
Norflurazon (Solicam)	Pre	G	Grasses; expensive
Oryzalin (Surflan)	pre	F	Grasses; inexpensive; needs to be watered in
Oxyfluorfen (Goal)	Pre/post	G	Broadleaves and grasses (dormancy)
Oxyfluorfen + penoxsulam (Pindar)	Pre	G	Weak on grass, expensive
Paraquat (Gramoxone)	Post	E	Burndown; short-lived
Pendimethalin (Prowl)	Pre	F-G	Grasses

Management tools	Pre/ post	Rating	Target weed/comments
Pronamide (Kerb)	Pre	G-E	Grasses (dormancy); very expensive
Pyraflufen-ethyl (Venue)	Post	F	Broadleaves and suckers; commonly tank-mixed; short-lived
Rimsulfuron (Matrix)	Pre/Post	E	Expensive; needs to be watered in
Sethoxydim (Poast)	Post	G	Grasses (use on ryegrass); resistance present in Italian ryegrass
Simazine (Princep)	Pre	F	Weak on lambsquarter; used as rotational tank mix; inexpensive; widely used
Unregistered/New chemistries			
Sulfentrazone (Shutdown)	Pre/post	G	Control of yellow nutsedge and other broadleaves
Pyroxasulfone (Zidua)	Pre	G	Control of yellow nutsedge and grasses
Cultural/Nonchemical			
Wonderweeder		P	Fast
Weed Badger		P	Slow
Flaming	Post	P	Wildfire danger
Side discharge	Post	P	Long term
Mowing	Post	P	Suppression of weed growth, done in row middles

Using PAMS Terminology

This system of terminology for IPM was developed for use by U.S. Federal agencies seeking to support adoption of IPM by farmers. The table below summarizes common tactics used in agricultural IPM using a Prevention, Avoidance, Monitoring, Suppression (PAMS) classification. We also define (in ***italics***) the ecological purpose that lies behind a particular practice. The PAMS tables throughout the text provide a simple basis for surveying practices that are used at different crop growth stages in terms of their contribution to a comprehensive IPM program.

P PREVENTION

Prevent introduction to the farm
- Pest-free seeds, transplants

Prevent reservoirs on the farm
- Sanitation procedures
- Eliminate alternative hosts
- Eliminate favorable sites in and off crop

Prevent pest spread between fields on the farm
- Cleaning equipment between fields

Prevent pests developing within fields on the farm
- Irrigation scheduling to prevent disease development
- Prevent weed reproduction
- Prevent pest-susceptible perennial crops by avoiding high-risk locations

A AVOIDANCE

Avoid host crops for the pest
- Crop rotation

Avoid pest-susceptible crops
- Choose genetically resistant cultivars
- Choose cultivars with growth and harvest dates that avoid the pest
- Place annual crops away from high-risk sites for pest development (even parts of a field)

Avoid crop being the most attractive host
- Trap cropping
- Use of pheromones
- Use crop nutrition to promote rapid crop development

Avoid making the crop excessively nutritious
- Use nutrition to promote rapid crop development
- Avoid excessive nutrients that benefit the pest

Avoid practices that increase the potential for pest losses
- Narrow row spacing
- Optimized in-row plant populations
- No-till or strip till

M MONITORING

Collect pests
- Scouting and survey approaches
- Traps

Identify pests
- Use of identification guides, diagnostic tools and diagnostic laboratories

Identify periods or locations of high pest risk
- Use weather-based pest-development and risk models
- Use soil and plant nutrient testing

Determine status and trends in pest risks and classify pest severity
- Maintain pest records over time for each field

Minimize pest risks over time
- Plan an appropriate PAMS IPM strategy, based upon pest status and trends

Determine interventions based upon risks and economics
- Use of decision-support tools, economic thresholds

S SUPPRESSION

CULTURAL	***Outcompete the pest with other plants*** • Cover crops ***Suppress pest growth*** • Mulches ***Suppress pest with chemicals from crops or other plantings*** • Bio-fumigant crops
PHYSICAL	***Physically injure pest or disrupt pest growth*** • Cultivation • Mowing • Flaming • Temperature management • Exclusion devices ***Physically remove pests*** • Mass trapping • Hand weeding
BIOLOGICAL	***Suppress pest reproduction*** • Pheromones ***Increase pest mortality from predators, parasites, and pathogens*** • Conservation biological control • Inundative release and classical biological control • Use of pest antagonists
CHEMICAL	***Use of least-risk, highest-efficacy pesticides*** • Use economic thresholds to determine that pesticide use is economically justified • Use pesticides as a last resort, as part of a PAMS IPM strategy

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Pesticide risk classification

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The pesticide risk analysis is based on work by the Oregon IPM Center that forms the basis for a number of third-party certification standards for IPM. We analyzed more than 650 pesticides, identifying those that were hazardous to human health, and those that posed manageable risks to aquatic life, wildlife, pollinators and bystanders. The analysis is intended to provide guidance that is supplementary to the pesticide label, which is the primary source of risk-management information and mandatory practices.

1. **Risk to aquatic life**

Pesticides qualified for this risk category if risks to one or more of the following risk models exhibited 10% or greater risk of an adverse outcome at a typical application rate: aquatic algae, aquatic invertebrates or fish (reproduction).

2. **Risk to terrestrial wildlife**

Pesticides qualified for this risk category if risks to one or more of the following risk models exhibited 10 percent or greater risk of an adverse outcome at a typical application rate: avian reproduction, avian acute or small mammal risk.

3. **Risk to pollinators**

Pesticides were selected based on a widely used hazard quotient resulting of pesticide application rate in gallons of active ingredient per hectare, and contact LD50 for the honey bee (*Apis mellifera*). Values of the hazard quotient less than 50 have been validated as low risk in the European Union, and monitoring indicates that products with a hazard quotient greater than 2,500 are associated with a high risk of hive loss. The hazard quotient value (350 or greater) used by IPPC corresponds to a 15% risk of hive loss. The quotient includes a correction for systemic pesticides, where risks to bees are amplified.

4. **Inhalation risk**

Inhalation risk to bystanders was calculated using the ipmPRiME model for inhalation toxicity, calculated on the basis of child exposure and susceptibility. This index is protective for workers who may enter fields during or after application, and also bystanders.

For more information

Jepson, P.C., Murray, K., Bach, O., Bonilla, M.A., Neumeister, L. (2020). Selection of pesticides to reduce human and environmental health risks: a global guideline and minimum pesticides list. Lancet Planetary Health 4: e56-53. https://doi.org/10.1016/S2542-5196(19)30266-9

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