Crop Profile for Pears in California

Prepared: October, 1999

General Production Information

- The United States is the world's second largest pear producer, with USDA statistics reporting U. S. production in 1998 at 833,000 metric tons, with an average of 900,000 metric tons per year for the last 10 years (22).
- California's annual production in 1997 was 312,000 short tons, about 28.2% of US production (16).
- There are approximately 300 growers ingrowers in California growing pears on just under 20,000 acres (21). The predominant variety is Bartlett.
- The five-year average cash value of pears at the first delivery point is $514,314,000 (1). From over 36,000 acres in the late1970s, California Bartlett acreage fell to less than 20,000 in the early 1980s and has stabilized at that level.
- The average cost to produce an acre of pears amounts to $7,375 per acre (2).
- Roughly two-thirds of California's annual Bartlett production is canned by processors, with tight restrictions on insect infestation and disease damage levels. This makes control of the pear's key insect pest, the codling moth, essential to economic production of pears.
- An average of 20-25% of the crop is shipped to the fresh market, where buyers and consumers demand fruit that is free of insects, disease, damage, and that has a clean finish. Potential damage from russet, scab, surface-feeding insects, and codling moths, must be minimized in order to produce fruit suitable for the fresh market.
- The remaining 10-15% is utilized in other processed products such as juice, concentrate, frozen, baby food, dried pears and fermentation (1).

Production Regions

The majority of pears produced in California are found in the northern third of the state in the counties of Sacramento, Yolo, Solano, San Joaquin, Mendocino, Lake, Yuba and Sutter. Other minor producing areas are the counties of El Dorado, Placer, Contra Costa, Madera, Fresno, Tulare and the Littlerock area of Los Angeles County.

Cultural Practices

Pears are most productive on loam-textured, deep uniform soils. Although, many orchards or portions of orchards are planted on less than ideal sites where soil modification or special treatment may be necessary. Sprinkler irrigation is the predominant form of irrigation with a few orchards still using flood and furrow irrigation where these methods are practical.

Pears begin blooming in the Early Districts of Sacramento, San Joaquin, Yolo, Sutter, Yuba and Solano about the 15th of March. The major varieties of Bartlett and Bosc are self-fruiting (parthenocarpic). Most California growers do not use cross-pollinizers or bees.

European Cultivars:

The predominant summer variety of pear grown in California is the smooth skinned Bartlett (Williams) averaging 285,310 short tons for the last five years (1). Other varieties of European summer pears are the Butirra Precoce Morettini (Juno) (earlier than Bartlett), Red Sensation, Max Red and Clapp Favorite (Rosired or Stark Crimsom). The predominant fall pear in California is Bosc with about 16,000 tons being produced yearly (21). This variety has the potential to increase to 25,000 tons/year. Other fall pears in order of importance are Comice, Seckel, Beurre Hardy (French Butter Pear) and Forelle.

The above varieties are grafted onto rootstocks. Rootstock selection is based on cultivar compatibility, soil texture and drainage, susceptibility to pests (primarily fire blight, oak root fungus and pear decline), and weather conditions of the orchard site. The more common European rootstocks are Winter Nelis, *Pyrus betulifolia* and the Old Home X Farmingdale crosses. Less common are *P. calleryana* and Bartlett.

Asian Cultivars:

While their plantings are small relative to European pears, Asian pears makeup an important part of some pome and stone fruit growers' marketing mix. They are planted throughout the Sacramento and San Joaquin Valleys. Some of the varieties are Ya Li, Shinseiki, Kosui, Hosui, 20th Century and Tsu Li (3).

IPM:

The California pear industry is committed to implementing environmentally sound pest management practices. To that aim it has supported research and implementation projects into pheromone-based mating disruption for codling moth control for the past 10 years that has steadily moved us in the adoption of this new technology.

Insect Pests

In California pears, the major insect pests are codling moth, pear psylla, and spider mites. Other secondary pests that occasionally cause damage are leafrollers, true bugs (boxelder, lygus and stink bugs), mealybugs, russet mites and San Jose scale.

Codling Moth, *Cydia pomonella*
The pear pest of primary importance in California is codling moth (CM) due to its lack of effective biological control agents, direct attack on pears, and effects on fruit storage. Growers try to control efficacy at less than 1% damage. While some of the other pests may also directly damage the fruit, the frequency and intensity are typically far less and easier to control.

Codling moths overwinter as full-grown larvae in an inactive state called diapause. The larvae pupate inside cocoons in early spring. Shortly thereafter they emerge as moths. Mating does not occur until sunset temperatures reach 62° F. Each mated overwintering female deposits 30 to 70 eggs. Eggs hatch when an average of 158 degree-days have accumulated from the time that they were laid. Young larvae bore into the fruit within the first 24 hours after hatching and tunnel to the core, where they feed on developing seeds. In early stages of fruit development, infested fruit normally fall to the ground. Later in fruit development, infested fruit rot from the core out making it difficult if not impossible to sort on a packing line. Infested fruit in canning pears rot first in the ripening process, infecting other pears in the bin with rot, causing extensive loss of case-yield per ton (8). Canners have pulled CM-infested bins of pears from the ripening rooms upon completion of ripening to find larvae crawling from pear to pear.

Monitoring: Pheromone traps are used extensively to monitor CM adults and coupled with degree-day modeling are used to time treatment applications.

Chemical Controls:
(All insecticide applications are assumed to be applied by ground unless otherwise noted.)

Pre-harvest chemical applications are an important component in the control of codling moth in pears. The following chemicals are used in conventional insecticide programs. Chemical information, including formulation, label rates, REI and PHI, was obtained from the manufacturers label many of which are found in the 1999 Crop Protection Reference (18).

- Azinphos-methyl – In 1997, a total of 50,162 lb a.i. azinphos-methyl was applied to 79.03% of the pear acreage. Azinphos-methyl was applied an average of 3 times at a median rate of 1.0 lb a. i./acre (11). A new label is under review at EPA and CDPR. Azinphos-methyl is the most

effective material against codling moth. It is somewhat selective against predaceous mites but toxic to generalist predators. It is less disruptive to natural pear psylla enemies such as lacewing. It is the preferred material because of its longer residual; however, with the new label it may not be feasible to use due to a long reentry interval.

- Methyl Parathion – Label has a 1-1.5 lb a.i./acre rate and a 30-day PHI in areas with less than 25 inches of rainfall per year. 48-hour REI. In 1997, a total of 13,862 lb a.i. methyl parathion was applied to 36.96% of the pear acreage. Methyl parathion was applied an average of 1 time at a median rate of 1.3 lb a.i./acre rate (11). Methyl parathion is applied in the pre-harvest season as a resistance management tool (See discussion under IPM). All uses of methyl parathion on pears were canceled as of January 1, 2000.

- Phosmet – Label has a 1.5-5 lb a.i./acre rate (not to exceed 5 lb a.i./acre) and a 7-day PHI. 24-hour REI. In 1997, a total of 10,053 lb a.i. was applied to 12.7% of the pear acreage. Phosmet was applied an average of 1 time at a median rate of 2.45 lb a.i./acre (11). This is the third OP for CM control. It was used considerably more in 1998 just previous to harvest because of the azinphos-methyl REI. Also, 1998 was a low population codling moth year. Researchers, farm advisors and PCAs advise this insecticide would not carry the orchard through the picking season without some CM damage in a normal year (5). A full rate application is not considered to have the residual of an azinphos-methyl or methyl parathion application. Thus, it is a poor choice for heavy CM populations. A pH of 6.5 tank-mixing water is necessary to achieve optimal results. This is sometimes hard to achieve without buffers, as farm well waters are notorious for their hard water. It has the same CM resistance problems as azinphos-methyl.

Chemical Resistance:
Codling moths have developed resistance to all of the above chemicals, except methyl parathion and chlorpyrifos.

Alternatives:
An alternative approach to a full insecticide program is the use of synthetic pheromone sources to prevent the successful mating of pest species. If mating can be disrupted, then reproduction is prevented, thus minimizing infestations of the crop due to lower population levels of the pest. A variety of synthetic pheromone sources are placed within the orchard at a rate of 120 to 400 dispensers per acre depending on the product for codling moth. Recent technological breakthroughs in dispenser efficacy and longevity have made the use of pheromone mating disruption programs highly effective for control of codling moth.

After 5 years of limited field testing that started in 1987, large field implementation trial using mating disruption as its core was started in Sacramento County in 1993 and in Mendocino County in 1996 (See Current Research).

Total elimination of OP and IGR insecticides is not feasible at this time. Supplemental OP and IGR

insecticide use for codling moth control are needed when populations are too high, the orchards are too small, in hilly terrain, have wind-exposed boarders or are not uniformly planted. If the orchard is close to a source of codling moth such as backyard apple and pear trees, bin piles, packing sheds or a walnut orchard supplemental OPs and IGRs may also be needed.

Biological Control:
Opportunities for biological control have never been greater since the introduction of alternatives to azinphos-methyl for control of codling moth. Codling moth parasitism levels in California are very low, ranging from 0-10%. In Eurasia, were codling moth originates, parasitism levels are higher ranging from 30 to 60%. Successful introduction of parasitoids would reduce codling moth populations thus making mating disruption a more effective control measure given that mating disruption is not as effective with high populations.

The compatibility of each parasitoid species with codling moth suppression is assessed before field release is considered. Of the eight species acquired, three species have been released in several locations in California. *Liotryphon caudatus* has been field released since 1992 and *Mastrus ridibundus* since 1995. Both species have been recovered from a number of release sites and in 1997 they were recovered in orchards were no in-season releases had taken place, indicating successful overwintering of the parasitoid populations in the field. A third species *Microdus rufipes* has been released in small numbers since 1995. Reproductive successful populations now appear to be present in California with *M. ridibundus* being the most active in pear orchards, generating up to 38% parasitism of the overwintering codling moth in trap bands.

Cultural Controls:
On-going research by Dr. Robert Van Steenwyk at UC Berkeley with post-harvest control of codling moth using sanitation techniques has shown a potential reduction of 50-60% in the overwintering flight the following spring. Removal of fruit prior to codling moth diapause, based on our understanding of photo period-diapause interactions and our empirical data, has shown that significant proportions of the overwintering population can be removed in the previous year. Presently, sending a crew immediately after harvest to knock down all pears left in the tree and then picking them up from the ground for juice achieves post-harvest sanitation. The cost effectiveness of this method depends on that year's price for juice and the tree density per acre. In orchards where tree density is too high or when the price for juice is too low growers cannot susta.i.n the additional costs from post-harvest sanitation. Dr. Van Steenwyk has been working on a reduced risk post-harvest treatment of ethephon that would accelerate the ripening of pears remaining on the tree after harvest making them unsuitable for CM larval survival. The Pear Advisory Board will seek a Section 24(c) for post-harvest use of ethephon. One key advantage of post-harvest sanitation is the high level of selectivity and ability to prevent outbreaks the next year, if high CM populations are found at harvest.

Pear Psylla, *Cacopsylla pyricola*

Pear psylla's status as a major pest of pears is based on its ability to vector a mycoplasma that causes pear decline and to develop resistance to insecticides. Pear decline reduces tree vigor and causes poor fruit set, small fruit size, and tree death. From 1945 to 1990 pear psylla has become resistant to 21 pesticides from four different classes of compounds. Pear psylla injects a toxin into the tree tissue as it feeds causing blackening and burning of the foliage. Honeydew produced by psylla feeding runs off and drips onto the fruit. A black sooty fungus grows on the honeydew, russeting the skin which causes the fruit to be downgraded. From a psylla management point of view, softer programs such as codling moth mating disruption afford better control of psylla than organophosphate programs that disturb the predator balance.

The present management of psylla relies on dormant oil sprays and one pyrethroid spray at delayed dormant timing if monitoring indicates a need for an additional pyrethroid application. Oil is used during the growing season coupled with abamectin, a microbial by-product and post-harvest clean up oil sprays. The main benefit of implementing the codling moth mating disruption program is to take advantage of the increasing diversity of natural enemies in orchards not regularly treated with organophosphates.

Monitoring: Pear psylla adults are monitored by beating tray sampling or presence/absence sampling of the top shoots of pear trees.

Chemical Control:

- Avermectin – Label has a 0.0117-0.0234 lb a.i./acre rate and a 28-day PHI. 12-hour REI. In 1997, a total of 255 lb a.i. was applied to 60.61% of the pear acreage. Avermectin was applied an average of 1 time at a median rate of 0.01 lb a.i./acre (11). One application. Applied at 0.023 lb a. i./ac after petal fall. This is the material of choice for pear psylla control due to efficacy and because it also controls spider mites.

- Esfenvalerate – Label has a 0.025-0.075 lb a.i./acre rate (not to exceed 0.375 lb a.i./acre/season) and a 28-day PHI. 12-hour REI. In 1997, a total of 1,094 lb a.i. was applied to 60.18% of the pear acreage. Esfenvalerate was applied an average of 1 time at a median rate of 0.05 lb a.i./acre (11). Applied at delayed dormant to white bud stage only; however, in any event before egg laying. After dormant oil spray and before bud-break, growers will take beating-tray samples. If overwintering adult populations are relatively high, a treatment will be applied. Esfenvalerate should not be applied during the growing season because it causes mite flair ups.

- Permethrin – Post-harvest dormant and pre-bloom applications only. Label has a 0.2-0.4 lb a.i./ acre rate (not to exceed 0.8 lb a.i/acre/season) and a 12-hour REI. In 1997, a total of 14 lb a.i. was applied to 0.59% of the pear acreage. Permethrin was applied an average of 1 time at a median rate of 0.11 lb a.i./acre (11). Permethrin is perhaps as efficacious as esfenvalerate; however, it can be very disruptive to mite predators (causing explosive mite populations later in the season), which is the reason for its limited use.

- Amitraz – Label has a 0.5-1.5 lb a.i./acre rate (not to exceed 3 lb a.i./acre/season) and a 14-day PHI. 24-hour REI. In 1997, a total of 644 lb a.i. was applied to 2.22% of the pear acreage. Amitraz was applied an average of 1 time at a median rate of 1.5 lb a.i./acre (11). Used primarily in wet (high rainfall) years where growers cannot apply dormant oil or delayed dormant application of esfenvalerate because the ground is too wet for ground application equipment. By the time these orchards become dry enough for ground application equipment, egg laying and hatch have already occurred requiring drastic measures to suppress the population to manageable levels. Disruptive to natural predators.

- Horticultural Oils - In 1997, a total of 2,460,930 lb a.i. was applied to 89.8% of the pear acreage. Oils were applied an average of 3 times at a median rate of 23.57 lb a.i./acre (11). Oil has a smothering effect on insects. Used in dormant applications as well as pre-harvest and post-harvest. In dormant applications rates are 15-20 gallons/acre. In-season applications rates are 4-6 gallons/acre depending on the viscosity of the oil. Certain stages (hardshell) in the life cycle of pear psylla are not susceptible to oils

Mites: European Red Mite, *Panonychus ulmi*; Two-spotted Spider Mite, *Tetranychus urtecae*; Pacific Spider Mite, *T. pacificus*; McDaniel Spider Mite *T. mcdanieli*

Mites in pears are tolerated at very low numbers. Feeding by 2 to 3 spider mites per leaf causes a characteristic blackening of the leaves. High mite population causes defoliation especially in hot weather. Defoliation can reduce fruit size and causes the trees to bloom in the fall, thus severely reducing the following year's crop. The threshold for economical damage is 2 mites per leaf (10). Mites are monitored throughout the growing season and during the dormant period. Sampling methods are published in the UC IPM Guidelines (17). If 1-50 mites per 100 leaves are found in the pear turn down stage, an oil treatment is recommended. As fruit is developing if more than 50 mites per 100 leaves are found a miticide is added to the oil spray. If post-harvest detection (in early districts) is between 51 –100 mites per 100 leaves an oil treatment is recommended if no predacious mites are present (17).

One control program relies on dormant and summer oil sprays, biological control by natural enemies and use of in-season abamectin as needed, and in some years a treatment using a selective ovicidal acaricide. As with psylla, organophosphate use tends to exacerbate mite outbreaks. Mite problems have historically been more severe in the coastal pear regions than in the Sacramento delta. The Mendocino area wide project has demonstrated that reducing organophosphate use eliminates the need for post-harvest cleanup miticide sprays and reduces the amount of abamectin needed pre-harvest. Historically it was believed that the predator mite *Metaseiulus occidentalis* was responsible for controlling mite populations. Recent research in the Pacific Northwest and California has shown that it is a complex of natural enemies that provide effective biological control of mites (6). The variance in control seems to depend on specific natural enemies, fauna, surrounding vegetation in individual orchards, the initial spider mite populations and weather conditions. Hot weather favors spider mite population build-up so that, even in the absence of organophosphate use, spider mite control measures are needed given the low threshold of associated damage. Being able to control mites with oil sprays and reserving the use of the

abamectin when needed will preserve this selective material. Low levels of spider mite resistance to abamectin have been documented in both the coastal and the delta pear regions in 1997 (4,6). Miticide resistance in spider mites pears during the mid-1980s presented a severe problem to growers with ever increasing rates and number of applications.

Chemical Controls:

- Avermectin – Label has a 0.0117-0.0234 lb a.i./acre rate and a 28-day PHI. 12-hour REI. In 1997, a total of 255 lb a.i. was applied to 60.61% of the pear acreage. Avermectin was applied an average of 1 time at a median rate of 0.01 lb a.i./acre (11). Applied at 0.023 lb a.i./ac after petal fall. This is the favored miticide material because it also controls pear psylla. Some low-level mite resistance has been documented (4,6).

- Clofentezine – Label has a 0.125-0.25 lb a.i./acre rate and a 21-day PHI. 12-hour REI. . In 1997, a total of 603 lb a.i. was applied to 25.15% of the pear acreage. Clofentezine was applied an average of 1 time at a median rate of 0.1 lb a.i./acre (11). This product is an ovicide and should be applied at the first sign of mite activity. Unfortunately, the mite threshold for pears is so low that the "first sign of mite activity" may produce economic damage. Thus, the pesticide is sometimes applied well in advance of "mite activity" whether it is eventually needed or not.

- Fenbutatin-oxide – Label has a 0.5-1 lb a.i./acre rate and a 14-day PHI. 48-hour REI. . In 1997, a total of 771 lb a.i. was applied to 5.52% of the pear acreage. Fenbutatin-oxide was applied an average of 1 time at a median rate of 0.69 lb a.i./acre (11). Not to exceed 2 applications or 2 lb a. i./acre/year.

- Hexythiazox – Label has a 0.09375-0.1875 lb a.i./acre rate a 28-day PHI. 12-hour REI. . In 1997, a total of 1 lb a.i. was applied to 0.02% of the pear acreage. Hexythiazox was applied an average of 1 time at a median rate of 0.11 lb a.i./acre (11). Apply only once per season. Ovicide.

- Horticultural Oils – In 1997, a total of 2,460,930 lb a.i. was applied to 89.8% of the pear acreage. Oils were applied an average of 3 times at a median rate of 23.57 lb a.i./acre (11). Dormant rates are 15-20 gallons/acre and in-season rates are 4-6 gallons/acre. Used in dormant, pre and post harvest applications. Dormant oil applications help to control overwintering European Red mite populations. Spring and summer applications smother eggs and young developing mites.

Leafrollers: Oblique-Banded Leafroller (*Choristoneura rosaceana*) and Fruit-tree Leafroller (*Archips argyrospila*)

Two leafroller species are occasional pests in pear orchards, the oblique-banded leafroller (OBLR), *Choristoneura rosaceana*, and the fruit-tree leafroller, *Archips argyrospila*. Of these two species, the oblique-banded leafroller is of greater concern because it has two generations a year and the second-

generation causes damage just before harvest. Larvae of the first generation feed in early spring primarily on leaves, but occasionally feed on flower buds, blossoms and young fruit when the leaves are in close proximity. When they feed on young fruit, they cause deep depressions that become rough and russetted by harvest. The second or summer generation causes extensive superficial skin feeding damage when insects feed between two pears in a cluster. Fruit-tree leafroller only causes the early spring damage (6).

Chemical Controls:

- Azinphos-methyl – In 1997, a total of 50,162 lb a.i. azinphos-methyl was applied to 79.03% of the pear acreage. Azinphos-methyl was applied an average of 3 times at a median rate of 1.0 lb a. i./acre (11). A new label is under review at EPA and CDPR. Azinphos-methyl is the most effective material against codling moth. It is somewhat selective against predaceous mites but toxic to generalist predators. It is less disruptive to natural pear psylla enemies such as lacewing. It is the preferred material because of its longer residual; however, with the new label it may not be feasible to use due to a long reentry interval.

- Chlorpyrifos – Label has a minimum rate of 0.75 lb a.i./ac or 0.25 to 0.5 lb a.i./100gallons of water. 24-hour REI. Dormant and delayed dormant application only. In 1997, a total of 2,678 lb a. i. was applied to 7.67% of the pear acreage. Chlorpyrifos was applied an average of 1 time at a median rate of 1.99 lb a.i./acre (11). The delayed dormant application is only efficacious for the fruit-tree leaf roller and only the first generation of OBLR.

- Esfenvalerate – Label has a 0.025-0.075 lb a.i./acre rate (not to exceed 0.375 lb a.i./acre/season) and a 28-day PHI. 12-hour REI. In 1997, a total of 1,094 lb a.i. was applied to 60.18% of the pear acreage. Esfenvalerate was applied an average of 1 time at a median rate of 0.05 lb a.i./acre (11). Applied at delayed dormant to white bud stage only; however, in any event before egg laying. After dormant oil spray and before bud-break, growers will take beating-tray samples. If overwintering adult populations are relatively high, a treatment will be applied. Esfenvalerate should not be applied during the growing season because it causes mite flair ups.

- Organophosphate insecticides used for codling moth control give background control of leafrollers. In recent years, there have been reports of sporadic poor leafroller control both in orchards under conventional control with organophosphate sprays and in orchards under mating disruption. Problems in conventional orchards may be due to poor timing or coverage or a decreased susceptibility to these insecticides. In orchards under mating disruption leafroller outbreaks have been more severe in the north coast and Lake County than in the Sacramento Delta pear-growing district. In the north coast district natural control is not always sufficient to keep leafroller populations in check in the absence of organophosphate use.

Biological Controls:
Bacillus thuringiensis, subsp. *kurstaki* (*Bt*) (14.5 billion International units/pound) - Rates are ½ to 2 lb/

acre. In 1997, a total of 29 lb a.i. was applied to 1.25% of the pear acreage. It was applied an average of 2 times at a median rate of 0.15 lb a.i./acre (11). *Bt* is presently the only alternative soft control for leafroller control. *Bt* effectively controls the first leafroller larvae instar before they roll the leaves extensively. Two to three treatments may be required for each generation. The most effective control is early in the spring targeted at the first generation larvae. Since *Bt* needs to be ingested it is important to apply it when weather forecasts predict 3 to 4 days of warm, dry weather. Larvae are more active and feed more in warm weather than in cooler or rainy weather. In very rainy springs these propitious weather conditions do not occur for proper control with *Bt*.

Secondary Insect Pests

Removal of broad-spectrum insecticides result in outbreaks of some pest species previously suppressed through the use of broad-spectrum neurotoxins. Experiences with mating disruption in the Randall Island pheromone project discovered increased problems with rust mites and lygus bugs and in the Mendocino project increased problems with leafroller and boxelder bug in selective areas. In addition, outbreaks of leafhoppers or pear blister mite have been associated historically with organic or minimal insecticide programs. The frequency and severity of other secondary pests is expected to be highly site-dependent and specific.

Plant Bugs: Consperse Stink Bug, *Euschistus conspersus*; Lygus Bugs, *Lygus hesperus*

Chemical Controls:

- Dimethoate – Label has a 0.25-0.5 lb a.i./acre rate and a 28-day PHI. 48-hour REI. In 1997, a total of 140 lb a.i. was applied to 1.99% of the pear acreage. Dimethoate was applied an average of 1 time at a median rate of 0.01 lb a.i./acre (11). It is used primarily for the control of the plant bugs: stinkbugs, boxelder bugs and lygus bugs. Although labeled as a miticide, this product is disruptive to mite predators.

- Formetanate hydrochloride – Label has a 0.23-0.46 lb a.i./100 gallons of water rate and a 7-day PHI. 48-hour REI. In 1997, a total of 2,076 lb a.i. was applied to 6.46% of the pear acreage. Formetanate hydrochloride was applied an average of 2 times at a median rate of 0.92 lb a.i./acre (11). Although, this product is labeled for pear rust mite, it is used for spot-treatment of plant bug infestations.

Pearleaf Blister Mite, *Phytoptus pyri*; Pear Rust Mite, *Epitrimerus* sp.; San Jose Scale,

Quadraspidiotus perniciosus

Chemical Controls:

- Liquid Lime Sulfur – Label has a 7 lb a.i./acre rate and a 48-hour REI. In 1997, a total of 106,614 lb a.i. was applied to 19.77% of the pear acreage. Lime sulfur was applied an average of 1 time at a median rate of 18.41 lb a.i./acre (11). Applied at 5 gallons/100 gallons of water in October or November (post-harvest) will control pearleaf blister mite and pear rust mite (10). Care must be taken to maintain thorough coverage. Additionally, applications should not be too early in the fall (hot days in October) or too late in November. Hot weather in early October may cause bud burn and too late an application may see the adult mites overwintering under the bud scales where efficacy is difficult to obtain.

- Wettable Sulfur – Label has an 8-16 lb a.i./acre rate and a 24-hour REI. In 1997, a total of 145,407 lb a.i. was applied to 46.08% of the pear acreage. Sulfur was applied an average of 1 time at a median rate of 10.4 lb a.i./acre (11). Applied at 5 lb/acre in the finger stage (pre-bloom) can also reduce mite populations (10).

- Horticultural Oils - In 1997, a total of 2,460,930 lb a.i. was applied to 89.8% of the pear acreage. Oils were applied an average of 3 times at a median rate of 23.57 lb a.i./acre (11). The dormant application or dormant oil spray is the most efficacious to San Jose scale and many other overwintering pear insects. Thorough coverage is important for scale efficacy. If a dormant spray is not applied, it is important to monitor for San Jose scale using pheromone traps and degree-days in the spring. Timing of San Jose scale sprays may not be the same as codling moth sprays (10).

Diseases

Pear Scab*, Venturia pirina*
Pear scab occurs most frequently in the North Coast and Sierra Foothill growing areas where spring rainfall is abundant. Scab symptoms first appear as velvety black spots on young fruit. Infected fruit usually drop; if not, the spots turn into brown, scabby lesions and the fruit becomes deformed as the season progresses. These deformities render the pear useless for commercial purposes. If the fungus continues to develop, the initial fruit lesions produce spores that cause secondary infections or "pinpoint scab".

The pear scab fungus primarily overwinters in infected leaves on the orchard floor; although, in severe infections, twig lesions can be a source of infection. During fall and winter, flask-shaped structures

(pseudothecia) project through the top of the leaf and look like small black bulges. Primary inoculum in the spring is from ascospores, which are born in asci or sacs that reside in pseudothecia. In spring, when trees are in the green-tip stage, ascospores begin to mature. Spring rains cause mature ascospores to be forcibly discharged from the pseudothecia.

These primary spores can be carried long distances by air currents to flowers, leaves or young fruit. If the surface of the plant remains wet and temperatures are suitable, the spores germinate and penetrate the cuticle and outer cells of the plant part, causing primary infection. Primary spores continue to mature in the pseudothecia for several weeks and are released whenever wet conditions occur.

Following infection of flowers, leaves and fruit, the fungus grows beneath the cuticle and eventually ruptures it and forms dark olive green lesions. Masses of secondary spores are produced within these lesions and become detached during rain. Water splashes these spores and any spores that land on fruit or leaves cause secondary infections. Once the fungus is established within the plant, free moisture is no longer required for its continued growth.

For scab infections to occur, three conditions must be met: mature spores must be present, the fruit or foliage must be wet for a specific length of time and temperatures must be within a certain range.

Fungicides useful for scab control have protectant and/or eradicant activity. To be effective, protectant fungicides (i.e., liquid lime sulfur, wettable sulfur, Captan, Mancozeb and Ziram) must be present before spores germinate and penetrate the plant surface. To ensure coverage of newly exposed growth, a protectant is applied before an infection period begins and repeat applications every other row at 5-10 day intervals are applied so long as weather conditions are propitious for infection. Eradicant fungicides (i.e., triflumizole) are systemic and are translocated within the host tissue. They can kill the scab fungus up to a certain length of time after infection occurs. This is called the kickback period.

Chemical Controls:

- Benomyl – Label has a 0.375 to 0.75 lb a.i./ac rate and a 14-day PHI. 24-hour REI. Not to exceed more than 5 lb/year. In 1997, a total of 5,354 lb a.i. was applied to 29.4% of the pear acreage. Benomyl was applied an average of 2 times at a median rate of 0.5 lb a.i./acre (11). Resistance has been documented (12).

- Triflumizole – Label has a 0.25 to 0.5 lb a.i./ac rate and a 14-day PHI. 12-hour REI. No more than 2 lb a.i./year is allowed. In 1997, a total of 644 lb a.i. was applied to 4.73% of the pear acreage. Triflumizole was applied an average of 1 time at a median rate of 0.31 lb a.i./acre (11).

- Fenarimol- Label has a 0.063 to 0.094 lb a.i./ac rate and a 30-day PHI. 12-hour REI. No more than 0.66 lb a.i./year is allowed. In 1997, a total of 254 lb a.i. was applied to 8.95% of the pear acreage. Fenarimol was applied an average of 1 time at a median rate of 0.09 lb a.i./acre (11). It was first registered in California in mid-season 1995.

- Mancozeb (EBDC) – Label has a 2.4 lb a.i./ac rate and a 77-day PHI. 24-hour REI. No more than 16.8 lb a.i./year is allowed. In 1997, a total of 80,427 lb a.i. was applied to 44.74% of the pear acreage. Mancozeb was applied an average of 3 times at a median rate of 2.1 lb a.i./acre (11).

- Ziram (DMDC) – Label has a 4.6 to 6.1 lb a.i./acre rate and a 5-day PHI. 48-hour REI. No more than 16.8 lb a.i./year is allowed. In 1997, a total of 50,176 lb a.i. was applied to 23.08% of the pear acreage. Ziram was applied an average of 1 time at a median rate of 6.08 lb a.i./acre (11).

- Sulfur – Label has an 8-16 lb a.i./acre rate and a 24-hour REI. In 1997, a total of 145,407 lb a.i. was applied to 46.08% of the pear acreage. Sulfur was applied an average of 1 time at a median rate of 10.4 lb a.i./acre (11).

Cultural Controls:
Post-harvest cleanup guidelines advise fall foliar applications of urea or lime sulfur to reduce primary spores the following spring. Urea speeds leaf decay, thus depriving the pseudothecia of a winter host. Lime sulfur will actually kill the spores on contact.

- Urea helps speed leaf decay in the winter, thus taking away the organism's food supply. A minimum of 50 pounds of low-biuret urea in 125 gallons of water/acre is required. In 1997, a total of 19 lb a.i. was applied to 1.91% of the pear acreage. Urea was applied an average of 1 time at a median rate of 0.06 lb a.i./acre (11). Urea applications will not kill scab twig lesions.

- Liquid lime sulfur applied 15 to 24 gallons per acre in the fall or in the delayed dormant period has been observed to kill scab twig lesions (12). Label has a 7 lb a.i./acre rate and a 48-hour REI. In 1997, a total of 106,614 lb a.i. was applied to 19.77% of the pear acreage. Lime sulfur was applied an average of 1 time at a median rate of 18.41 lb a.i./acre (11).

- Copper sprays have been used in delayed dormant or bud break stage as a protectant. However, after fruit formation, copper heavily russets the smooth skinned Bartlett pear. This renders it useless for the fresh market. In 1997, a total of 36,444 lb a.i. was applied to 42.44% of the pear acreage. Coppers were applied an average of 3.3 times at a median rate of 0.76 lb a.i./acre (11).

Biological Controls:
There are no biological controls.

Chemical Resistance:
Dr. Doug Gubler, UC Davis, and his assistant Ken Dell have documented benomyl resistance in approximately 10% of the isolates collected from Mendocino and Lake Counties in 1998.

Resistance management in the case of high-risk fungicides would consist of alternating applications of fungicides with different modes of action or with low resistance risk protectants such as mancozeb or

ziram.

Fire Blight, ***Erwinia amylovora***

Fire blight is a severe bacterial disease problem in California pears. In spring, disease symptoms can appear as soon as trees begin active growth. Overwintering cankers exude watery, light tan bacterial ooze that turns dark after exposure to air and cause leaves dark streaks on branches and trunks.

Flowers are usually infected first in the spring. Infected flowers and flower stems wilt and turn dark. Blight infections move into twigs and branches from infected blossom clusters. When they do, infected leaves and small shoots wilt and eventually turn black. When blight bacteria spread from blossoms into wood, the newly infected wood underneath the bark has pink to orangish-red streaks. As the canker expands, the infected wood dies, turns brown, and dries out.

Late bloom (rat-tail bloom) or shoot infections in April, May and June during favorable fire blight weather can cause losses of infected pear limbs and trees. Cankers can girdle and kill entire branches or trees in a few weeks. The closer the canker is to the trunk or rootstock (bud union), the greater the potential for damage or loss of the tree.

Fire blight bacteria overwinter in cankers. In spring, when the weather is sufficiently warm and moist and trees are actively growing, bacteria multiply in diseased tissues. A light brown liquid, consisting of bacterial cells in slime, oozes from the branch or twig surfaces. These bacterial cells are transmitted to nearby blossoms or succulent growing shoots by hail, rain, insects or wind. The bacterial cells colonize the flower's stigmas and under favorable conditions, the colony grows rapidly. Ideal conditions for infection, disease development, and spread are rainy or humid weather with daytime temperatures in the range of 75° to 85° F, especially when night temperatures are above 55° F.

Bees and other insects transmit the bacteria from the stigmas of infected blossoms to healthy blossoms. During a fire blight epidemic in an orchard, many insect species are attracted to the bacterial ooze on infected trees and help spread the pathogen.

Once fire blight bacteria enter the blossoms, they may cause only a localized infection and eventually die, or they may move into the twigs and branches. Fire blight bacteria that survive generally do not move through the wood uniformly but invade healthy wood by moving in narrow paths, 1/2 to 1-1/2 inches wide in the outer bark, ahead of the main infection. These long narrow infections (stringers) may extend 2 to 3 feet beyond the edge of the main infection or canker. Removing bark from the stringer shows the diseased tissue closest to the main canker is brown. Further along the stringer, the tissue turns red and then appears as a red flecking. At the front of the infection, the tissue may appear healthy but it is actually infected 12 inches or more beyond the visible infection.

Blossom applications of copper materials or antibiotics such as streptomycin or terramycin are used in

pears to reduce the spread of fire blight bacteria. Pest control advisors monitor fire blight bacteria populations in pear blossoms as well as average daily temperatures or degree-hours to schedule fire blight sprays.

Chemical Control:

- Oxytetracycline – Label rate per acre: maintaining 160-200 ppm is critical for efficacy, 200 ppm is equal to 0.17 lb a.i./100 gallons of water. 60-day PHI. 12-hour REI. . In 1997, a total of 12,579 lb a.i. was applied to 64.29% of the pear acreage. Oxytetracycline was applied an average of 2.9 times at a median rate of 0.156 lb a.i./acre (11). This product is rarely applied at more than 100 gallons/acre because of the increased cost at higher gallonages. Oxytetracycline is the antibiotic of choice for fire blight control.

- Streptomycin Sulfate - Label has a 0.255-0.51 lb a.i./acre rate and a 30-day PHI. 12-hour REI. . In 1997, a total of 4,462 lb a.i. was applied to 66.51% of the pear acreage. Streptomycin sulfate was applied an average of 3 times at a median rate of 0.07 lb a.i./acre (11). Dr. Steve Lindow, UC Berkeley, has documented resistance in some orchards in 1997; however, this resistance is no greater than it was a decade ago.

- Copper Compounds: Copper Hydroxide, Copper Oxide and Copper Oxychloride Sulfate –No PHI. 24-hour REI. . In 1997, a total of 36,444 lb a.i. was applied to 42.44% of the pear acreage. Coppers were applied an average of 3.3 times at a median rate of 0.76 lb a.i./acre (11). Wettable copper compounds russet the smooth skinned Bartlett pear. Thus, they are not used during or after bloom. Growers use copper dust in rotation with the antibiotics as a resistance management tool.

Cultural Control:
Removing infected wood is essential to controlling fire blight in pear orchards. One active overwintering canker located high in a tree can infect many surrounding trees. A few overwintering cankers per acre can provide enough inoculum to render ineffective a preventative spring spray program. Thus, growers employ teams of blight-cutters during spring and fall to remove cankers that have overwintered as well as new blight infections.

Biological Control:
A naturally occurring organism, *Pseudomonas fluorescens* has recently been registered as BLIGHT BAN A-506, which acts as a competitive exclusion agent. The integration of Blight Ban into blight control programs shows promise for reductions in the use of antibiotics. In field trials with A-506 the frequency of antibiotic sprays was reduced by about 50% of the normal antibiotic fire blight spray program. Do not tank-mix Blight Ban A-506 with oxytetracycline. Oxytetracycline can be applied after the establishment of the bacteria in the orchard. Blight Ban A-506 is incompatible with copper compounds.

Weather conditions play a vital role in the timing of spray applications. Research into the level of blight bacteria content of an orchard in conjunction with improved knowledge of monitoring of temperature and humidity thresholds offers the potential for reduced antibiotic applications.

Armillaria Root Rot (Oak Root Fungus), *Armillaria mellea*

Armillaria root rot symptoms can be either a general slow, decline in vigor in pear trees or a tree may wilt and die in several weeks. *Armillaria mellea* can survive for years in the absence of a living host on old infect roots or other woody debris in the soil. In pear orchards, *Armillaria* infects healthy trees by penetrating roots. Infected pear trees can tolerate the fungus for years without noticeable symptoms. Although many pears are listed as immune or highly resistant to *Armillaria*, infected orchards have been found in the North Coast and some in the Sacramento Delta region. Recent increases in the incidence of Armillaria root rot may be caused by a switch to solid set sprinklers, which keep the soil fairly moist throughout the season. There are no biological or cultural controls effective against Armillaria root rot (17).

Chemical Control:

Fumigation may be effective control. Removal of infected trees, stumps and roots greater than 1 inch in diameter and apparently healthy trees adjacent to infected tree is recommended (17).

- Methyl bromide – Label has a 392-853 lb a.i./acre rate and a 24-month PHI. In 1997, a total of 19,840 lb a.i. was applied to 0.12% of the pear acreage. Methyl bromide was applied an average of 2 times at a rate of 396 lb a.i./acre (11).

- Metam sodium – Label has a 127-318 lb a.i./acre rate. In 1997, a total of 13 lb a.i. was applied to 0% of the pear acreage. Metam sodium was applied an average of 2 times at a median rate of 163.4 lb a.i./acre (11).

Post-Harvest Diseases

Pears are susceptible to a variety of post-harvest pathogens due to long storage periods after harvest. Post-harvest diseases are caused by fungi. Gray mold caused by *Botrytis cinerea* is the most important post-harvest disease of pears. Gray mold infections begin at wounds, stem punctures, or at the stem or calyx end of the fruit. Significant losses can be attributed to gray mold due to its ability to spread quickly from infected fruit to adjacent healthy fruit in storage.

Other post-harvest diseases of pear in California include: blue mold (*Penicillium* spp.), Alternaria rot (*Alternaria alternata*), and Mucor Rot (*Mucor* spp.) (19).

Chemical Control:

- Sodium Hypochlorite – Label rate: 200-300 ppm chlorine. In 1997, 134 lb a.i. was applied to 364 tons of pears.

- Thiabendazole – In 1997, 4 lb a.i. was applied to 937 tons of pears. Resistance has been noted (21).

- Ortho-phenylphenol – In 1997, 4.8 lb a.i. was applied to 2,806 miscellaneous units (cartons?).

Cultural Control:
The incidence of many post-harvest diseases can be reduced by good sanitation methods to reduce exposure of the fruit to pathogen spores. Harvesting and handling methods that minimize wounding and bruising are also helpful in reducing post-harvest diseases. Additionally, rapid cooling after harvest and low-temperature storage facilities slow the growth of fungi and the aging process in the fruit (19).

Biological Control:
A new product containing *Candida oleophila* 1-182 has limited efficacy against *Penicillium* and *Botrytis* (21).

Weeds

Commercially adopted methods for economically controlling weeds in California pear orchards include mowing, cultivation, and the use of selected cover crops and herbicides. Weed control is an integral component within a successful and economically viable IPM program for commercial pear production, and is not simply a means for cosmetic enhancement. Poorly managed weed growth is detrimental to all commercial tree fruits -including pears for a number of economic reasons: 1) weeds compete directly with young and old pear trees for water and nutrients; 2) weedy orchards have higher humidity and slower drying conditions, creating an environment ideal for the development of diseases such as pear scab and crown rot; 3) dense weed stands lower orchard temperatures, increasing the risk of frost damage in the spring; 4) weeds are also excellent hosts for spider mites and true bugs providing a ready access to the tree; and 5) weedy orchards provide a habitat ideal for detrimental rodents.

Cultural Controls:

Mechanical Control:
Cultivation, mowing, or a combination of both can manage weeds in established orchards. Cultivation

does incorporate a desired amount of organic matter back into the upper soil profile. Cultivation and mowing are primarily used in the alleys. Because cultivation near the tree trunks can cause increased soil compaction, physical damage to the tree by cutting feeder roots and trunk increasing the chance for disease invasion, and unsatisfactory weed control, herbicides are frequently applied in a strip treatment down the tree row.

Mechanical mowing is used primarily during the spring and summer months in irrigated orchards. Mowing is commonly used in most pear orchards because it tends to be less disruptive to the soil and trees, and also tends to be more economical than cultivation. Chemical mowing, the use of varying rates of glyphosate to control existing ground cover, helps conserve soil-stored water, as well as provide mulch which further helps to conserve water. Soil compaction is minimized as well.

As cultural control technology becomes increasingly more sophisticated in the future, new feats of engineering may allow production agriculture the opportunity to further reduce their dependency on chemical weed control.

Selective Cover Crops:
Cover crops for pears, other than a composition of general weed species, have been researched extensively in the last few years in California. University of California Cooperative Extension researchers are studying specific annual and perennial cover crop species that provide the desired characteristics, unlike those of a regular weed ground cover.

Cover crops, when properly managed, allow for good water penetration while reducing erosion. They also tend to have higher populations of beneficial insects and mites than clean-cultivated orchards, provide excellent competition for weeds, and in the case of leguminous cover crops, such as clovers, provide a certain level of beneficial nitrogen to the trees. The majority of pear growers in California are currently employing some form of ground cover in their orchards. Further research will be required to identify selective cover crop species that are economically feasible for a grower to plant and that will perform well under less optimal conditions.

In 1993, UC research discovered that the plant species composition of pear orchard floors, which include such weeds as annual and perennial ryegrass, are supporting high populations of bacteria that were conducive to both severe fruit russeting and frost damage. Researchers identified a number of specific cover crop species that have been shown to harbor considerably lower populations of russeting bacteria, while maintaining all the favorable characteristics of a perennial cover crop. We need to continue research into cover crops selection and supplemental fertilization needs. We also need to improve education and implementation of commercially select cover crops for economical weed management (14).

Chemical Control:
Chemical control is the most frequently used method for controlling weeds in the tree rows. Keeping weeds away from tree trunks without injuring trees is very difficult with mowing and cultivation.

Herbicides provide pear growers with the necessary flexibility to economically control/suppress weed growth where needed in a timely fashion.

The California pear industry has been conservative and conscientious in its use of herbicides for weed management. Of the limited number of herbicides currently registered for commercial use in pear orchards, the pear industry utilizes only a small percentage of them on a regular basis. Pre-emergence herbicides can control weeds from several weeks up to a year, depending on yearly rainfall, solubility of the material, soil properties, frequency and method of irrigation, weed species, and dosage applied. Pre-emergence herbicides control weed seedlings as they germinate and must be selected on the basis of the weed species found in the orchard. Splitting a pre-emergence treatment into two applications can prolong control, particularly in areas with heavy rainfall, in orchards with sandy soils, or in orchards with a heavy growth of summer annuals.

Post-emergence herbicides are applied primarily to spot treat perennials in the tree row when monitoring indicates a need. Rate and use depend upon the weed species present and the size of the weeds. Glyphosate is the herbicide used most extensively by the California pear industry, both in terms of total acreage and volume applied. This is because it is economical, broad-spectrum, very efficacious and inherently safe. It has also incorporated very well with the current and future IPM framework for pears. With herbicide application technology continually advancing, such as with the recent introduction of the Ultra Low Volume technology, pear growers are now able to apply considerably less glyphosate per acre to their orchards and the environment, while still achieving the same degree of efficacy as in the past.

Monitoring is essential for choosing the correct pre-emergence herbicides and deciding whether a post-emergence herbicide is needed and which one to use. Records are important to weed management. Weed survey information collected over several years is valuable in identifying changes in weed populations and in planning an IPM program.

New or enhanced herbicidal spray application technology, ultimately improve overall safety, economics (time and product used), efficiency, and efficacy of the compound.

Herbicides below are used primarily in the row strip (4’ to 6’) unless otherwise noted

- Norflurazon – Pre-emergence herbicide. Label has a 2 to 4 lb a.i./ac rate (depending on soil type). 12-hour REI. In 1997, a total of 1,240 lb a.i. was applied to 4.94% of the pear acreage. Norflurazon was applied an average of 1 time at a median rate of 0.86 lb a.i./acre (11).

- 2,4-D (amine) – Post-emergence herbicide. Label has a 1.4 lb a.i./acre rate and a 14-day PHI. 48 hour REI. Not to exceed two applications per season with a 75-day reapplication interval. In 1997, a total of 4,924 lb a.i. was applied to 19.04% of the pear acreage. 2, 4-D was applied an average of 1 time at a median rate of 0.57 lb a.i./acre (11). This is the herbicide of choice for field bindweed, which twines itself around solid set sprinklers and renders them inoperable.

- Diuron – Pre-emergence herbicide. Label has a 3.2 lb a.i./acre rate. 12-hour REI. In 1997, a total of 2,515 lb a.i. was applied to 9.77% of the pear acreage. Diuron was applied an average of 1 time at a median rate of 1.3 lb a.i./acre (11).

- Glyphosate – Post-emergence herbicide. Label has a 0.375 to 0.75 lb a.i./acre rate (depending on application equipment) and a 14-day PHI. 12-hour REI. In 1997, a total of 18,020 lb a.i. was applied to 56.06% of the pear acreage. Glyphosate was applied an average of 1 time at a median rate of 0.83 lb a.i./acre (11).

- Oryzalin – Pre-emergence herbicide. Label has a 2 to 6 lb a.i./acre rate. 12-hour REI. 6 In 1997, a total of 3,777 lb a.i. was applied to 5.07% of the pear acreage. Oryzalin was applied an average of 1 time at a median rate of 2.1 lb a.i./acre (11). It is the only pear pre-emergence herbicide that can safely be applied around one-year old trees.

- Paraquat dichloride – Post-emergence herbicide. Label has a 0.625 to 0.94 lb a.i./acre rate. 12-hour REI. Restricted use only. In 1997, a total of 6,487 lb a.i. was applied to 19.91% of the pear acreage. Paraquat dichloride was applied an average of 1 time at a median rate of 0.87 lb a.i./acre (11).

- Simazine - Pre-emergence herbicide. Label has a 2-4 lb a.i./acre rate and a x day PHI. 12-hour REI. Not to exceed one application per year. In 1997, a total of 5,502 lb a.i. was applied to 17.21% of the pear acreage. Simazine was applied an average of 1 time at a median rate of 1.8 lb a.i./acre (11).

Biological Control:
Since most weeds tend to be very host specific, there are very few biological control agents commercially available today that are capable of addressing weed control on a broad spectrum basis. Several species of insects have been identified as biocontrol agents on certain weed species, puncture vine weevil for example, but the few that exist do not impact the primary weed species that are presently the most noxious and economically detrimental in commercial pear orchards. Biological control of weeds in orchards is limited because the orchard environment is disturbed frequently by cultural operations and agricultural chemicals. Populations of natural enemies of weeds cannot develop high enough levels to control weeds adequately.

Vertebrate Pests

Pocket Gophers*, Thomomys* spp
Pocket gophers are stout-bodied, short-legged rodents 6 to 8 inches long. Pocket gophers are common in

areas of abundant plant growth. They feed primarily on succulent underground parts of herbaceous plants. They live almost entirely underground. They create extensive burrows for living and feeding.

Pocket gophers frequently live in orchards. They are active throughout the year. In ideal situations, their numbers may reach 30 to 40 gophers per acre. They cause tree damage or death by girdling roots or crowns at or below the soil level (20).

Control:

Cultural:
Habitat modification to remove vegetation will discourage gophers. No chemical or mechanical repellents effectively control pocket gophers. Traps placed in the burrows are effective for small populations. Trapping is time consuming and expensive.

Chemical:

- Strychnine – 0.5% bait. Placed in the burrow by use of mechanical burrow builder or with hand probes. Usually very effective with virtually no secondary wildlife hazards. In 1997, a total of 9 lb a.i. was applied to 1.37% of the pear acreage. Strychnine was applied an average of 1 time at a median rate of 0.01 lb a.i./acre (11).

- Chlorphacinone and Diphacinone – 0.005% and 0.01% baits. Applied to burrows in the same manner as strychnine. In 1997, a total of 0.01 lb a.i. was applied to 6 acres (11).

Field mice, multiple species
Meadow Mice, *Microtus californicus*
Meadow mice are likely to be found wherever they find food and cover such as weeds or ground covers. They may partially or completely girdle trees by feeding on the bark and cambium layer of the trunk anywhere from just below the soil line to as far up the trunk as they can reach. Young trees are attacked more readily and sustain the greatest damage. Full-grown meadow mice are larger than house mice but smaller than Norway or roof rats. Their presence can be recognized by networks of small runways through grass or other cover and their numerous shallow burrows. Meadow mouse burrows are distinguished from those made by gophers because meadow mice do not plug entrance holes (20).

Control:

Cultural:
Making the orchard and surrounding habitat unfavorable to their development by keeping weed growth down is helpful. Clearing mulches, vegetation, and trash away from the tree trunk to a radius of 1 meter by hoeing or mowing or using herbicides will also reduce or prevent damage.

Place ¼- or ½ inch mesh hardware cloth around the trunk.

Chemical:

- Zinc phosphide – 0.5% bait. In 1997, a total of 31 lb a.i. was applied to 3.2% of the pear acreage. Zinc phosphide was applied an average of 1 time at a median rate of 0.06 lb a.i./acre (11). Applied with a broadcast spreader or by hand around mice burrows.

Current Research:
To improve efficacy, larger scale pheromone projects were designed to obtain codling moth control for a more sustained period than possible in small plot trials. The Randall Island Project, winner of the State of California's IPM Innovator award, was initiated in 1993 and the Areawide Mendocino Project in 1996. These ongoing projects have achieved a 75% organophosphate reduction for codling moth control. Adoption of mating disruption requires an increase in the information base for growers because of the novelty of the approach, the increased rates of required monitoring, and the potential for pest outbreaks normally not found in organophosphate-dominated systems. To increase adoptions in all pear regions of California we will start new implementation projects in each of four pear-growing regions in 1999. Simultaneously, the pear industry is supporting other control measures in a multi-faceted approach to reduce codling moth populations. The efficacy of puffers, a new pheromone dispenser technology, began being studied in large-scale trials in 1999. Foreign exploration and importation of natural enemies of codling moth has taken place since 1992. Sanitation, the removal of pears immediately after harvest, has been studied since 1993.

In the area of disease control, the pear industry has supported Dr. Steve Lindow's research into biological agents for russet and fireblight control since 1982. His work culminated with the registration of a naturally occurring organism registered as BLIGHT BAN A-506, which acts as a competitive exclusion agent. We are presently supporting research into modeling epidemiology and disease risk for better timing pear scab control measures and looking at the potential for urea and/or lime sulfur foliar sprays and liming for reducing pear scab inoculum.

Safer chemical controls that appear promising include the general class of insect growth regulators, such as tebufenozide, spinosad and second and third generation spin-offs from the above mentioned IGRs. Insect growth regulators appear to be able to provide some control of codling moth without disrupting natural enemy activity thus allowing for biological intense pest management. The level of control is dependent on the compound and level of cross-resistance. Insect growth regulators are envisioned as a keystone soft chemical necessary to deal with sporadic outbreaks of codling moth or some secondary pests, e.g., leafrollers, as the transition to pheromone mating disruption for codling moth occurs in pears. Incorporation of these materials into more comprehensive programs minimizes the risk to non-target species and workers, and decreases the potential outbreaks by other pest species by preventing the disruption of the entire system.

Development of a soft insecticide program to deal with leafroller outbreaks may prove critical in pheromone mating disrupted orchards. Research is being conducted on the use of pheromones for leafroller control but results have been mixed. Development of soft insecticide programs, such as insect growth regulators, may provide an interim solution until pheromone mating disruption of leafrollers comes into place. IGRs are widely used in European pear production with great safety and success. As yet, no IGRs are registered for pears in California or throughout the US.

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