Crop Profile for Citrus in California

Prepared: December, 2003

Executive Summary

Lemons, Oranges, Grapefruits, Tangerines, and Kumquats

This Pest Management Analysis summarizes the pest management tools that are used in the control of pests that are economically important to California's citrus industry. Though this Pest Management Analysis is a statewide summary, it is crucial to note that significant differences exist among the citrus growing regions of California in both their spectrum of pests and the pest management techniques that are viable in these regions. Therefore, wherever possible, comments in this Pest Management Analysis have been developed to identify differences among the four primary growing regions: referred to as the San Joaquin Valley Region, the Coastal-Intermediate Region, the Interior Region, and the Desert Region.

Integrated Pest Management. Citrus production in California is one of the state's best examples of an integrated approach to pest management. In an effort to maximize the appropriate control of economically important pests, California's citrus industry recognizes that a cost-effective program must ensure that pest management tools are not lost due to the onset of resistance. Pest levels are monitored closely to ensure that pest management decisions are initiated prudently and carefully coordinated. As a result, most growers use a mixture of cultural, biological, and chemical control practices to control economically important pests. This Pest Management Analysis describes these practices.

Availability of Chemical Tools Crucial. There are a limited number of chemical pesticides approved for use on citrus. Therefore, it is crucial to ensure that these few pesticide products remain available to the industry so that citrus production in California can maintain viable resistance management programs and effective integrated pest management. Wherever possible, existing, safe chemical registrations need to be maintained.

Vulnerable Chemicals Under FQPA. With the possible exception of organophosphates and carbamates, the California citrus industry is not solely dependent on any chemical that is currently thought to be vulnerable under FQPA. However, relatively few chemical ingredients are registered for use on citrus. As a result, the loss of any single insecticide, miticide, or fungicide will adversely impact the strongly entrenched IPM practices used by growers and accelerate the onset of resistance. Similarly, loss of any of the pesticides available to the industry would have a significant adverse effect on resistance management and the use of beneficial organisms. There is a critical need to have these pest management tools available so that they may be used for control of periodic or sporadic outbreaks. It should be noted that many of the important natural enemies (*Aphytis*, *Comperiella*, *Euseius tularensis* and *Rodolia cardinalis*) have developed some resistance to certain organophosphates and carbamates. This has allowed some of these chemicals (chlorpyrifos in particular) to be used at reduced rates to control pests such as citricola scale and katydid in IPM orchards where natural enemies are being released for red scale control.

Use of Chemical Alternatives. Use of reduced risk pesticides such as *Bacillus thuringiensis* (Bt) is rapidly increasing. A number of reduced-risk pesticides were registered during 1998-2002, including Success, Esteem, Applaud, Admire, Danitol and Assail. These new tools have been integrated into the pest management systems employed by citrus growers as evidenced by the table below.

	1998 pesticide use 2002 pesticide use # of apps/# of acres	**# of apps/# of acres**
Applaud (buprofezin)	211	2,986/1,612
Assail (acetamiprid)	0	165/1,839
Bt	17/172	3,082/22,150
Esteem (pyriproxyfen)	27/217	6,696/35,750
Success (spinosad)	5/43	11,961/105,260

Growing Regions. The four major growing regions in the state, San Joaquin Valley Region, the Coastal-Intermediate Region, the Interior Region, and the Desert Region, differ from each other in their spectrum of important pests and the pest management techniques that are viable within these regions. The distribution of citrus commodities within these regions is summarized in Table 1 below:

Table 1: Acreage Percent Per Region*

Region	**Lemons**	**Navels**	**Valencias**	**Grapefruit**	**Tangerines**
Interior	1%	2%	3%	5%	0%

Coastal-Intermediate	65%	1%	24%	23%	5%
San Joaquin Valley	17%	94%	65%	6%	72%
Desert	17%	3%	8%	66%	22%

*Data supplied by the California Agricultural Statistics Service 2002 California Citrus Acreage Report

The San Joaquin Valley Region includes more than half the acres of California's citrus production. This region has summers that are hot and dry and winters that are typically cold and wet. Almost all of the state's navel orange production is grown in this region though Valencia orange production is also significant along with lemon and grapefruit production. Over half of the state's tangerines are grown in the San Joaquin Valley region.

The Coastal-Intermediate Region, from Santa Barbara County south to the San Diego/Mexico border, has a milder climate influenced by marine air. This region is the major producer of lemons and limes. Valencias are the primary orange variety produced in this region.

The Interior Region includes western Riverside and San Bernardino Counties, inland portions of San Diego, Orange, and Los Angeles Counties and other growing regions that are only marginally affected by coastal climatic influence, in contrast to the coastal intermediate district, which is significantly influenced by the moderating influence of the coastal climate. The interior district tends to be warmer and dryer in the summer and colder in the winter than the coast.

The Desert Region, primarily the Coachella Valley and Imperial Valley, produce citrus under conditions where temperatures fluctuate widely between day and night with low humidity most of the year. The desert region is the primary location for production of grapefruit. A good amount of the state's lemons and tangerines are produced here.

Important Insect and Mite Pests. For citrus grown in California, the most important regional insect pests are listed below in Table 2. The table presents the pests in the relative order of importance for the individual regions.

Table 2: Insect and Mite Pests: Prioritized for Each Region.

San Joaquin Valley	Coastal-Intermediate	Desert Valleys	Interior District
PRIMARY Citrus Red Mite California Red Scale Citricola Scale Citrus Peelminer Citrus Thrips Forktailed Katydid Glassy-winged Sharpshooter SECONDARY Argentine Ant Bean Thrips Brown Garden Snail Citrus Cutworm	PRIMARY Argentine Ant Brown Garden Snail California Red Scale Citrus Bud Mite Citrus Thrips Glassy-winged Sharpshooter SECONDARY Black Scale Broad Mites Fuller Rose Beetle Greenhouse Thrips Mealybugs Citrus Rust	PRIMARY California Red Scale Citrus Thrips Texas Citrus Mite Woolly Whitefly Yuma Spider Mite SECONDARY Brown Garden Snail Citrus Flat Mite Citrus Leafminer Citrus Peel Miner Citrus Red Mite	PRIMARY Argentine Ant Black Scale Brown Garden Snail California Red Scale Citrus Red Mite Citrus Thrips Glassy-winged Sharpshooter SECONDARY Bean Thrips Citrus Flat Mite Citrus Rust Mite Fuller Rose Beetle

Citrus Flat Mite Cottony Cushion Scale Earwigs Fuller Rose Beetle Grasshoppers Native Gray Ant Southern Imported Fire Ant Twospotted Spider Mite	Mites Whiteflies	Mealybugs	Grasshoppers Mealybugs

Table 2 illustrates that the spectrum and importance of insect and mite pests differ significantly in the growing regions of California. As a result, the loss of a specific chemical tool may not have any significant impact in one region under conditions where the loss would have a dramatic adverse economic consequence in another region.

Diseases. Compared to insect and mite pests, diseases of citrus are more limited in their impact to California citrus. Post-harvest infestations of green mold and blue mold and, to a lesser extent, sour rot, impact the industry's processing and storage of citrus, particularly lemons. In general, root-borne fungal diseases, such as Armillaria Root Rot, Brown Rot, and Dry Root Rot, are of greater economical consequence to California's citrus industry than are foliar-based diseases. Numerous foliar and fruit diseases are important, such as Botrytis Rot, Phytophthora Gummosis, Septoria Spot, and Stubborn Disease. Chemical tools are needed for the eventuality of disease outbreaks. These remaining tools should be maintained for long-term disease control.

Table 3: Chemical Controls of Primary Citrus Pests	
Chemical Insecticide	**Primary Pests Controlled: Insects & Mites**
Acetamiprid (Assail)	Citricola Scale, Glassy-winged Sharpshooter, Citrus Leafminer
Abamectin (Agrimek/Zephyr)	Citrus Thrips, Mites - Citrus Red, Two-Spotted Spider, Citrus Bud, Broad and Citrus Rust
Bacillus thuringiensis	Citrus Cutworm, Fruittree Leafroller, Amorbia, Western Tussock Moth
Buprofezin (Applaud)	California Red Scale, Citricola Scale
Carbaryl (Sevin)	California Red Scale, Fruittree Leafroller, Fuller Rose Beetle, Black Scale, Amorbia, Western Tussock Moth, Citricola Scale, Grasshoppers

Chlorpyrifos (Lorsban)	California Red Scale, Citrus Cutworm, Fruittree Leafroller, Black Scale, Citricola Scale, Amorbia, Western Tussock Moth, Broad Mite, Argentine Ant, Native Gray Ant, Southern Fire Ant, Katydids, Mealybugs, Grasshoppers
Copper Band	Brown Garden Snail
Copper Sulfate	Brown Garden Snail
Cryolite	Citrus Cutworm, Fuller Rose Beetle, Amorbia, Western Tussock Moth, Katydids
Cyfluthrin	Citrus Thrips, Katydids, Glassy-winged Sharpshooter
Diazinon	Whiteflies
Dicofol (Kelthane)	Citrus Red Mite, Broad Mite, Citrus Flat Mite, Yuma Spider Mite
Dimethoate	Citrus Thrips, Katydids, Citricola Scale
Fenbutatin Oxide (Vendex)	Citrus Red Mite, Citrus Bud Mite, Citrus Rust Mite

Fenpropathrin	Citrus Thrips, Katydids, Glassy-winged Sharpshooter
Formetanate HCL (Carzol)	Citrus Thrips
Imidacloprid (Admire/Gaucho)	Glassy-winged Sharpshooter, Citricola Scale, Citrus Leafminer
Malathion	Cottony Cushion Scale
Metaldehyde	Brown Garden Snail
Methidathion (Supracide)	California Red Scale, Black Scale, Citricola Scale, Cottony Cushion Scale, Mealybugs
Methomyl (Lannate)	Citrus Cutworm, Fruittree Leafroller, Amorbia, Western Tussock Moth, Glassy-winged Sharpshooter
Narrow Range Oil	California Red Scale, Black Scale, Citrus Red Mite, Citrus Bud Mite, Whitefly
Propargite (Comite)	Citrus Red Mite
Pyridaben	Citrus Red Mite
Pyriproxyfen (Esteem)	California Red Scale

Sabadilla Alkaloids (Veratran D)	Citrus Thrips
Spinosad (Success)	Citrus thrips
Wettable Sulfur	Broad Mite, Citrus Flat Mite, Citrus Rust Mite, Yuma Spider Mite
Chemical Nematocide	**Primary Pests Controlled: Nematodes**
1,3-Dichloropropene (Telone)	Citrus Nematode, Sheath Nematode
Aldicarb (Temik)	Citrus Nematode, Sheath Nematode
Fenamiphos (Namacur)	Citrus Nematode, Sheath Nematode
Metam Sodium (Vapam)	Citrus Nematode, Sheath Nematode
Methyl Bromide	Citrus Nematode, Sheath Nematode
Chemical Fungicide	**Primary Pests Controlled: Diseases**
1,3-Dichloropropene (Telone)	Phytophthora Gummosis
Chloropicrin	Phytophthora Gummosis

Copper	Phytophthora Gummosis, Septoria Spot
Copper Sulfate	Brown Rot, Septoria Spot
Fosetyl-aluminum (Alliete)	Phytophthora Gummosis, Brown Rot
Mefenoxan	Phytophthora Gummosis
Metalaxyl (Apron)	Phytophthora Gummosis
Metam Sodium (Vapam)	Phytophthora Gummosis, Armillaria Root Rot
Methyl Bromide	Phytophthora Gummosis, Armillaria Root Rot
Sodium Tetrathiocarbonate (Enzone)	Phytophthora Gummosis, Armillaria Root Rot
Zinc Sulfate - Copper Sulfate, Hydrated Lime	Brown Rot, Septoria Spot
Chemical Herbicide	**Primary Pests Controlled: Weeds**
Bromacil	broadleaf, grassy and some perennial weeds
Diuron (Karmex)	most broadleaf weeds

EPTC (Eptam)	most grasses and some broadleaf weeds
Glyphosate (Roundup)	broadleaf, grassy and perennial weeds
MSMA	narrow range control of grassy weeds and perennial weeds
Napropamide (Devrinol)	grassy weeds and some broadleaf weeds
Norflurazon	broadleaf and grassy weeds and field bindweed
Oryzalin (Surflan)	grassy weeds and some broadleaf weeds
Paraquat Dichloride (Gramoxone)	broadleaf and seedling grass weeds
Simazine (Princep)	Pre-emergent, broadleaf, weak on grassy weeds
Trifluralin (Treflan)	grassy weeds, some broadleaf and perennial weeds
Post Harvest	**Primary Pests Controlled**
2,4-D Isopropyl Ester	Alternaria Rot, Cottony Rot, Trichoderma, Botrytis

Candida oleophila	Green Mold, Blue Mold, Cottony Rot, Trichoderma, Botrytis
Imazalil	Green Mold, Blue Mold, Cottony Rot, Trichoderma Botrytis
Lime Sulfur	Green Mold, Blue Mold, Sour Rot, Cottony Rot, Trichoderma, Botrytis
Pseudomonas syringae	Green Mold, Blue Mold, Cottony Rot, Trichoderma, Botrytis
Sodium Hypochlorite	Green Mold, Blue Mold, Cottony Rot, Trichoderma, Botrytis
SOPP (2 Phenyl phenol)	Green Mold, Blue Mold, Sour Rot, Cottony Rot, Trichoderma, Botrytis
Thiabendazole (TBZ)	Green Mold, Blue Mold, Diplodia, Phomopsis, Cottony Rot, Trichoderma, Botrytis
Quaternary Ammonia Compounds (?)	Green Mold, Blue Mold, Sour Rot, Cottony Rot, Trichoderma, Botrytis
Plant Growth	**Pre-harvest Effect Controlled**
2,4-D Isopropyl Ester	Reduce abscission
Gibberellic Acid	Delay senescence

Research Needs - Future Challenges. Research and development into pest management techniques to control ants is a priority, as is the development of new active ingredients and biological controls of katydids, peelminer, leafminer, citricola scale and bud mites. Control methods against phytophthora need to be developed further. Finally, nematode research will be crucial. The foreign restriction of California citrus exports has accelerated the need for research on pests such as fuller rose beetle and bean thrips. Research on new pests, such as the glassywing sharpshooter, is also needed.

Under the Clean Air Act and the Montreal Protocol, use of methyl bromide, preplant, will be phased out beginning in 2005. Only those growers who apply for, and successfully receive, an exemption from the phase out, will be permitted to use methyl bromide. Applications for critical use exemptions must be completed and submitted on an annual basis and must demonstrate that no technically and economically feasible alternatives are available. Exemption requests will be granted on an annual basis.

General Production Information

Production. California produces 80% of the United States lemons, 28% of the tangerines, 21% of the oranges, and 10% of the grapefruit (excludes Pummelos and Hybrids) commercially grown in the United States (1,2). Tangerines include Tangerines, Mandarins, Tangelos, and Tangors (1).

Ranking. In 2002**,** California was first in the nation in the production of lemons and second in the nation in the production of oranges, grapefruits and tangerines. Overall, California is second in citrus production. Florida is first, Texas is third, and Arizona ranks fourth (1, 2).

Acreage. In 2002, citrus were harvested in California from a total of about 266,250 acres, statewide, as follows (3):

- Oranges 193,000 acres (72%) (66% navel and 34% Valencia)
- Lemons 49,500 acres (18%)
- Grapefruit 14,000 acres (5%)
- Tangerines 9,000 acres (3%)
- Limes 750 acres (<1%)

Production Value. In 2002, the value of California's overall citrus crop was about $889,292,000 (3). The short ton values were as follows:

Crop Short Tons Value

- Oranges 1,931,300 $514,460,000 (58%)
- Lemons 695,400 $287,026,000 (32%)
- Grapefruit 197,700 $ 47,485,000 (5%)
- Tangerines 82,500 $ 38,821,000 (4%)
- Limes 5,500 $ 1,500,000 (<1%)

Fresh-Market. The primary end-product of citrus grown in California is fresh-market. For oranges, 82% of the market is fresh compared to Florida where only 5% of the crop is fresh market oranges. For tangerines and grapefruit, about 70% of the market is fresh. For lemons, about 50% of the market is fresh (2).

Exports. California exports approximately 40% of the citrus harvest to other countries. The value of these exports in 2002 was $**298** million for oranges, $**75** million for lemons, and $**39** million for grapefruit (4). Major exporting nations include Japan, Canada, Hong Kong, Korea, and France.

Cost Per Acre. The total cost to produce an acre of citrus ranges from $5,000 to $15,000 per acre with production in the San Joaquin Valley region the most costly (8, 9). Production costs prior to harvesting are around $1,000 to $3,000 per acre. In 2002, there were approximately 6,500 citrus growers (9).

Integrated Pest Management. Citrus production in California is one of the strongest integrated pest management (IPM) systems in the state.

Production Regions

Citrus are grown in four major areas of California:

- The San Joaquin Valley Region
- The Coastal-Intermediate Region
- The Interior Region
- The Desert Region

In addition, there is a small citrus growing area in the Northern Sacramento Valley where a majority of the tangerines are grown (8).

Interior Region. The interior region includes western Riverside and San Bernardino counties, inland portions of San Diego, Orange, and Los Angeles Counties and other growing regions that are only marginally affected by coastal climatic influence, in contrast to the coastal intermediate district, which is significantly influenced by the moderating influence of the coastal climate (8). The interior district tends to be warmer and dryer in the summer and colder in the winter than the coast

Coastal-Intermediate Region. The coastal-intermediate region, from Santa Barbara County south to the San Diego/Mexico border, has a milder climate influenced by marine air (8). The region differs from the Interior Region in climate, cultivars grown, and pest problems. The Coastal Intermediate and Interior regions account for the majority (about 66%) of the state's lemon production. (3). Over 90% of the state's lime production comes from these regions, primarily from the southern coastal areas (3). Approximately 23% of the grapefruit production is from the coastal- intermediate region. For oranges, the coastal-intermediate region emphasizes Valencia production (about 24% of the state's acreage) with only limited acreage producing Navel oranges (about 1% of the state's acreage)(3). Only limited acres are devoted to tangerine production.

San Joaquin Valley Region. More than half the acres of citrus are grown in the San Joaquin Valley region (about 65% of the state's acreage)(3). This region has summers that are hot and dry and winters that are typically cold and wet (8). Most of the state's navel orange production, about 94%, is grown in this region as well as about 65% of the Valencia orange production. About 72% of the state's tangerines are grown in the San Joaquin Valley. Lemon acreage is 17% and grapefruit acreage is 6% of the state's total (3).

Desert Region. The desert region, primarily the Coachella Valley and Imperial Valley, produce citrus under conditions where temperatures fluctuate widely between day and night with low humidity most of the year (8). The desert region is the primary location for production of grapefruit, with about 66% of the state's production being produced in a region that represent only about 20% of the state's citrus growing acreage. About 22% of the state's tangerine production comes from the desert region.

Cultural Practices

Citrus Crops. Oranges, lemons, grapefruit (excludes Pummelos and hybrids), tangerine, kumquats, and various other citrus crops are grown in California. For purposes of this Pest Management Analysis, tangerines refer not only to tangerines, but also mandarins, tangelos, and tangors. Lime production and pest management issues are included with those discussed for lemons, since lemons and limes are produced in the same regions within California.

Varieties. There are a few varieties of citrus that dominate California's production. The primary varieties are as follows:

> **Washington Navel Oranges** are predominantly grown in the San Joaquin Valley where it takes about 9 months for fruit to mature (8). About 94% of the state's navel orange

acreage is in this region (3). The main harvest is from late fall through early spring and sometimes into early summer.

Valencia Oranges are typically grown in the coastal-intermediate and interior areas for the fresh market. Valencia oranges mature in 12 to 15 months and are harvested from spring through late fall (8). About 24% of the Valencia oranges are grown in the coastal-intermediate and interior regions, and 65% in the San Joaquin Valley region (3).

Eureka Lemons are the most common cultivar on the coastal-intermediate region, where approximately 65% of the state's lemon acreage is (3, 8).

Lisbon Lemons are better adapted to the Desert, Interior and San Joaquin Valley regions. Mature fruit are harvested over a 9-month period (8). About 35% of the state's lemon acreage is in these growing regions (3).

Marsh Grapefruit are grown in the desert valley regions where it is harvested in the winter and early spring (8). About 66% of the state's grapefruit acreage is in the desert region (3).

Tangerine varieties are also primarily grown in the desert region (22%) and the San Joaquin Valley region (72%)(3, 8).

All growing regions have some acreage of nearly all major cultivars.

Rootstock. Selected cultivars are grafted onto rootstocks that are selected for improving tree vigor, fruit size and quality, cold hardiness and adaptability to soil conditions, as well as resistance or tolerance to diseases and nematodes. The rootstocks generally used in California are the Troyer and Carrizo citrange for oranges, lemons and grapefruits, Citrus Macrophylla, Rough lemon and Cleopatra mandarin for lemon, grapefruit, oranges, and mandarins, and the Trifoliate orange for oranges and mandarins. C35 citrange is a newer rootstock that generally produces trees that are smaller, more compact and easier to harvest (8,9) and is used with all varieties except Eureka lemon.

Soil Types and Irrigation. Citrus are ideally suited to medium to deep, well-drained soils. Orchards are typically irrigated with low-volume drip or micro-sprinkler systems, although furrow and low head sprinklers are also used in some areas (8, 9).

Ground Cover. Ground covers are not typically maintained in orchards, non-cultivation of orchard soils with herbicide-treated tree rows is common (8, 9).

Pruning. Most citrus trees do not require annual pruning. Young citrus trees do not require pruning for 2 to 3 years after transplanting to an orchard, except for the removal of sucker shoots off the trunks. From the age of 3 to 6 years, however, a light selective pruning by hand may be done to remove crowding and cross branches. Bearing orange and grapefruit trees require little pruning, primarily topping and removal of branches for spacing between trees. In the interior region, pruning is often performed every 4 years. Bearing lemon trees require selective pruning to strengthen the shoots and prevent crowding in the center of the tree and are typically pruned every year in California (8, 9). About 30% of the crop are hedged or topped every year.

Organic Production. Organically-grown citrus in 2002 was produced on a little more than 1,000 acres (9).

Pests of California Citrus

The following summaries of citrus pests and their management are based on the excellent guideline summaries developed through the coordination of the University of California Integrated Pest Management (UC-IPM) Project (6). We wish to acknowledge this contribution.

The pest and pest management updated summaries are based, in part, on documentation from the UC-IPM Project's Pest Management Book (8), the UC-IPM and California Department of Pesticide Regulation's (DPR) pest management survey from 1994 (7), and extensive input and coordination from the members of the California Citrus Quality Council and other sources of documentation on citrus pest management (9). The summaries are also based on extensive comments and suggestions from many individuals from the agricultural community, who are experts in their field and who participated in meetings held in the fall of 2002 and the spring of 2003, the sole purpose of which was to update the Citrus Crop Profile.

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Insect Pests

CALIFORNIA RED SCALE
Aonidiella aurantii

Damage. California red scale is the number one pest of concern in the San Joaquin Valley Region, requiring treatment almost every year. It is also one of the top four pests of concern in the Desert, Interior, and Coastal-Intermediate Regions, though outbreaks requiring treatment in these regions typically occur less frequently (typically every other year) or on less acreage (typically around 50% of the region's acreage).

California red scale attacks all parts of the tree including twigs, leaves, branches, and fruit. Heavily infested fruit may be downgraded in the packinghouse and, if population levels are high, serious damage can occur to trees. Severe infestations cause leaf yellowing and leaf drop, dieback of twigs and limbs, and occasionally death of the tree. Tree damage is most likely to occur in late summer and early fall when scale populations are highest and moisture stress on the tree is greatest.

Description of Pest. California red scale are small reddish-brown armored scales that are distributed throughout the citrus-growing regions of the state except in parts of the Coachella Valley where both red and yellow scale are under an eradication program. California red scale can be found on the wood as well as on fruit and leaves.

Monitoring. Scale numbers are monitored first by counting male scale collected on sticky, white pheromone cards during each of the four yearly flights. If male scale numbers are above the threshold (for example > 1,000 during the fourth flight) then a treatment the following year may be needed. In addition to pheromone traps, counts of the percentage of infested fruit in the grove are made. Pheromone trap catches can be unreliable in groves treated with insecticides because the male scales are more sensitive to some of these treatments than female scales. Trap catches in Aphytis wasp release blocks can also be unreliable since the parasites prefer to attack female scales.

CONTROLS

Cultural

Ant Control. Growers control ants, particularly the Argentine ant in southern California and the native gray ant in the San Joaquin Valley, because these ants severely disrupt parasites that parasitize California red scale. These ants also tend to honeydew-producing pests such as soft scales or mealybugs, making ants a severe problem in many growing regions, including the Interior or Coastal-Intermediate Regions.

Dust Reduction. Growers minimize excessive dust, manure, white wash and other coatings on leaves and fruit that interfere with parasitism. Oil or water treatments are used on roads.

Pruning. Parasitic wasps are most efficient at finding scale on fruit on the outside of the tree. Interior pruning and skirting of trees (pruning trees 24 to 30 inches above the ground) helps to make scale on interior fruit and wood available to parasites.

Post Harvest Washer. If fruit is infested with scale at the end of the season, it can be washed using a high-pressure fruit washer. The majority of packing houses have this equipment and generally run the pressure at about 300 psi to remove both live and dead scale from fruit. This is more or less successful depending on the age and condition of the fruit. Early fruit and soft fruit can be damaged during high-pressure washing.

Clean Harvest. Fruit that is left on the tree at the end of the season may be infested with scale and these are known as 'shiners'. This situation should be minimized because it can produce scale that move onto the newly developing fruit.

Biological

***Aphytis melinus*.** 5,000-10,000 wasps released per acre (up to ten times per year). Growers release mass-reared *Aphytis melinus* wasp parasites into groves that have insufficient biological control against California red scale. If parasitization due to these releases is successful, chemical treatment is not required. The range of activity for this beneficial insect is limited to armored scales. *Aphytis melinus* will persist and provide scale control throughout the season if broad-spectrum pesticides are limited to low rates and infrequent use. Releases vary by regions, with 50,000 - 100,000 parasites/acre/year being released in the San Joaquin Valley region and a total of 10,000-40,000/year released in the interior and coastal-intermediate regions.

General Predators and other Parasites. Several other insects are beneficial in controlling California red scale. These include *Aphytis lingnanensis* and *Encarsia perniciosis* in the coastal-intermediate region. In all regions, green lacewing (*Chrysopa* spp.), lady beetles (*Rhyzobius lophanthae*), the wasp parasite *Comperiella bifasciata*, and twice-stabbed lady beetle (*Chilocorus* spp.), are also found.

Chemical

Applications of organophosphate and carbamate insecticides are timed to reach the crawler stage. Optimum treatment timing is usually in May (first generation) or July (second generation) because scales have not yet climbed onto fruit. Applications of insect growth regulators are generally during the white cap stage just before the insect molts.

Resistance to broad-spectrum insecticides chlorpyrifos, methidathion, and carbaryl have recently been found in California red scale populations in an estimated 40% of the San Joaquin Valley acreage. Use of these broad-spectrum insecticides has, accordingly, become limited in recent years in this region.

Chlorpyrifos. Chlorpyrifos (LORSBAN) is an organophosphate that is used to control California red scale although increasing resistance has been noted. Since resistance to chlorpyrifos has become prevalent in the San Joaquin Valley region, very high rates of the product are now needed to be effective in the valley. Though chlorpyrifos is used in all citrus growing regions, it is used at different rates in these regions to treat different primary pests. Chlorpyrifos is applied at an average rate of 3-6 lb ai per acre in the San Joaquin Valley region but at only 1 to 2 lbs ai per acre in the coastal regions and generally less than a pound per acre in the desert region. This difference is due to the different pests in these different regions. Use of chlorpyrifos has dropped in recent years with an increased use of the alternative chemicals, such as pyriproxyfen.

As a broad-spectrum insecticide, chlorpyrifos is one of the few insecticides available to treat a number of insect pests such as ants, katydids, citricola scale and greenhouse thrips for which biological control is not adequate. Chlorpyrifos is one of the least disruptive of the broad-spectrum pesticides because of its short persistence and development of resistance in some of the natural enemies (tularensis, Aphytis, vedalia beetle). It is not used during November- March (initiation of bloom) due to ridging of the new crop of fruit. Thorough coverage is need for chlorpyrifos to be effective. It is toxic to bees and should not be applied during daylight hours during bloom. It is now available in low odor formulations for use near residences.

Pyriproxyfen. Pyriproxyfen (ESTEEM) is an insect growth regulator that acts as a juvenile hormone mimic. It is active against molting scale and so is applied during the white cap stage, just prior to the first molt. It is highly toxic to predatory beetles such as vedalia and so has caused cottony cushion scale outbreaks up to several miles around the treatment site. It does not cause outbreaks in the treated location because it has activity against the cottony cushion scale. It is highly effective and is generally used once every two years.

Buprofezin. Buprofezin (APPLAUD) is an insect growth regulator that acts as a chitin synthesis inhibitor. Applaud may only be used once per season. It is highly toxic to predatory beetles such as vedalia and so has caused cottony cushion scale outbreaks offsite. It does not cause outbreaks in the treated location because it has activity against the cottony cushion scale. It is less efficacious against California red scale than pyriproxifen, but more effective against other scale pests and somewhat softer on the vedalia beetle.

Narrow Range Oil. Narrow range spray oils can be effective against California red scale if coverage is thorough. Oil sprays are often used in conjunction with releases of the parasitic wasp *Aphytis melinus* to control scale. Oils can be used to combat organophosphate resistant red scale. Growers must take care when applying narrow range oil to avoid applying it at high temperatures and low humidity when fruit and leaves can be damaged (phytotoxicity), when risk from frost damage can be increased, or natural enemies reduced. Hazards are associated with oil treatments to green lemons because of phytotoxicity during degreening. Oil treatments can delay color or cause spotting in ripening fruit. Oils can be used by organic growers.

Carbaryl. Carbaryl (SEVIN) is a carbamate and is used to the largest extent in the San Joaquin Valley Region for the control of California red scale. Carbaryl is a broad-range insecticide that is used to treat several insect pests important to the citrus industry, such as a katydid, black scale, fuller rose beetle, grasshoppers and citricola scale. Resistance has been seen in some California red scale populations. Use of carbaryl may increase citrus red mite and citrus thrips populations because it is toxic to predatory mites. Carbaryl should not be applied during bloom as it is toxic to bees. It may be applied in combination with oil (0.5%) for increased effectiveness.

Methidathion. Methidathion (SUPRACIDE) is a broad-range organophosphate applied almost exclusively to citrus in the San Joaquin Valley Region. As an insecticide, it is applied to treat several pests on San Joaquin Valley citrus, although some resistance has been seen in some scale populations. Applications of methidathion are rare in other citrus growing regions of the state. Applications are not made during bloom. Low volume sprays are allowed only under a Special Local Need permit from a county agricultural commissioner. It may be applied in combination with oil (0.5%) for increased effectiveness.

CITRUS THRIPS
Scirtothrips citri

Damage. Citrus thrips is one of the top four insect pests in all California citrus growing regions. Citrus thrips are the number one insect pest in the Desert Region. In the San Joaquin Valley Region it is of greatest importance on navel oranges. Coastal-Intermediate Region lemons are also affected. On fruit, the citrus thrips punctures epidermal cells, leaving scabby, grayish or silvery scars on the rind. Second instar larvae do the most damage because they feed mainly under the sepals of young fruit and are larger **and feed more** than first instars. As fruit grow, damaged rind tissue moves outward from beneath the sepals as a conspicuous ring of scarred tissue.

Description of Pest. Adult citrus thrips are small, yellow insects with fringed wings. First instar and second instar larvae feed actively on tender leaves and fruit, especially under the sepals of young fruit. Prepupae and pupae of thrips do not feed and complete development on the ground or in the crevices of trees. When adults emerge, they move actively around the tree foliage. They can produce up to eight generations during the year.

Monitoring. Monitoring for citrus thrips is critical in the control of this pest to minimize economic loss. Samplers must be able to distinguish citrus thrips from flower thrips, which feed on flower parts but do not damage citrus and do not require intervention. Fruit samples are checked for immature citrus thrips and the undersurface of inside foliage is monitored for predaceous mites. Monitoring is continued as long as small, susceptible fruit are on the tree. As fruit get larger, treatment thresholds go up. The threshold for treatment is 5% of navel fruit infested with immature thrips in the absence of predatory mites and 10% in the presence of at least 0.5 predatory mites/leaf.

CONTROLS

Orchard management practices and chemical treatments affect citrus thrips populations. Citrus thrips are less of a problem in orchards that receive minimal pesticide treatments than in orchards that are heavily treated. Thrips populations tend to increase after treatments with organophosphates and carbamates because of the reduction of natural enemies and because of pesticide-induced stimulation (hormoligosis) of the citrus thrips population. Wet, cool springs are less favorable for thrips development and generally require fewer chemical treatments.

Cultural

There are no specific cultural control techniques utilized for citrus thrips.

Biological

Predators. A number of natural enemies attack citrus thrips including the predaceous mite *Euseius tularensis*, spiders, lacewings, dustywings, minute pirate bugs, etc. In some years and in some regions when citrus thrips densities are excessively high, no amount of *E. tularensis* or other natural enemies in combination with selective pesticides can keep citrus thrips below an economic threshold.

Chemical

Citrus thrips is less of a problem in orchards that receive minimal broad-spectrum pesticide treatments than in orchards that are heavily treated. Thrips populations tend to increase after treatments with organophosphates and carbamates. Citrus thrips has a history of rapidly developing resistance to chemicals that are used repeatedly and frequently for its control. Various populations of citrus thrips have developed resistance to dimethoate, formetanate, cyfluthrin, and fenpropathrin particularly in the San Joaquin Valley region. With the limited number of pesticides available for control of citrus thrips, growers monitor citrus thrips levels carefully and minimize treatments.

Cyfluthrin. Cyfluthrin (BAYTHROID) is a broad-spectrum pyrethroid insecticide that is commonly used on oranges in the San Joaquin Valley region only and is rarely used on other commodities in the valley. The chemical is rarely used in any other region of the state, including the Desert Region, where citrus thrips are the major pest. Some citrus thrip resistance has been seen in the San Joaquin Valley. Only 6.4 oz per crop per season is permitted. Cyfluthrin is toxic to both beneficial mites and beneficial insects and disrupts biological control. It is also used for glassy-winged sharpshooters and katydids.

Formetanate Hydrochloride. Formetanate hydrochloride (CARZOL) is a carbamate insecticide that is used in the San Joaquin Valley Region and the desert region to control several citrus pests including citrus thrips. It is rarely used in the coastal-intermediate and interior regions. Formetanate hydrochloride is a broad-spectrum insecticide that is persistent unless washed off by rain. Resistance to formetanate hydrochloride has developed in a number of citrus thrips populations in the San Joaquin Valley. No more than two applications can be made per season. It is toxic to both beneficial mites and beneficial insects and disrupts biological control.

Abamectin. (AGRI-MEK) is most commonly used in the coastal-intermediate region of California to control citrus bud mites, not citrus thrips. Abamectin is used to a lesser extent in the San Joaquin Valley Region. It is not applied pre-bloom, during bloom, in nurseries or to nonbearing trees. It is always applied in combination with a narrow range oil. Abamectin is relatively nontoxic to beneficial insects and mites. It is most effective if substantial numbers of predators are present. The biggest disadvantage of abamectin is the higher cost compared to alternate treatments. Repeated applications increase the likelihood of citrus thrips resistance. Multiple applications, if needed, should be made at least 30 days apart. There is a limit of three applications or 40 fl oz/acre during the growing season in citrus. Treatments applied for citrus thrips suppress most mite pests.

Sabadilla Alkaloids. Sabadilla alkaloids (VERATRAN D) have a narrow range of activity (citrus thrips only) and are used on all citrus varieties. Sabadilla is nontoxic to beneficial insects and mites. It is most effective if substantial numbers of predators are present. Sabadilla is a short residual stomach poison, and is effective when applications are timed to coincide with mid-hatch. Sabadilla should be buffered to pH 4-5 to increase efficacy and persistence.

Dimethoate. Dimethoate (CYGON) is an organophosphate that is occasionally used to control citrus thrips. Dimethoate is used to control several citrus pests, such as the katydid. Resistance to dimethoate has developed in San Joaquin Valley and Desert Regions. No more than two applications are made on mature fruit. Dimethoate is toxic to both beneficial mites and beneficial insects and disrupts biological control. Many populations of San Joaquin Valley citrus thrips have developed resistance to this insecticide.

Spinosad. Spinosad (SUCCESS), a macrocyclic lactone isolated from the soil microorganism *Saccharopolyspsora spinosa*, was registered in 1998 in California for use on citrus. It is more efficacious if applied with oil. There is an organic form (Entrust) that became available in 2003. It is relatively nontoxic to natural enemies. It also has activity against lepidopteran larvae and young katydids.

Fenpropathrin. (DANITOL) was registered in 2001 in California for use on citrus. Some citrus thrip resistance has been seen in the San Joaquin Valley. Fenpropathrin is toxic to both beneficial mites and beneficial insects and disrupts biological control. It is also used for glassy-winged sharpshooter and katydids.

CITRUS CUTWORM

Citrus cutworm: *Egira (Xylomyges) curialis*
Variegated cutworm: *Peridroma saucia*

Damage. Citrus cutworm is a key pest in the San Joaquin Valley region, an occasional pest in the interior region, and a rare pest in coastal-intermediate and desert valley regions. Damage by citrus cutworm can be substantial because they prefer to feed on young fruit. A smaller number of citrus cutworms cause more damage than larger numbers of other caterpillars because they are larger and move throughout the tree during feeding. After petal fall, young fruit often have feeding scars. Variegated cutworm is rarely an economically important pest in citrus.

Description of Pest. Citrus cutworm has only one generation a year. Mature larvae drop to the ground and pupate in soil. Pupae remain dormant until the following spring. Generally only citrus cutworm is an economic pest. Other species, most notably the variegated cutworm, are occasionally found on citrus but rarely cause economic damage.

CONTROLS

Cultural

There are no cultural practices that are commonly used to specifically control citrus cutworm.

Biological

Parasites. Two parasites attack citrus cutworm larvae and are highly effective in reducing the next year's population. *Ophion* spp., a parasitic wasp, attacks cutworms just before they are ready to mature. The parasitized larvae pupates in the soil where it is consumed by the parasite larva. Another parasitic wasp, *Banchus* spp., also attacks cutworm larva. In some groves, a fungal pathogen has been found to infect and kill up to 25% of the pupae.

Chemical

Applications of broad-spectrum organophosphate, carbamate, or pyrethroid insecticides to control citrus thrips at petal fall will often provide secondary control of citrus cutworm.

***Bacillus thuringiensis* var. Aizawai or Kurstaki.** *Bacillus thuringiensis* (Bt) is the most common treatment for citrus cutworm prior to petal fall. Timing of applications is important because Bt has a short residual period. It should be applied only during warm weather to control young, actively feeding worms. *Bacillus thuringiensis* (Bt) insecticides, both the *aizawai* and *kurstaki* varieties, are specific to caterpillar pests. These insecticides are relatively nontoxic to parasites that attack the caterpillars and to beneficial insects and mites that feed on other citrus pests. Bt may be applied during bloom.

Spinosad. (SUCCESS) is a short-residual stomach poison. Success is somewhat more effective than Bt and is very effective against citrus thrips and so is more commonly used at petal fall.

Cryolite. Cryolite (KRYOCIDE) has a narrow range of activity (foliage feeders such as worms, katydids, and Fuller rose beetle), but is persistent unless washed off by rain. Higher application rates are used to treat larger worms and larger trees. Cryolite is a slow-acting stomach poison specific to foliage-feeding pests and may take several days of warm weather to kill worms. It is relatively nontoxic to parasites that attack the caterpillars and to beneficial insects and mites that feed on other citrus pests.

Chlorpyrifos. (LORSBAN) is a broad-spectrum insecticide that is used to control several important citrus pests, such as California red scale. It is only used to treat citrus cutworm if pest pressure is a major problem. It may not be applied more than twice per fruit year and applications should not be made less than 30 days apart. During bloom is should be applied from 1 hour after sunset until 2 hours before sunrise.

Naled. (DIBROM) is a broad-spectrum organophosphate insecticide that controls insect pests, as well as, beneficial mites.

Methomyl. (LANNATE) is an oxime carbamate that is a broad spectrum insecticide generally applied in the San Joaquin Valley to oranges, grapefruit, and lemons but rarely onto citrus in any other region. Methomyl is a restricted use material that may only be applied by permit from a county agricultural commissioner. It kills beneficial insects, such as mites. It is toxic to bees and during bloom is applied from one hour after sunset until two hours before sunrise. It is also used to disinfest citrus of glassy-winged sharpshooters just prior to harvest.

CITRUS RED MITE
Panonychus citri

Damage. Citrus red mite is one of a key group of mite pests in the Desert Region along with other mites such as the citrus flat mite, Yuma spider mite, and Texas citrus mite. It is less of a concern in other citrus growing regions, where the bud mite, rust mite and broad mites are of greater concern. Outbursts of this pest are usually the result of disruption in the pest/beneficial balance caused by pesticides. The citrus red mite was considered to be more of an important pest in other regions until more recently, when it was determined that San Joaquin Valley navels and coastal lemons can tolerate much higher populations than previously thought and treatment is not normally required in healthy orchards under an Integrated Pest

Management program. Populations tend to be heavier in spring and fall, especially in orchards where natural enemies are destroyed by the use of broad-spectrum insecticides such as the carbamates carbaryl and formetanate hydrochloride, the organophosphates methidathion and dimethoate, and the pyrethroids Cyfluthrin and Fenpropathrin. On leaves, citrus red mite feeding results in a pale stippling visible primarily on the upper surface of the leaf. In severe infestations, the stippling enlarges to dry necrotic areas. Eventually, leaves may drop and twigs dieback. Stippling or silvering also occurs on green fruit but usually disappears when fruit change color. In the inland areas, the thresholds are lower in the fall during hot dry Santa Ana winds. In the San Joaquin Valley, there is a relatively high threshold (8 adult mites per leaf) of tolerance for this pest.

Description of Pest. Adult female citrus red mites are oval and lay eggs on both sides of leaves. The life cycle from egg to egg may be as short as 12 days during warm weather. Populations increase in spring, late summer, and early fall in response to new growth: citrus red mites prefer to feed on fully expanded young leaves, but will also infest fruit. This mite over winters as red eggs.

Monitoring. When mites are present, growers begin monitoring about every two weeks by sampling leaves. Low to moderate populations are considered to be beneficial as they provide food for natural enemies. Populations exceeding 8 adult females per leaf are treated.

CONTROLS

Cultural

Irrigation Practices. Good irrigation reduces red mite outbreaks because mites reproduce faster on water-stressed trees.

Dust Control. Dust, white wash, manure and other dry coatings on the leaves aggravate citrus red mite.

Biological

Predaceous mites, predaceous insects, and a virus are important in regulating citrus red mite populations. The virus and high temperatures can dramatically reduce citrus red mite populations.

***Euseius tularensis*.** *Euseius tularensis* is the most important natural enemy of citrus red mite. This beneficial mite can establish their populations before citrus red mites are numerous because they have alternate food sources (pollen, citrus thrips larvae, nectar, and honeydew). They mainly attack immature stages of the citrus red mite. The female of both species is about the same size as the female citrus red mite but is pear-shaped, shiny, and translucent. Predator eggs are clear, oval, and about twice the size of citrus red mite eggs. Eggs hatch and develop into adults in about 8 days. *Euseius tularensis* populations vary in their tolerance to various miticides and insecticides with some populations being fairly resistant to many materials because of past exposure.

General Predators. Other predators of the citrus red mite include a beneficial mite, *Euseius stipulantus*, a small black lady beetle , *Stethorus picipes*, a predaceous dustywing, *Conwentzia barretti*, and the sixspotted thrips, *Scolothrips sexmaculatus*.

Natural Virus. A disease caused by a virus specific to citrus red mite is widespread in citrus-growing areas. The disease becomes epidemic under hot, moderately dry conditions when mite populations are high. Symptoms of virus-infected mites include stiff movements, legs curled under the body, and subsequent disintegration of the body. Growers in the San Joaquin Valley typically depend on the heat of summer and the virus to eliminate citrus red mite.

Chemical

Narrow Range Oil. Narrow range oil is the most common treatment for citrus red mite. Growers must take care when applying narrow range oil to avoid applying it during high temperatures when fruit and leaves can be damaged (phytotoxicity) or natural enemies reduced and in the fall when risk from frost damage can be increased. In warmer desert regions, oil treatments will damage the trees. Hazards are associated with oil treatments to green lemons because of phytotoxicity during degreening.

Fenbutatin Oxide. Fenbutatin oxide (VENDEX) has a narrow range of activity and the period of persistence is short. Fenbutatin oxide should not be applied during bloom. In hot weather, there is a potential of phytotoxicity. Higher rates may be used during cool weather periods. Fenbutatin oxide is highly selective and has little effect on natural enemies. It is typically applied in combination with a narrow range spray oil. There are also serious hazards associated with oil treatments to green lemons because of phytotoxicity after sweating.

Propargite. Propargite (OMITE) is an organosulfur compound intended for use on oranges, grapefruit and lemons. Propargite should not be applied within 40 days of an oil application, but oil may be applied 30 days or more after propargite. Propargite is highly selective, more so that dicofol or oxythioquinox, because, when used at low rates, it is relatively nontoxic to beneficial mites. In southern California, propargite applications are allowed only under Special Local Needs permit. No more than two applications/fruit year at least 21 days apart.

Dicofol. Dicofol (KELTHANE) is an organochlorine which is applied at label rates to all varieties of citrus. It has a narrow range of activity, but is persistent. Applications are largely confined to the San Joaquin Valley region. Dicofol is of intermediate selectivity because it acts primarily against mites with minimal impact on beneficial insects such as lacewings, lady beetles, and *Aphytis melinus*, which help control worms, scale, thrips, and other pests. It is however, toxic to predaceous mites such as *Euseius tularensis*, because of its persistence. A closed cab system is required when making applications.

Abamectin. (AGRI-MEK) is most commonly used in the Coastal-Intermediate Region. This use is primarily targeted to control citrus bud mites, not citrus red mites. Abamectin is used to a lesser extent in the San Joaquin Valley region though typically not to control this pest. It is not applied pre-bloom, during bloom, in nurseries or to nonbearing trees. It is always applied in combination with a narrow range oil. Abamectin is relatively nontoxic to beneficial insects and mites. It is most effective if substantial numbers of predators are present. Multiple applications, if needed, should be at least 30 days apart.

Pyridaben. Pyridaben (NEXTER) is a miticide that can be used to control mites in citrus. It is often used during periods of wet and cool conditions. To be most effective, multiple applications should be applied at a minimum of 30 days apart.

CITRUS BUD MITE
Eriophyes sheldoni

Damage. Citrus bud mite is a primary pest of Coastal-Intermediate Region lemons as well as with other citrus in that region. It is an occasional pest of the Interior Region while the San Joaquin Valley and Desert Regions are rarely affected by citrus bud mites. The mites feed inside the buds, killing them or causing a rosette-like growth of the subsequent foliage and distortion of flowers and fruit, which may or may not reduce yield.

Description of Pest. Citrus bud mite is very small. Adult females lay eggs mostly in the bud scales of recent growth. Populations peak in summer, and summer and fall blooms are most likely to suffer damage.

Monitoring. Growers monitor orchards to detect bud mites before damage occurs, checking buds on green angular twigs from mid-spring to autumn. If 40% to 50% of the buds are infested with live mites, economic damage through loss of fruit buds and distorted fruit may occur in Eureka lemons. Under current petroleum oil treatments, treatment of bud mite in Lisbon lemons is unlikely to produce an economic return.

CONTROLS

Cultural

There are no cultural practices used specifically to target citrus bud mite.

Lisbon lemons are less likely than Eureka lemons to suffer damage.

Biological

Predators. General predators feed on citrus bud mites when they are not within the buds. Predacious mites will feed on this pest when they are in the outer, loose scales of buds.

Chemical

Chemical treatments are made March-November in order to protect fruit buds 2-3 months before the injury is observed.

Chlorpyrifos. (LORSBAN) is an important broad-spectrum insecticide that is used to control several important citrus pests. It may not be applied more than twice per fruit year and applications should not be made less than 30 days apart. Chlorpyrifos is toxic to bees. Many growers apply chlorpyrifos in combination with oil for California red scale and with some effectiveness against bud mite.

Abamectin (AGRI-MEK) is not applied pre-bloom, during bloom, in nurseries or to nonbearing trees. It is always applied in combination with a narrow range oil. Avermectin is relatively nontoxic to beneficial insects and mites. Multiple applications, if needed should be at least 30 days apart.

Narrow Range Oil. Narrow range spray oils must be carefully applied to avoid phytotoxicity when risk from frost damage can be increased or natural enemies reduced. Hazards are associated with oil treatments to green lemons because of phytotoxicity after degreening. Although mite populations may be significantly reduced by NR oil treatments, the most recent research suggests that the negative off-setting phytotoxicity of the oil may not improve the economic return to the grower beyond doing nothing.

BROWN GARDEN SNAIL
Helix aspera

Damage. The brown garden snail is a key pest in the Coastal-Intermediate and Desert Regions and a pest of lesser importance in the San Joaquin Valley and Interior Regions. It can be especially problematic in wet years. The brown garden snail can cause extensive damage in orchards by feeding on ripe and ripening fruit and young tree leaves, and in nurseries by feeding on young tree bark. It can cause severe problems in citrus orchards, where no-till weed control and sprinkler and drip irrigation create an ideal environment for snail development.

Description of Pest. The brown garden snail is about one inch in diameter at maturity and has a distinct color pattern. It is most active during the night and early morning when it is damp. In southern California, particularly along the coast, young snails are active throughout the year. Mature snails hibernate in the topsoil during winter.

CONTROLS

Cultural

Pruning. Growers prune tree skirts 24 to 30 inches above the ground before the rainy season and apply a barrier trunk treatment.

Trunk Barriers. Barrier trunk treatments are made with a band of copper foil wrapped around the trunk, which repel snails for several years. A copper foil band is affixed around the tree trunk at a height of 1-2 feet above the ground with about an 8-inch overlap so it will slip and allow for trunk growth. To be effective, growers must also prune tree skirts so that snails will not have access to the trees.

Cultivation: destroys the snails.

Irrigation: Fewer snails under furrow versus microsprinklers due to cultivation in the absence of decollates, and the reverse is true if decollates are present.

Monitoring. Growers conduct visual inspections in the orchard to determine pest pressure.

Biological

Rumina decollata. The decollate snail, *Rumina decollata*, can reduce brown garden snail populations to insignificant levels in 4 to 10 years. The most effective way to manage brown garden snails while establishing the decollate snail is to combine skirt pruning and trunk banding with decollate snail releases. Decollate snails do not climb trees, thus they will not be affected by pruning or trunk banding. To establish the decollate snail, growers distribute about 8 to 10 decollate snails to the shady northeast skirt zone of every other tree in every other row or by releasing available decollate snails in a cluster of core trees. After the colony grows, some of the snails are transferred to other trees in the grove. Growers provide an unbaited buffer zone of at least two tree rows between the expanding colony and the baited areas of the orchard so that the decollate snail will not feed on poison bait and die. Chemical baits are typically applied before the introduction of the decollate snail in order to reduce the brown garden snail population. In California, *Rumina decollata* may only be released in Fresno, Kern, Imperial, Los Angeles, Madera, Orange, Riverside, San Bernardino, San Diego, Santa Barbara, Tulare, and Ventura counties.

Geese and ducks. Geese and ducks are also effective control agents of brown garden snail.

Chemical

Copper Sulfate. Tree trunks are banded with a slurry of basic copper sulfate with a small quantity of boiled linseed oil added as a sticker. It is painted or sprayed on the tree trunks in about a 4-inch-wide band. Copper sulfate should be buffered with fresh hydrated lime to avoid injury to the trunk. To be effective, growers must also prune tree skirts so that snails will not have access to the trees.

Metaldehyde. Metaldehyde is a bait generally applied in the northern portion of the Coastal-Intermediate Region. It has a narrow range of activity but will kill both pest and beneficial species of snails.

FULLER ROSE BEETLE
Asynonychus godmani

Damage. The Fuller rose beetle is a secondary pest in all citrus growing regions within California. The Fuller rose beetle itself does not generally cause economic damage in citrus but the presence of eggs on fruit exported to Japan is requiring that shipments be fumigated. Fumigation is expensive and may be damaging to lemons, oranges and grapefruit. Fuller rose beetle adults feed along the margins of citrus leaves, creating notches and leaving a characteristic sharp, ragged appearance.

Description of Pest. Adult Fuller rose beetles are brown snout beetles. The beetle has one generation a year. Eggs are laid in a mass of several dozen on fruit, especially underneath the button or in cracks and crevices in the tree. When eggs hatch, larvae drop to the ground and live in the soil where they feed on roots of citrus for 6 to 10 months.

Monitoring. Growers monitor for Fuller rose beetle damage. If it is found, they sample for adults from July to November by shaking or beating branches onto a sheet or tray. If beetles are found, fruit is sampled for egg masses, especially in the areas where adult feeding damage has been found. Growers look for egg masses on the underside of the fruit button.

CONTROLS

Cultural

Skirt Pruning. Growers prevent the flightless adult beetles from reaching the canopy by using skirt pruning and trunk treatments. They skirt prune trees 24 to 30 inches above the ground to prevent adults from reaching the canopy.

Trunk Barriers. Barrier trunk treatments are applied to the trunk. Sticky material should be applied on top of a wrap to avoid sunburn damage to the trunk. Sticky material can be expected to last 2 to 10 months, depending on wash-off by sprinklers and the amount of dirt and leaf contamination. Sticky material will also control ants, and if it contains tribasic copper sulfate, it is effective against brown garden snail as well.

Sticky Polybutene Materials. Sticky polybutene materials should not be applied directly on the trunk of young or top worked trees because of the danger of sunburn. Caution is used in applying multiple applications (more than 3 or 4) to prevent symptoms of bark cracking. This treatment can only be successful if hanging branches, sticks, weeds, etc. are not allowing Fuller rose beetle access to trees.

Biological

***Fidiobia citri*.** The egg parasite, Fidiobia citri, can parasitize up to 50% of each egg mass. Parasitized eggs are a dark gold color and they may persist long after unparasitized eggs have hatched.

Chemical

Cryolite. Cryolite (KRYOCIDE) has a narrow range of activity (foliage feeders such as worms, katydids, and Fuller rose beetle), but is persistent unless washed off by rain. Cryolite is a slow-acting stomach poison specific to foliage-feeding pests and may take several days of warm weather to kill Fuller rose beetles.

Carbaryl. Carbaryl (SEVIN) is used to the largest extent in the San Joaquin Valley region for the control of California red scale, and is only occasionally used to control Fuller rose beetle.

BLACK SCALE
Saissetia oleae

Damage: Black scale is an occasional pest in the Coastal-Intermediate and Interior Regions and is largely absent in the San Joaquin Valley and Desert Regions. When it occurs in the San Joaquin Valley, it is usually on grapefruit. Natural biological control of black scale can be insufficient, requiring chemical treatments. Feeding by black scale reduces tree vigor and can cause leaf or fruit drop and twig dieback. Excreted honeydew supports the growth of sooty mold.

Description of Pest. Black scale is one of the soft scales. Female black scales reproduce without mating and lay eggs once or twice a season, depending on the region (two in coastal areas). Crawlers move about for some time before settling on leaves. After the second molt, young scales migrate to twigs.

Monitoring. Black scale is especially a problem if parasite activity has been upset. Growers monitor for newly settled scales in late June or early July to determine if natural parasite population is controlling pest.

CONTROLS

Cultural

Ant Control. Ants in the orchard are controlled because honeydew seeking species which feed on the honeydew excreted by scales, mealybugs, whiteflies and aphids, protect their favorite food source from natural enemies.

Skirt pruning for ant control. Growers skirt prune trees 24 to 30 inches above the ground to prevent ants from reaching the canopy. Skirt pruning does not reduce yield (except for lower fruit removed during pruning) but can significantly reduce honeydew foraging ants at the base of the tree. Organic growers can use sticker products as a barrier to ants. Treatments are best applied to ants at the end of winter before ants begin foraging and increasing colony size.

Biological

Several predators and parasites have been introduced against the black scale. The most significant are *Metaphycus helvolus, M. lounsburyi (bartletti), and Scutellista cyanea*.

Metaphycus Helvolus. Release a minimum of 2,000 adults/acre/year. Metaphycus helvolus is a parasitic wasp that provides substantial control of black scale in southern California. In addition to laying its eggs in the scale, the adult female parasite feeds on the body fluids of young scale. M. helvolus is only available for release by growers who are members of the Fillmore Citrus Protection District. Releases are typically made in late summer or early fall. M. helvolus parasitizes only smaller stages of the scale. Ant control is important in the success of control by M. helvolus. Metaphycus and Scutellista cyanea are also significant parasites. Metaphycus helvolus is available commercially on a limited basis.

Chemical

Narrow Range Oil. Narrow range spray oils can be effective against red, yellow, purple and black scale if coverage is thorough. Growers must take care when applying narrow range oil to avoid applying it at times when fruit and leaves can be damaged (phytotoxicity), when risk from frost damage can be increased, or natural enemies reduced. Hazards are associated with oil treatments to green lemons because of phytotoxicity after degreening.

Methidathion. Methidathion (SUPRACIDE) is a broad-range organophosphate applied to treat several pests on San Joaquin Valley citrus though most of these applications target California red scale. Applications are not made during bloom. Low volume sprays are allowed only under a Special Local Need permit from a county agricultural commissioner. Methidathion may be applied in combination with narrow range oil which increases survival of natural enemies and reduces the risk of phytotoxicity from oils.

Carbaryl. Carbaryl (SEVIN) is applied in the San Joaquin Valley region primarily for the control of California red scale, but may also be used to control black scale. Use of carbaryl is lower in the other regions. Carbaryl is a carbamate that may be applied in combination with narrow range oil at reduced rates. Use of carbaryl may increase citrus red mite populations.

CITRICOLA SCALE
Coccus pseudomagnoliarum

Damage. Citricola scale is an emerging key pest of citrus in the San Joaquin Valley Region. A severe infestation may reduce tree vigor, kill twigs, and reduce flowering and fruit set. It is a rare pest, usually under natural biological control, in other regions. As they feed, citricola scale excrete honeydew, which accumulates on leaves and fruit. Sooty mold grows on honeydew and interferes with photosynthesis in leaves and causes fruit to be downgraded.

Description of Pest. Citricola scale is a soft scale. Crawlers of the citricola scale appear in late April. They settle primarily on the underside of leaves, but in severe infestations they also settle on the upper leaf surface and on twigs, rarely on fruit. By November, immature scales begin migrating to twigs. There is only one generation a year.

Monitoring. Growers check for citricola scale when monitoring other scales, but look especially close during January and again in August. Citricola scale is most likely to reach damaging levels in San Joaquin Valley orchards that are not regularly treated with organophosphates or carbamates.

CONTROLS

Cultural

Ant Control. Controlling ants will help improve biological control.

High Pressure Washer. Regular and high-pressure fruit washers remove the sooty mold that grows on the honeydew excreted by the scale.

Biological

Parasitic Wasps. Biological control of the citricola scale is not always effective in the San Joaquin Valley region, where *Metaphycus helvolus*, and *M. luteolus* are found naturally. *Coccophagus* can also be a significant parasite. Citricola scale is under complete biological control in the interior, southern region where alternate hosts such as black scale support the survival of the parasites.

Chemical

High populations (i.e., over 1 scale per twig) require treatment before bloom. When the population is low, treatments are postponed until fall when scales are small nymphs and residing on the leaves of trees and are therefore easier to control. The threshold in August-September is 0.5 per leaf or greater than 15% of the leaves infested.

Narrow Range Oil. Oil is the only option for organic growers. However, oil does not control citricola scale very well and must be applied every year. Narrow range oils (415, 440) are used only for light to moderate Citricola scale infestation on grapefruit, lemons, navel and Valencia oranges. Oils can be effective against scale if coverage is thorough. In orchards where resistance to organophosphate and carbamate insecticides is a severe problem, petroleum oil sprays can be a useful supplement together with other chemical treatments to control scale. Growers must take care when applying narrow range oil to avoid applying it at times when fruit and leaves can be damaged (phytotoxicity), when risk from frost damage can be increased or natural enemies reduced. Narrow range 440 spray oil is preferred in the San Joaquin Valley region during warmer months because of greater persistence, but at some risk to enhanced phytotoxicity. In warmer desert regions, oil treatments will damage the trees. Hazards are associated with oil treatments to green lemons because of phytotoxicity after sweating.

Chlorpyrifos. Chlorpyrifos (LORSBAN) is a broad-spectrum organophosphate insecticide intended for use on all varieties of citrus. Chlorpyrifos is less selective than oil; however, a lower rate (1-3 pints per acre) can more effectively reduce citricola scale than oil, and a high label rate of chlorpyrifos can suppress densities so low that another spray may not be needed for up to 3 years for this pest. Though chlorpyrifos is used in all growing regions, it is used at different application rates in these regions to control various pests. As a broad-range insecticide, chlorpyrifos is used to treat several insect pests on citrus.

Imidacloprid. (PROVADO OR ADMIRE). The foliar (Provado) formulation is more effective than the systemic (Admire) formulation, however, it is also more toxic to natural enemies. Imidacloprid has shorter pre-harvest and reentry intervals and higher efficacy against citricola scale compared to chlorpyrifos during the spring months. Provado is broad spectrum affecting all natural enemies. Admire is more selective affecting primarily vedalia beetles and so should not be used where cottony cushion scale is a problem. These insecticides are also used for glassy-winged sharpshooter control.

Acetamiprid. (ASSAIL) has shorter pre-harvest and reentry intervals and higher efficacy against citricola scale compared to chlorpyrifos during the spring months. Acetamiprid has shorter pre-harvest and reentry intervals and higher efficacy against citricola scale compared to chlorpyrifos during the spring months. Acetamiprid is broad spectrum affecting all natural enemies. This insecticide should not be used where cottony cushion scale is a problem because it does not control that pest and it is toxic to vedalia beetle. This insecticide is also used for glassy-winged sharpshooter control.

COTTONY CUSHION SCALE
Icerya purchasi

History: Cottony cushion scale was under excellent biological control by the vedalia beetle until the introduction of various broad-spectrum pesticides (DDT, carbamates, and pyrethroids) and more recently the insect growth regulators (pyriproxifen and buprofezin) and neonicotinoid insecticides (imidacloprid and acetamiprid).

Damage. Cottony cushion scale is a key pest (within the top four) in the San Joaquin Valley Region but only of secondary importance in the other regions. Cottony cushion scale extract plant sap from leaves, twigs, and branches, thus reducing tree vigor. If infestations are heavy, leaf and fruit drop can occur along with twig dieback. The scale secretes honeydew, which promotes the growth of sooty mold. If infestations are heavy and continuous, the yield of the tree will be greatly reduced.

Description of Pest. First and second instar feed on twigs and leaves, usually along the veins. Third instars and adults are found mainly on branches and the trunk, rarely the fruit. There are three generations a year.

Monitoring. Growers monitor for both the cottony cushion scale and its natural predators during the spring and fall months by examining the trunks and internal limbs of trees. In the San Joaquin Valley, cottony cushion scales may flare up after treatments with broad-spectrum insecticides such as organophosphates and carbamates for citrus thrips and orange worms in spring, insect growth regulators for California red scale, or neonicotinoids for glassy-winged sharpshooters which eliminate most of vedalia beetle, a predator of scale. These beetles usually recover and control scale infestations the following year.

CONTROLS

Cultural

Ant Control. Ants are attracted to the honeydew excreted by this scale but do not interfere greatly with its biological control.

Biological

Biological control typically manages this pest but recently, use of pyrethroids, pyriproxyfen, buprofezin, and imidacloprid, has decimated vedalia beetle populations leading to widespread outbreaks of cottony cushion scale throughout the San Joaquin Valley. Two natural enemies can effectively control cottony cushion scale: the vedalia beetle and a parasitic fly, *Cryptochaetum iceryae*.

Cryptochaetum iceryae In coastal areas, the parasitic fly *Cryptochaetum iceryae* can usually be observed parasitizing cottony cushion scales. The emerging parasite leaves an exit hole in the mummified scales. The parasitic fly was also introduced from Australia and is a very effective parasite of this scale in coastal areas. The fly deposits its eggs inside the scale body. Upon hatching, parasite larvae feed on the scale body and pupate within the remains of the scale.

Vedalia Beetle. The vedalia beetle, *Rodolia cardinalis*, was introduced from Australia in the early 1890s. The adult and larva feed on all stages of the scale. Female beetles lay eggs underneath the scale or attached to the egg sac. Young larvae move into the egg mass and feed on eggs. Later, larvae feed on all scale stages. The vedalia beetle is susceptible to cyfluthrin, fenpropathrin, pyriproxyfen, Buprofezin, acetramiprid, and imidacloprid.

Chemical

Malathion. Malathion is an organophosphate that is occasionally applied as thorough coverage to citrus trees. Malathion may be applied in combination with narrow range oil at reduced rates, but should not be applied during bloom as it is toxic to bees.

Methidathion. Methidathion (SUPRACIDE) is a broad-range organophosphate applied almost exclusively to citrus in the San Joaquin Valley region to treat several pests. Applications of methidathion are rare in other citrus growing regions of the state. Applications are not made during bloom. Low volume sprays are allowed only under a Special Local Need permit from a county agricultural commissioner. Methidathion may be applied in combination with narrow range oil which increases survival of natural enemies and reduces the risk of phytotoxicity from oils.

AMORBIA (WESTERN AVOCADO LEAFROLLER)
Amorbia cuneana

Damage. Amorbia is an occasionally important pest in the Coastal-Intermediate, Interior, and San Joaquin Valley Regions. It is normally absent in the desert valley regions. Amorbia is primarily a pest of avocado, but can also cause damage in citrus groves. Infestations generally occur in groves planted near avocado. Amorbia larvae may feed on young fruit at petal fall. They also feed on new growth flushes, often rolling the leaves or tying leaves to fruit and feeding on the peel of young or maturing fruit and under the calyx. Damaged fruit often decays at the feeding site.

Description of Pest. There are two to three generations a year. Amorbia larvae may feed on young fruit and leaves.

Monitoring. While monitoring for citrus thrips at petal fall is performed by checking under the button on the base of fruit for small amorbia larvae. Larger larvae are monitored later in spring by looking for webbing and leaf rolls in young foliage and feeding damage on young and mature fruit located on the outside canopy. Because amorbia is more likely to be present in orchards located near avocados, growers of these orchards are more careful to monitor for the presence of amorbia larvae. Not a problem in coastal areas due to biological controls.

CONTROLS

Cultural

There are no cultural practices that are commonly used to specifically impact amorbia.

Biological

Trichogramma platneri. A variety of natural enemies attack egg, larval, and pupal stages of amorbia. One of the most effective egg parasites is the tiny wasp, Trichogramma platneri. Parasitized eggs are black. This wasp is available commercially.

General Predators. A tachinid fly and several parasitic wasps attack the larvae stages. The tachinid fly attaches its eggs near the head of the larva and the emerging maggots bore into the amorbia larva to develop inside.

Chemical

***Bacillus thuringiensis* var. Aizawai or Kurstaki.** *Bacillus thuringiensis* (Bt) is the most common treatment for amorbia prior to petal fall. Timing of applications is important because Bt has a short residual period. It should be applied only during warm weather to control young, actively feeding worms. *Bacillus thuringiensis* (Bt) insecticides, both the *aizawai* and *kurstaki* varieties, are specific to caterpillar pests. These insecticides are relatively nontoxic to parasites that attack the caterpillars and to beneficial insects and mites that feed on other citrus pests. Bt may be applied during bloom.

Cryolite. Cryolite (KRYOCIDE) is applied to control foliage feeders, such as amorbia, katydids and Fuller rose beetle. It is rarely used on valley lemons and rarely used in any other growing region other than the San Joaquin Valley. Higher application rates are used to treat larger worms and larger trees. Cryolite is a slow-acting stomach poison specific to foliage-feeding pests and may take several days of warm weather to kill worms. It is effective unless washed off by rain. It is relatively nontoxic to parasites that attack the caterpillars and to beneficial insects and mites that feed on other citrus pests.

Chlorpyrifos. Chlorpyrifos (LORSBAN) is a broad-spectrum organophosphate insecticide intended for use on all varieties of citrus. Though chlorpyrifos is used in all growing regions, it is used at different application rates in these regions. Due to increasing levels of resistance build up against organophosphates in the San Joaquin Valley region, Lorsban is generally applied at higher rates. As a broad-range insecticide, Lorsban is used to treat several insect pests on citrus.

Carbaryl. Carbaryl (SEVIN) is generally applied in the San Joaquin Valley region. Use of this carbamate is lower in the other regions

Naled. Naled (DIBROM) is a broad-spectrum organophosphate that controls insect pests, as well as, beneficial mites.

Methomyl. Methomyl (LANNATE) is a broad-spectrum oxime carbamate that may only be applied by permit from a county agricultural commissioner as it is a restricted use material. It kills beneficial insects, such as mites. It is toxic to bees and during bloom is applied from 1 hour after sunset until 2 hours before sunrise.

WESTERN TUSSOCK MOTH
Orgyia vetusta

Damage. Western tussock moth infestations are most common in the Interior Region with infestations in the San Joaquin Valley Region being sporadic. They are common on many orchard trees, such as apple, cherry, prune, walnut, avocado and citrus, as well as on live oak trees, perennial lupine and certain ornamentals. A heavy infestation of this pest in the citrus orchard may destroy all new spring growth. The larva may also eat into newly set or young fruit. The damage is similar to that of katydids, grasshoppers, and citrus cutworm. In addition, orchard workers coming into contact with western tussock moth cocoons sometimes experience dermal irritation and rashes.

Description of Pest. Western tussock moth has one generation a year. Mature larvae spin their cocoons and pupate mainly on scaffold branches and trunks. Adults emerge from late April through July and, after mating.

Monitoring. Growers monitor for this pest by looking for egg masses or larvae of western tussock moth in the spring to determine the population level before damage occurs. One healthy egg mass per tree may results in economic loss. Treatment is warranted if 100 larvae are identified in one hour of search.

CONTROLS

Cultural

There are no cultural practices used to target specifically Western tussock moth.

Biological

Predators. A dermestid egg predator, *Trogoderma sternale*, is common in some areas of southern California where its larvae and adults may destroy up to 50% of the Western Tussock Moth egg masses. Dermestid beetles are common from March through September. A small parasitic wasp, Dibrachys spp. has also been seen on egg masses.

Chemical

Treatments are timed after 90% of the eggs have hatched.

***Bacillus thuringiensis* var. Aizawai or Kurstaki.** *Bacillus thuringiensis* (Bt) is the most common treatment for western tussock moth. Timing of applications is important because

Bt has a short residual period. It should be applied only during warm weather to control young, actively feeding worms. *Bacillus thuringiensis* (Bt) insecticides, both the aizawai and kurstaki varieties, are specific to caterpillar pests. These insecticides are relatively nontoxic to parasites that attack the caterpillars and to beneficial insects and mites that feed on other citrus pests. Bt may be applied during bloom.

Naled. Naled (DIBROM) is a broad-spectrum insecticide that controls insect pests, as well as, beneficial mites.

Chlorpyrifos. Chlorpyrifos (LORSBAN) is a broad-spectrum organophosphate insecticide intended for use on all varieties of citrus. As a broad-range insecticide, chlorpyrifos is used to treat several insect pests on citrus.

Carbaryl. Carbaryl (SEVIN) is applied in the San Joaquin Valley region primarily for the control of California red scale, but is also used to control Western tussock moth. Use of this carbamate is lower in the other regions.

Methomyl. Methomyl (LANNATE) is a broad-spectrum oxime carbamate that is applied primarily to San Joaquin Valley citrus but rarely on citrus in any other region. Methomyl is a restricted use material that may only be applied by permit from a county agricultural commissioner. It kills beneficial insects, such as mites. It is toxic to bees and during bloom is applied from 1 hour after sunset until 2 hours before sunrise.

Cryolite. Cryolite (KRYOCIDE) has a narrow range of activity (foliage feeders such as worms, katydids, and Fuller rose beetle), and is persistent unless washed off by rain. Higher application rates are used to treat larger worms and larger trees. Cryolite is a slow-acting stomach poison specific to foliage-feeding pests and may take several days of warm weather to kill worms. It is relatively nontoxic to parasites that attack the caterpillars and to beneficial insects and mites that feed on other citrus pests.

BROAD MITE
Polyphagotarsonemus latus

Damage. Broad mites are pests of Coastal-Intermediate Region lemons only beginning in March. Infestations are enhanced by the presence of Argentine ants. Feeding results in scarred tissue that cracks as fruit grows, leaving a characteristic pattern of scars and new tissue. Broad mites are rarely an economic pest in the Interior, San Joaquin Valley, and Desert Regions.

Description of Pest. Broad mites feed on fruit and leaves, preferring young fruit up to about 1 inch in diameter that are located on the inside of the canopy. Although most feeding occurs on fruit, broad mites may also feed on young expanding leaves causing them to curl and are often found in depressions on fruit where the females lay their eggs. These mites are very small and cannot be seen without a hand lens.

Monitoring. Monitoring for broad mite is performed by visual inspection of leaves for curl and young fruit clusters.

CONTROLS

Cultural

There are no cultural practices used specifically to target broad mites.

Biological

There are no specific biological controls for broad mites.

Chemical

Wettable Sulfur. Wettable sulfur is applied to thoroughly cover foliage as soon as mites are detected. It is intended for use on all varieties of citrus. Applications are not made when temperatures are high or within 2 months of a previous oil spray. Sulfur can burn lemons (phytotoxicity) under high temperatures.

Chlorpyrifos. Chlorpyrifos (LORSBAN) is a broad-spectrum organophosphate insecticide intended for use on all varieties of citrus. As a broad-range insecticide, chlorpyrifos is used to treat several insect pests on citrus.

Avermectin. Abamectin, (AGRI-MEK) is the most commonly used miticide in the coastal-intermediate region. Abamectin is used to a lesser extent in the San Joaquin valley region. It is not applied pre-bloom, during bloom, in nurseries or to nonbearing trees. It is always applied in combination with a narrow range oil. Abamectin is relatively nontoxic to beneficial insects and mites. It is most effective if substantial numbers of predators are present. The biggest disadvantage of abamectin is the cost compared to alternate treatments. Repeated applications increase the likelihood of citrus thrips resistance. Multiple applications, if needed should be at least 30 days apart.

Dicofol. Dicofol (KELTHANE) is an organochlorine which is applied to all varieties of citrus. It has a narrow range of activity, but is persistent. Applications are largely confined to the San Joaquin Valley region. Dicofol is of intermediate selectivity because it acts primarily against mites with minimal impact on beneficial insects such as lacewings, lady beetles, and *Aphytis melinus*, which help control worms, scale, thrips, and other pests. It is, however, toxic to predaceous mites such as *Euseius tularensis*, because of its persistence.

CITRUS FLAT MITE
Brevipalpus lewisi

Damage. Citrus flat mite is often an economically important pest on tangerines in the Desert Region and a sporadic pest of citrus in the San Joaquin Valley and Interior Regions. It is one of a group of mite pests in the Desert Region along with the citrus red mite, Yuma spider mite, and Texas citrus mite. Feeding results in a scabbing of the injury caused by thrips and leafhoppers, which would otherwise disappear as the fruit change color. The flat mite is fairly heat tolerant, so populations persist during the hot summer.

Description of Pest. The flat mite adult is much smaller than the citrus red mite, is flat, and varies in color. The flat mite is usually a secondary invader, feeding on rind tissue damaged by leafhopper feeding, thrips oviposition, or wind.

Monitoring. Growers monitor the flat mite from early spring through summer. When populations are high, the mites move over the entire fruit. Once growers find one or more infested fruit and if flat mites were a problem the previous year, the orchard is watched closely. Treatment is rarely needed because chemical treatments for other mites also control this pest.

<u>CONTROLS</u>

Cultural

There are no common cultural practices designed specifically to impact citrus flat mite.

Biological

There are no specific biological control agents against citrus flat mite.

Chemical

Wettable Sulfur. Wettable sulfur is applied to thoroughly cover foliage as soon as mites are detected. It is intended for use on all varieties of citrus. Applications are not made when temperatures are high or within 2 months of a previous oil spray.

Dicofol. (KELTHANE) is an organochlorine which is applied to all varieties of citrus. It has a narrow range of activity, but is persistent. Dicofol is of intermediate selectivity because it acts primarily against mites with minimal impact on beneficial insects such as lacewings, lady beetles, and *Aphytis melinus*, which help control worms, scale, thrips, and other pests. It is, however, toxic to predaceous mites such as *Euseius tularensis*, because of its persistence.

CITRUS RUST MITE (SILVER MITE)
Phyllocoptruta oleivora

Damage. Citrus rust mite is a pest of the Coastal-Intermediate Region and occasionally of inland districts. The rust mite feeds on the outside exposed surface of fruit that is 0.5 inch or larger. Feeding destroys rind cells and the surface becomes silvery on lemons, rust brown on mature oranges, or black on green oranges. Rust mite damage is similar to broad mite damage, except that somewhat larger fruit are affected. Most rust mite damage occurs from late spring to late summer. This pest is most commonly a problem in the coastal-intermediate region.

Description of Pest. This pest is known as the rust mite on oranges and the silver mite on lemons. It is an infrequent pest in most areas. Citrus rust mite is about the same size as a bud mite and requires a hand lens to view, but is deeper yellow in color than the bud mite and wedge-shaped rather than cylindrical. A generation may be completed in 1 to 2 weeks in summer but development slows or stops in winter, depending on temperature.

Monitoring. Growers monitor the citrus rust mite from early spring through summer. When populations are high, the mites move over the entire fruit. Once growers find one or more infested fruit and if rust mites were a problem the previous year, the orchard is watched closely. Threshold levels depend on the previous year's rust mite problems and current market conditions. Generally problems show up in the same area or areas of the orchard due to the specific microclimate requirements of the mite.

CONTROLS

Cultural

Dust Reduction. Growers minimize dust within the orchard by paving roads or using water trucks to wet dirt roads that are in high use. Trees may also be washed with water to remove dust though this is rarely practiced.

Biological

No effective natural enemies are known, but general mite predators, such as black lady beetle, predaceous dusty-wing, and the six spotted thrips, feed on rust mites at times.

Chemical

If the citrus rust mite population increases quickly or if scarring appears, a treatment is generally required. In some cases, the infestation is localized and a spot treatment may be sufficient for control. Once established, rust mite is difficult to gain control of with multiple applications of any miticide.

Wettable Sulfur. Wettable sulfur is applied to thoroughly cover foliage as soon as mites are detected. It is intended for use on all varieties of citrus. Applications are not made when temperatures are high or within 2 months of a previous oil spray. Sulfur is very effective but it is difficult to avoid high temperatures in the intermediate areas, which may cause phytotoxicity. Areas of sustained high temperatures generally do not have rust mite problems.

Abamectin. Abamectin (AGRI-MEK) is most commonly used in the coastal-intermediate region where its use is primarily targeted to control citrus bud mites. Abamectin is used to a lesser extent in the San Joaquin valley region. It is not applied pre-bloom, during bloom, in nurseries or to nonbearing trees. It is always applied in combination with a narrow range oil. Abamectin is relatively nontoxic to beneficial insects and mites. It is most effective if substantial numbers of predators are present. Multiple applications, if needed, should be at least 30 days apart.

YUMA SPIDER MITE
Eotetranychus yumensis

Damage. The Yuma spider mite occurs as a pest on grapefruit and lemon in the Desert Region. It is one of several mites that are important in the Desert Region, including the Texas citrus mite, the citrus red mite, and the citrus flat mite. This mite may cause some leaf drop.

Description of Pest. It is similar in shape to the citrus red mite but is light straw to dark pink colored and produces substantial webbing on the underside of leaves. It feeds and lays peach-colored eggs under the webbing.

CONTROLS

Cultural

Dust Reduction. Growers minimize dust within the orchard by paving roads or using water trucks to wet dirt roads that are in high use. Trees may also be washed with water to remove dust though this is rarely practiced.

Biological

There are no specific biological control agents for Yuma spider mites

Chemical

Generally damage from Yuma spider mites is not severe enough to warrant treatment. If monitoring indicates a treatment is necessary, sulfur may only be applied during the period from October to March 15 whereas dicofol can be applied anytime during the year.

Wettable Sulfur. Wettable sulfur is applied to thoroughly cover foliage as soon as mites are detected. It is intended for use on all varieties of citrus. Applications are not made when temperatures are high or within 2 months of a previous oil spray.

Dicofol. Dicofol (KELTHANE) is an organochlorine which is applied to all varieties of citrus. It has a narrow range of activity but is persistent. Applications are largely confined to the San Joaquin Valley region. Dicofol is of intermediate selectivity because it acts primarily against mites with minimal impact on beneficial insects such as lacewings, lady beetles, and *Aphytis melinus*, which help control worms, scale, thrips, and other pests. It is, however, toxic to predaceous mites such as *Euseius tularensis*, because of its persistence.

ARGENTINE ANTS
Iridomyrmex humilis

Damage. Ants can be extremely disruptive to an Integrated Pest Management program within an orchard, especially Argentine ants. The argentine ant is typically the number one pest of concern in the Interior Region and the number two pest of concern in the Coastal-Intermediate Region. It is more of an occasional pest in the San Joaquin Valley and Desert Regions. These ants feed on honeydew excreted by soft scales, mealybugs, cottony cushion scales, whiteflies, and aphids. As part of this relationship, they also protect these insects from their natural enemies, thereby interrupting biological control of the honeydew-producing pests. In the process of keeping most natural enemies away, they also protect other pests, such as California red scale, that profit from the lack of natural enemies.

Description of Pests. The most prevalent of the ant species, the Argentine ant, is a small, uniformly deep brown ant. Worker ants build their nests underground. Ant populations peak in midsummer and early fall.

Monitoring. Growers monitor the orchard in spring when honeydew-producing insects, such as aphids, appear. For young trees, growers inspect for ants and bark damage under the trunk wraps.

<u>CONTROLS</u>

Cultural

Pruning Skirts. Growers prune tree skirts, removing branches within 12 to 30 inches of the ground, and apply sticky material to the trunk to prevent access to the trees by ants.

Soil Cultivation. Cultivation also reduces ant populations, but may create so much dust that biological control of other pests is disrupted.

Biological

No effective natural enemies of the Argentine ant are known.

Chemical

Chlorpyrifos. Chlorpyrifos (LORSBAN) is a broad-spectrum organophosphate insecticide intended for use on all varieties of citrus. As a broad-range insecticide, Lorsban is used to treat several insect pests on citrus. Both granular (6.7 lb AI/acre) and liquid formulations (1 lb AI/acre) are available. The 4E formulation of Lorsban is applied for a number of other pests including red scale, katydids, citricola scale, and worms. The granular formulation of chlorpyrifos is exclusively for ants.

Bait stations. Sugar bait stations with a variety of toxicants are nearing registration.

NATIVE GRAY ANTS
Formica aerata

Damage. Ants can be extremely disruptive to an Integrated Pest Management program within an orchard, especially native gray ants. The native gray ant is the major ant pest of the San Joaquin Valley Region. It is less of a concern in the other regions. These ants feed on honeydew excreted by soft scales, mealybugs, cottony cushion scales, whiteflies, and aphids. As part of this relationship, they also protect these insects from their natural enemies, thereby interrupting biological control of the honeydew-producing pests. In the process of keeping most natural enemies away, they also protect other pests, such as California red scale, that profit from the lack of natural enemies.

Description of Pests. Native gray ants are gray and considerably larger than the other two species, Argentine and fire ants. They nest in topsoil or under rocks and debris and move in irregular patterns. In contrast to Argentine and fire ants, the native gray ant is solitary and its importance in disrupting biological control is often underestimated.

Monitoring. Growers monitor the orchard in spring when honeydew-producing insects, such as aphids, appear. For young trees, growers inspect for ants and bark damage under the trunk wraps.

CONTROLS

Cultural

Pruning Skirts. Growers prune tree skirts, removing branches within 12 to 30 inches of the ground, and apply sticky material to the trunk to prevent access to the trees by ants. Sticky materials typically last from 2 to 10 months and also prevent the access by Fuller rose beetles. If the sticky material contains tribasic copper sulfate, it will also control brown garden snails. The persistence of sticky material can be increased by applying it high above the ground to reduce dust and dirt contamination and to decrease irrigation wash-off.

Soil Cultivation. Cultivation also reduces ant populations but may create so much dust that biological control of other pests is disrupted.

Biological

No effective natural enemies are known.

Chemical

Chlorpyrifos. Chlorpyrifos (LORSBAN) is a broad-spectrum organophosphate insecticide intended for use on all varieties of citrus. As a broad-range insecticide, chlorpyrifos is used to treat several insect pests on citrus. Both granular and liquid formulations are available. The 4E formulation of chlorpyrifos is applied for a number of other pests including red scale, katydids, citricola scale and worms. The granular formulation of chlorpyrifos is exclusively for ants.

Bait Stations: Sugar bait stations with a variety of toxicants are nearing registration.

SOUTHERN FIRE ANTS
Solenopsis xyloni

Damage. Ants can be extremely disruptive to an Integrated Pest Management program within an orchard. The southern fire ant is primarily a pest of the San Joaquin Valley Region. These ants feed on honeydew excreted by soft scales, mealybugs, cottony cushion scales, whiteflies, and aphids. As part of this relationship, they also protect these insects from their natural enemies, thereby interrupting biological control of the honeydew-producing pests. In the process of keeping most natural enemies away, they also protect other pests, such as California red scale, that profit from the lack of natural enemies. Fire ants directly damage young trees by feeding on the twigs and bark, sometimes girdling the young trees.

Description of Pests. The southern fire ant is light reddish brown with a black abdomen. These ants build nests of loose mounds or craters near bases of trees and do not aggregate in colonies as large as those of the Argentine ant.

Monitoring. Growers monitor the orchard in spring when honeydew-producing insects, such as aphids, appear. For young trees, growers inspect for ants and bark damage under the trunk wraps.

CONTROLS

Cultural

Painting trunks and removing wraps. To avoid damage by fire ants, remove the wraps that they make their homes in.

Soil Cultivation. Cultivation also reduces ant populations but may create so much dust that biological control of other pests is disrupted.

Biological

No effective natural enemies are known.

Chemical

Chlorpyrifos. Chlorpyrifos (LORSBAN) is a broad-spectrum organophosphate insecticide intended for use on all varieties of citrus. As a broad-range insecticide, chlorpyrifos is used to treat several insect pests on citrus. Both granular and liquid formulations are available. The 4E formulation of chlorpyrifos is applied for a number of other pests including red scale, katydids, citricola scale, and worms. The granular formulation of chlorpyrifos is exclusively for ants.

Abamectin. (CLINCH) is applied on a corn cob grits bait with soybean oil as an attractant. It takes several weeks to reduce the ant population. It is very important for the grower to apply it shortly after irrigation at times when the ants are active. The ants must take the bait to their nests.

Pyriproxifen. (ESTEEM ANT BAIT) is applied on a corn cob grits bait with soybean oil as an attractant. It takes several weeks to reduce the ant population. It is very important for the grower to apply it 24 hours after irrigation at times when the ants are active. The ants must take the bait to their nests.

KATYDIDS
Forktailed katydid: *Scudderia furcata*

Damage. Katydids are a pest of increasing concern in the San Joaquin Valley and Interior Regions. The Forktailed katydid causes occasional economic damage in these regions. This species feeds on young fruit at petal fall with subsequent buildup of scar tissue and distortion of expanding fruit. Katydids take a single bite from a fruit and then move to another feeding site, causing damage to a large quantity of fruit with a relatively small population. They also eat holes in leaves and maturing fruit, creating injury that resembles damage by citrus cutworm. The angular winged katydid is less abundant than the Forktailed katydid and feeds only on leaves.

Description of Pest. Katydids resemble grasshoppers but have long antennae. Females lay their eggs in two overlapping rows on twigs and leaves. Katydids have only one generation a year.

Monitoring. Growers look for damage at the time of petal fall to detect infestations of fork-tailed katydids. If katydids are found in an orchard with high previous katydid damage, especially at petal fall, chemical treatment is typically applied and can be in conjunction with treatment for citrus thrips. The threshold tolerance of katydid is very low because they move over the tree quickly and can damage a large number of fruit in a short amount of time.

<u>CONTROLS</u>

Cultural

There are no cultural practices specifically designed to control katydids.

Biological

In orchards with limited broad-spectrum pesticide use, natural parasites often attack katydid eggs, but rarely in sufficient numbers to prevent damage from occurring.

Chemical

Naled. Naled (DIBROM) is a broad-spectrum organophosphate that controls insects pests, as well as, beneficial mites. Naled has limited efficacy due to short persistence.

Chlorpyrifos. Chlorpyrifos (LORSBAN) is a broad-spectrum organophosphate insecticide that is used to control several important pests and is intended for use on all varieties of citrus. It is effective at low rates (4 oz/acre) and growers may tank mix a low rate of chlorpyrifos with Success to get control of citrus thrips and katydids simultaneously while minimizing the impact on natural enemies.

Dimethoate. Dimethoate (CYGON) is an organophosphate that is used to control several citrus pests. No more than 2 applications are made on mature fruit. It is applied at hatch. Dimethoate is toxic to both beneficial mites and beneficial insects and disrupts biological control. Growers may tank mix a low rate of dimethoate with Success to get control of citrus thrips and katydids simultaneously while minimizing the impact on natural enemies.

Cryolite. Cryolite (KRYOCIDE) is primarily applied in the San Joaquin valley region and is rarely used on valley lemons and rarely used in any other growing region. It has a narrow range of activity (foliage feeders such as worms, katydids, and Fuller rose beetle), but is persistent unless washed off by rain. Higher application rates are used to treat larger worms and larger trees. Cryolite is a slow-acting stomach poison specific to foliage-feeding pests and may take several days of warm weather to kill worms. It is relatively nontoxic to parasites that attack the caterpillars and to beneficial insects and mites that feed on other citrus pests.

Spinosad. Spinosad (SUCCESS), a macrocyclic lactone isolated from the soil microorganism *Saccharopolyspsora spinosa*, is applied at label rates to citrus. It was recently registered for use on lemons, oranges, and grapefruits. It is used primarily for citrus thrips and is not effective on larger instars of katydids.

Cyfluthrin. Cyfluthrin (BAYTHROID) is a broad-spectrum pyrethroid insecticide that is commonly used on oranges in the San Joaquin Valley Region but is rarely used on other commodities in the valley and is not used in other citrus growing regions. It is toxic to both beneficial mites and beneficial insects and disrupts biological control. It is effective at low rates and growers may tank mix a low rate of cyfluthrin with Success to get control of citrus thrips and katydids simultaneously, while minimizing the impact on natural enemies.

Fenpropathrin. **(**DANITOL) Fenpropathrin, also a pyrethroid, was registered in 2001 in California primarily for use on citrus thrips. Fenpropathrin is toxic to both beneficial mites and beneficial insects and disrupts biological control. It is also used for glassy-winged sharpshooter. It is effective at low rates and growers may tank mix a low rate of fenpropathrin with Success to get control of citrus thrips and katydid simultaneously, while minimizing the pact on natural enemies.

MEALYBUGS
Citrus Mealybug: *Planococcus citri*
Citrophilus Mealybug: *Pseudococcus calceolariae*
Longtailed Mealybug: *Pseudococcus longispinus*
Comstock Mealybug: *Pseudococcus comstocki*

Damage. Mealybugs are a sporadic pest to citrus and are more problematic in the Coastal-Intermediate Region. These pests extract plant sap, reducing tree vigor, and excrete honeydew. If a cluster of mealybugs feeds along a fruit stem, fruit drop can occur. Damage is most severe in spring and fall. Ant control is critical for mealybug control.

Description of Pests. Mealybugs are soft, oval, flat, and distinctly segmented. The species differ mainly in the thickness and length of the waxy filaments. Female mealybugs lay several hundred eggs on the leaves, fruit, or twigs. Newly hatched nymphs are light yellow and free of wax, but soon start to excrete a waxy cover. There are two to three overlapping generations a year.

CONTROLS

Cultural

Skirt Pruning. Growers prune tree skirts, removing branches within 12 to 30 inches of the ground.

Ant Control. Ants often hamper the activity of parasites and predators, therefore, ant populations are kept under control.

Biological

General Predators. Parasites provide good control of the citrophilus, longtailed, and Comstock mealybugs if they are not destroyed by treatments for other pests. Native predators include lady beetles, lacewings, and syrphid flies.

***Cryptolaemus montrouzieri*.** An introduced predator of the citrus mealybug, the mealybug destroyer, Cryptolaemus montrouzieri, is a voracious feeder of the pest in both the larval and adults stages. Its larvae resemble a mealybug but are about twice as large as the adult citrus mealybug females. The adult is a small beetle with dark brown wing covers and a light brown head and prothoraic shield. It does not winter well and therefore commercial releases are sometimes necessary where citrus mealybugs were a problem the previous year. Growers release about 500 Cryptolaemus per acre.

Chemical

Treatment is rarely required for mealybugs. If a heavy population of mealybugs must be reduced quickly, a treatment can be applied, but release Cryptolaemus after about 2 weeks to reestablish biological control.

Chlorpyrifos. Chlorpyrifos (LORSBAN) is a broad-spectrum organophosphate insecticide intended for use on all varieties of citrus. Though chlorpyrifos is used in all growing regions, it is used at different application rates in these regions.

Methidathion. Methidathion (SUPRACIDE) is a broad-range organophosphate applied to treat several pests on San Joaquin Valley citrus. Applications are not made during bloom. Low volume sprays are allowed only under a Special Local Need permit from a county agricultural commissioner. Methidathion may be applied in combination with narrow range oil which increases survival of natural enemies and reduces the risk of phytotoxicity from oils.

WHITEFLIES
Woolly Whitefly: *Aleurothrixus floccosus*
Citrus Whitefly: *Dialeurodes citri*
Nesting Whitefly: *Paraleyrodes minei*
Silverleaf Whitefly:

Damage. Whiteflies suck phloem sap, causing leaves to wilt and drop when populations are large. Nymphs collect dust and support the growth of sooty mold; large infestations blacken entire trees, as well as, attract ants, which interfere with the biological control of whiteflies and other pests. Woolly whiteflies are most significant pests in the desert region. Other regions have very few whitefly pests.

Description of Pest. Whiteflies are tiny, flying insects that derive their name from the mealy white wax covering their wings and body. While adult whiteflies are similar in appearance, the immature stages are more distinctive. The life cycle of all whitefly species is similar. Lemons are most heavily infested by bayberry whitefly because they continuously provide new foliage, which is required to feed and lay eggs upon. Woolly whitefly populations peak in the autumn. Citrus whitefly has two generations per year, with adult emergence peaking between April and July.

CONTROLS

Cultural

Dust Reduction. Dusty conditions in and around the orchard hamper the activity o natural enemies. Growers control dust within the orchards by oiling or wetting/watering orchard roads, driving slowing on dirt roads and reducing traffic through the grove.

Pruning. To enhance the natural parasites and predators in the orchard, growers alternate row pruning which provides refuge for parasites.

Ant Control. Ants often hamper the activity of parasites and predators, therefore, ant populations are kept under control.

Skirt Pruning. Growers prune tree skirts, removing branches within 12 to 30 inches of the ground.

Biological

General Predators. Several natural enemies attack the immature stages of whiteflies and provide partial to complete biological control when undisturbed by ants, dust, or insecticide treatment. *Eretmocerus* spp. and *Encarsia* spp. are natural enemies that typically provide control of the bayberry whitefly in the coastal intermediate and interior regions, but not in the San Joaquin Valley. *Amitus spiniferus* and *Cales noaki* also provide control of the wooly whitefly in the coastal intermediate region. Conserve natural enemies by applying Bacillus thuringiensis (Bt) for orangeworms and sabadilla for citrus thrips if monitoring indicates a need to control these pests. In addition, selective pesticides such as Agri-mek are recommended for control of citrus thrips.

Chemical

Chemical treatment of whiteflies has not been effective. Temporary suppression may be achieved, only to be followed by a resurgence of the pest.

Narrow Range Oil. Narrow range spray oils must be used carefully by growers to avoid applying it at times when fruit and leaves can be damaged (phytotoxicity), when risk from frost damage can be increased, or natural enemies reduced. Narrow range 440 spray oil is preferred in the San Joaquin Valley region during warmer months because of greater persistence but at some risk to enhanced phytotoxicity. In warmer desert regions, oil treatments will damage the trees. Hazards are associated with oil treatments to green lemons because of phytotoxicity after sweating.

Diazinon. Diazinon is minimally used in the San Joaquin and Desert Valley regions.

GREENHOUSE THRIPS
Heliothrips haemorrhoidalis

Damage. Greenhouse thrips is primarily a pest of the coastal-intermediate region. It is not unusual for coastal Valencia oranges to sustain significant damage from this pest when a mild winter is followed by mild spring and summer conditions, however, the damage is sporadic. Lemons are also occasionally attacked. Navel oranges are generally not attacked because they are grown too far inland from the moderating effects of the ocean. The control of greenhouse thrips is often the consequence of chemical treatments targeting other pests. Greenhouse thrips suck out the contents of epidermal cells on leaves and fruit, including the chlorophyll or pigment, causing cells to turn pale in color. Thrips tend to congregate where two or more fruits are in contact, which is where injury is most likely to be found. Affected areas take on a dirty, spotted appearance as thrips continue to deposit darkened droplets of liquid excrement while feeding.

Description of Pest. Adult females insert eggs into the leaf or fruit surface. Neither pupal stage feeds, but remains among the feeding congregation of thrips. There are generally from five to six generations per year along coastal southern California. Greenhouse thrips prefer moderate coastal temperatures and humidity. In general, periods of stressful temperatures such as very cold winters or hot dry Santa Ana wind conditions will result in high mortality of all active stages.

Monitor. Maintenance of records of the locations of previous years' infestations is helpful. These areas are monitored in late March or during April to determine the potential for damage in the current year. Observations are made through harvest. There is no established threshold.

CONTROLS

Cultural

Early Harvest. Since greenhouse thrips feeding injury is cumulative over the season, planning for an early harvest in severely affected areas of citrus production can minimize the amount of damage. In addition, since much of the greenhouse thrips population resides on the fruit, it is removed from the orchard at harvest. An early harvest strategy can thus reduce the crop-to-crop overlap time and minimize the greenhouse thrips movement to the following year's crop.

Biological

Thripobius semiluteus. Only one effective natural enemy is known to attack greenhouse thrips, the minute larval parasite *Thripobius semiluteus*. Parasitized thrips larvae appear swollen and have more parallel sides compared to the tapered sides of healthy thrips larvae. The immobile parasite pupae appear black among the colonies of translucent, unparasitized thrips. The intermittent nature of thrips populations in coastal citrus makes it difficult to have sustained biological control in citrus without occasional inoculative releases of this parasite. *Thripobius* is no longer sold commercially.

General Predators. Other less effective natural enemies are known, including an egg parasite, *Megaphragma mymaripenne*, and two predatory thrips species, *Franklinothrips orizabensis* and *Leptothrips mali*, also known as the black hunter.

Chemical

Chlorpyrifos. Chlorpyrifos (LORSBAN) is an organophosphate that is the most common chemical treatment of greenhouse thrips. Greenhouse thrips are easily killed by organophosphates, such as malathion and chlorpyrifos applied to control scale. Generally if thrips are present in lemons when a spring scale treatment is applied, this will be sufficient for the season. As a broad-range insecticide, chlorpyrifos is used to treat several insect pests on citrus.

Malathion. Malathion is an organophosphate that is occasionally applied as thorough coverage to citrus trees. Greenhouse thrips are easily killed by organophosphates such as malathion and chlorpyrifos applied to control scale. Generally if thrips are present in lemons when a spring scale treatment is applied, this will be sufficient for the season.

Narrow Range Oil. Growers must take care when applying narrow range oil to avoid applying it at times when fruit and leaves can be damaged (phytotoxicity), when risk from frost damage can be increased, or natural enemies reduced. Narrow range 440 spray oil is preferred in the San Joaquin Valley region during warmer months because of greater persistence, but at some risk to enhanced phytotoxicity. In warmer desert regions, oil treatments will damage the trees. Hazards are associated with oil treatments to green lemons because of phytotoxicity after sweating.

FRUITTREE LEAFROLLER
Archips argyrospilus

Damage. Fruittree leafrollers are occasional pests in the San Joaquin Valley and Interior regions. They are only rare pests in other growing regions. Fruittree leafrollers cause damage in spring by feeding on newly set fruit or on ripening Valencias, navels, or grapefruit. In situations with weak or drought stressed trees with little flush, larvae will tie leaves to fruit and bore inside, providing entry sites for secondary decay organisms, resulting in fruit drop. Outbreaks often occur following freeze and/or frost events.

Description of Pest. Larvae of the fruittree leafroller are green caterpillars. The caterpillars tie or roll leaves or blossoms together with silken threads and feed inside these nests. Early in spring, young larvae feed mostly on new growth flushes, often resulting in curled leaf terminals. There is only one generation a year.

Monitoring. Growers monitor leafroller worm over time and fruittree leafroller eggs by establishing one or two permanent observation trees at five locations per orchard block. To monitor caterpillars, growers search the outer canopy of the south and east side of four trees at each sampling site.

CONTROLS

Cultural

Fruit Removal. Fruit are picked as soon as they mature so that fruittree leafroller do not have time to bore into the fruit.

Biological

Predators. Endemic populations of general beneficial insects may be beneficial to the fruittree leafroller but their impacts are not known for now. General predators prey on small larvae, and *Trichogramma* spp. may parasitize the eggs.

Chemical

Bacillus thuringiensis. *Bacillus thuringiensis* (Bt) is applied at label rates to all varieties of citrus. It is the most common treatment for leafrollers prior to petal fall. Timing of applications is important because Bt has a short residual period. It should be applied only during warm weather to control young, actively feeding worms. *Bacillus thuringiensis* (Bt) insecticides are specific to caterpillar pests. These insecticides are relatively nontoxic to parasites that attack the caterpillars and to beneficial insects and mites that feed on other citrus pests. Bt may be applied during bloom.

Chlorpyrifos. Chlorpyrifos (LORSBAN) is an important broad-spectrum insecticide that is used to control several important citrus pests and is the second most common treatment for fruittree leafroller, following Bt. It may not be applied more than twice per fruit year and applications should not be made less than 30 days apart. Chlorpyrifos is toxic to bees.

Naled. Naled (DIBROM) is an organophosphate that provides good control of leafroller worms. It is a broad-spectrum insecticide that controls insects pests as well as beneficial mites.

Methomyl. Methomyl (LANNATE) is a broad-spectrum carbamate that kills beneficial insects, such as mites. It is toxic to honeybees and should not be applied during bloom. It is rarely used outside the San Joaquin Valley region.

Carbaryl. Carbaryl (SEVIN) is a broad-spectrum carbamate that is occasionally applied for control of fruittree leafroller. Carbaryl kills the target pest as well as beneficial mites. It is toxic to bees and during bloom is applied from 1 hour after sunset until 2 hours before sunrise.

BROWN SOFT SCALE
Coccus hesperidum

Damage. Brown soft scale are rarely an economically important pest. Infestations are more significant when ants are present, when there are upsets in the balance between other pests and beneficials, or when high levels of dust are present. The scale is economically important every few years in select locations in the state. Biologically controls are only occasionally effective, necessitating supplemental control through chemical treatments. Heavy feeding by the brown soft scale reduces tree vigor, kills twigs, and reduces yields. Sooty mold grows on excreted honeydew and may affect fruit grade. The honeydew also attracts ants, which interfere with the biological control of a number of pests, including other scales. At low levels, the presence of brown soft scale can be helpful as an additional food source for *Aphytis*. Insecticides are not very effective on brown soft scale and so ant control is more important than scale control for this pest.

Description of Pest. Young scales move around until they are about half grown. They have mottled, yellowish, rounded shells. The young molt twice and reach maturity on leaves or twigs; they rarely move onto fruit. There are three to five overlapping generations a year. Populations are usually highest from midsummer to early fall.

Monitoring. Growers monitor brown soft scale from June through October, when disruption of biological control may be a problem. The level of parasitism is checked by looking for parasite exit holes and for developing parasites within the scale body. Management of brown soft scale focuses on preserving its natural enemies and controlling ants.

CONTROLS

Cultural

Ant Control. Ants in the orchard are controlled because honeydew seeking species which feed on the honeydew excreted by scales, mealybugs, whiteflies and aphids, protect their favorite food source from natural enemies.

High Pressure Washer. Regular and high-pressure fruit washers remove the sooty mold that grows on the honeydew excreted by the scale.

Biological

***Metaphycus luteolus*.** The most effective parasite of brown soft scale is *Metaphycus luteolus*, which destroys the scale in its early instars before it can reproduce or cause substantial injury. Ants should be controlled to obtain maximum benefit from biological control.

Lady Beetles. In addition, several endemic species are also beneficial in keeping brown soft scale populations moderate including lady beetles *Rhyzobius (Lindorus) lophanthae*, *Chilocorus orbus*, and *Chilocorus cacti* prey on brown soft scales. Be sure ants are controlled to obtain maximum benefit from biological control.

Chemical

Individual treatment of this scale is rarely necessary and insecticides are not very effective. Generally the biological control agents are fully effective when ants are controlled. If natural enemies do not control the scales, a spot treatment with an oil spray is usually sufficient to control the infestation.

POTATO LEAFHOPPER
Empoasca fabae

Damage. The potato leafhopper is a relatively common pest in the San Joaquin Valley Region but a rare pest in other regions. The potato leafhopper feeds on fruit by puncturing rind cells, causing yellowish to light brown, roundish scars on fruit. The scars are particularly apparent on green fruit.

Description of Pest. The potato leafhopper is a potential pest of citrus in some areas, especially in groves near tomato fields, cotton fields, or pastures in the San Joaquin Valley. It is a green, slender insect with bristle like antennae and rows of spines along its hind legs. It breeds in large numbers on wild plants and field crops. Leafhoppers may migrate to citrus groves to spend the winter in the shelter of the trees.

Monitoring. Growers use a yellow, sticky card or traps to determine if leafhoppers are present.

CONTROLS

Cultural

There are no cultural practices that reduce the impact of the potato leafhopper.

Biological

There are no known biological controls.

Chemical

Hydrated Lime. Hydrated lime is applied at rates of 100 to 150 lbs/acre as an outside coverage to trees. In the fall, hydrated lime may be applied in combination with a Bordeaux spray, used to control Brown Rot and *Septoria,* to repel leafhoppers. Because this is a preventative treatment, it must be made before migration into the grove occurs.

PURPLE SCALE
Lepidosaphes beckii

Damage. Purple scale is an occasional pest in certain coastal areas where the mild climate and humid conditions favor its buildup. It is largely absent in the San Joaquin and desert valley regions. It attacks all parts of the tree. Its feeding causes yellowish halos to develop on leaves; on young fruit the feeding sites remain green. When populations are high, defoliation and twig dieback can occur; this usually takes place in limited patches on the lower north side of trees.

Description of Pest. Purple scale is one of the armored scales. The cover of the adult female purple scale resembles a mussel shell in shape. After egg hatch, crawlers emerge from under the cover and settle on branches, twigs, leaves, or fruit and begin to form their covers. Temperatures about 80°F greatly reduce a population. Two generations occur between May and October and a third may be partially completed before cold weather starts.

CONTROLS

Cultural

Dust Reduction. Purple scales are most likely to build up on dusty trees. Growers minimize dust within the orchard by using water trucks to wet dirt roads that are in high use. Trees may also be washed with water to remove dust though this is rarely practiced.

Biological

Aphytis lepidosaphes. Parasites usually provide good control of purple scale. *Aphytis lepidosaphes*, a parasitic wasp that is naturally distributed in areas where purple scale occurs. This parasite develops externally on the body of immature scales under the scale cover. *Aphytis lepidosaphes* is not commercially available; therefore, growers need to conserve the naturally occurring populations of this beneficial in the grove.

Other Predators. Several predators including the twice-stabbed lady beetle, *Chilocorus* spp., and the Australian lady beetle, *Rhyzobius (Lindorus) lophanthae*, are also important.

Chemical

If a treatment is needed, it may be sufficient to spot treat with an oil spray or wash the dusty trees with water. To reduce the impact on natural predators such as *Aphytis lepidosaphes*, when chemical treatments are necessary, growers spot treat or treat every fourth to sixth row at 4- to 6-week intervals during late summer months.

Narrow Range Oil. Narrow range spray oils can be effective against purple and yellow scale if coverage is thorough. In orchards where resistance to organophosphate and carbamate insecticides is a severe problem, petroleum oil sprays can be a useful supplement together with other chemical treatments to control scale.

Chlorpyrifos. Chlorpyrifos (LORSBAN) is a broad-spectrum organophosphate insecticide intended for use on all varieties of citrus. As a broad-range insecticide, chlorpyrifos is used to treat several insect pests on citrus although its use is rarely targeted towards control of purple scale.

Carbaryl. Carbaryl (SEVIN) is a carbamate that should not be applied during bloom as it is toxic to bees. Carbaryl may be applied in combination with narrow range oil at reduced rates which increases the survival of natural enemies and reduces the risk of phytotoxicity from use of the oil in warmer growing areas. Use of carbaryl may increase citrus red mite populations.

Methidathion. Methidathion (SUPRACIDE) is a broad-range organophosphate applied almost exclusively to citrus in the San Joaquin Valley Region. It is applied to treat several pests on San Joaquin Valley Region. Applications of methidathion are rare in other citrus growing regions of the state. Applications are not made during bloom. Low volume sprays are allowed only under a Special Local Need permit from a county agricultural commissioner.

BEET ARMYWORM
Spodoptera exigua

Damage. Beet armyworm is occasionally found on citrus feeding on foliage, but it rarely causes economic damage. Treatment for beet armyworm on citrus is rarely required.

Description of Pest. Larvae of the beet armyworm are dull green caterpillars with many fine, wavy, light-colored stripes down the back and a broader stripe along each side. They usually, but not always, have a dark spot on the side of the thorax above the second true leg.

Monitoring. The presence of beet armyworm larvae on citrus is identified at the same time that growers monitor citrus for more significant pests. Once identified, the impact of feeding by larvae is monitored to ensure that damage does not reach economic levels.

CONTROLS

Chemical

Damage from beet armyworm larvae does not typically reach economic levels. Chemical treatments for other pests will also control the beet armyworm population.

CALIFORNIA ORANGEDOG
Papilio zelicaon

Damage. Orangedog caterpillars feed on tender citrus leaves, occasionally defoliating young trees but rarely causing economic damage in mature orchards. It is only sporadically important to California citrus.

Description of Pest. The California orangedog, or black anise swallowtail, is a native butterfly that feeds on both perennial anise (sweet fennel) and citrus.

CONTROLS

Cultural

Sweet Fennel Trapping. California orangedog prefers sweet fennel, which is sometimes interplanted, as a trap crop, in strips with citrus and mowed regularly after the egg-laying peak in each generation.

Biological

Hyposoter spp. This parasite is critical to maintain a biologically intensive Integrated Pest Management program. The effectiveness of *Hyposoter spp.* is dependent upon the spray program as broad-spectrum insecticide treatment to control other pests may decrease the *Hyposoter* population.

Chemical

***Bacillus thuringiensis* var. Aizawai or Kurstaki.** *Bacillus thuringiensis* (Bt) is the most common treatment for California orangedog. Timing of applications is important because Bt has a short residual period. It should be applied only during warm weather to control young, actively feeding worms. These insecticides are relatively nontoxic to parasites that attack the caterpillars and to beneficial insects and mites that feed on other citrus pests. Bt may be applied during bloom.

Cryolite. Cryolite (KRYOCIDE) has a narrow range of activity (foliage feeders such as worms, katydids, and Fuller rose beetle), but is persistent unless washed off by rain. It is relatively nontoxic to parasites that attack the caterpillars and to beneficial insects and mites that feed on other citrus pests.

LOOPERS
Omnivorous looper: *Sabulodes aegrotata*
Citrus looper: *Anacamptodes fragilaria*
Cabbage looper: *Trichoplusia ni*

Damage. Loopers are rarely of economical consequence in California citrus. They rarely damage mature fruit. Larvae primarily consume new growth flushes in young orchards but also feed on blossoms and young fruit. Mature larvae eat holes in leaves or consume them entirely.

Description of Pest. Loopers occur in most citrus-growing areas, usually together with other orangeworms. The larvae have no prolegs in the middle of the body and therefore move in a characteristic looping or measuring fashion. The female moth lays eggs singly on leaves. There are several generations a year.

CONTROLS

Biological

Loopers have many natural enemies, including *Apanteles* spp.

Chemical

Treatment targeted for control of loopers on citrus in California is rarely required. Malathion treatments to control other pests may trigger looper outbreak.

OMNIVOROUS LEAFROLLER
Platynota stultana

Damage. Omnivorous leafroller is an occasional pest of citrus in the San Joaquin Valley Region and in the Interior and Coastal-Intermediate Regions. In spring, small larvae spin webs and feed on new foliage. Later in the season they tie leaves to fruit and feed under the buttons, leaving ring scarring similar to that of citrus thrips. In summer and fall, they tie leaves to ripening fruit and feed on the rind.

Description of Pest. The larva of the omnivorous leafroller resembles other tortricid caterpillars, especially the orange tortrix. The larvae roll and tie leaves together or to fruit with silken threads. When mature they pupate inside the rolled leaves within a cocoon. Adult female moths lay overlapping eggs in clusters that resemble fish scales on the upper surface of leaves and on fruit. There are five to six generations a year, depending on temperatures.

Monitoring. Growers monitor omnivorous leafroller weekly from spring through fall in the south and east quadrants of trees. In spring, they look for small larvae under sepals at the same time they monitor for citrus thrips. A higher number of larvae can be tolerated in spring, when they feed on young leaves, than in fall, when they are more likely to damage ripening fruit.

CONTROLS

Cultural

There are no cultural practices used to target specifically omnivorous leafroller.

Biological

Parasites. Several parasites attack the larva of the omnivorous leafroller. The most common are a tachinid fly, *Erynnia tortricis*, and an eulophid wasp, *Elachertus proteoteratis*. *Trichogramma* spp. The parasites are most effective during midsummer.

Chemical

***Bacillus thuringiensis* var. Aizawai or Kurstaki.** *Bacillus thuringiensis* (Bt) is the most common treatment for omnivorous leafroller. Timing of applications is important because Bt has a short residual period. It should be applied only during warm weather to control young, actively feeding worms. *Bacillus thuringiensis* (Bt) insecticides, both the *aizawai* and *kurstaki* varieties, are specific to caterpillar pests. These insecticides are relatively nontoxic to parasites that attack the caterpillars and to beneficial insects and mites that feed on other citrus pests. Bt may be applied during bloom.

Cryolite. Cryolite (KRYOCIDE) has a narrow range of activity (foliage feeders such as worms, katydids, and Fuller rose beetle), but is persistent unless washed off by rain. Higher application rates are used to treat larger worms and larger trees. Cryolite is a slow-acting stomach poison specific to foliage-feeding pests and may take several days of warm weather to kill worms. It is relatively nontoxic to parasites that attack the caterpillars and to beneficial insects and mites that feed on other citrus pests.

Chlorpyrifos. Chlorpyrifos (LORSBAN) is a broad-spectrum organophosphate insecticide intended for use on all varieties of citrus. As a broad-range insecticide, chlorpyrifos is used to treat several insect pests on citrus, though the applications rarely target omnivorous leafroller.

Carbaryl. Carbaryl (SEVIN) is a carbamate primarily applied to citrus in the San Joaquin Valley. Use of carbaryl is lower in the other regions.

Naled. Naled (DIBROM) is a broad-spectrum organophosphate applied to control insect pests as well as beneficial mites.

Methomyl. Methomyl (LANNATE) is a broad-spectrum oxime carbamate that is applied to citrus in the San Joaquin Valley region but rarely on citrus in any other region. Methomyl is a restricted use material that may only be applied by permit from a county agricultural commissioner. It kills beneficial insects, such as mites. It is toxic to bees and during bloom is applied from 1 hour after sunset until 2 hours before sunrise.

ORANGE TORTRIX
Argyrotaenia citrana

Damage. Orange tortrix is a pest on Valencias and navel oranges in the Coastal-Intermediate and Interior Regions. First generation orange tortrix larvae feed on leaves. Second generation larvae appear when the growth is hardening off and move preferentially to young fruit and feed around the button. This feeding causes only superficial scars. Later generations feed among clusters of ripening fruit, eating holes into the rind that allow decay organisms to enter; the fruit usually drops within 1 to 2 weeks. It is not a problem in the San Joaquin or desert valley regions.

Description of Pest. The major distinguishing characteristic between orange tortrix and omnivorous leafroller caterpillars is that the small mounds at the base of the bristles on the side and back of the omnivorous leafroller are white, whereas on the orange tortrix they are not. Orange tortrix larvae feed inside nests spun around plant parts. The larvae pupate in dense cocoons inside the nests and adult moths emerge in 8 days to 3 weeks, depending on temperature. In coastal areas, orange tortrix may have more than three generations a year, whereas in intermediate districts it has two or three.

Monitoring. Growers monitor orange tortrix larvae throughout spring and summer at 7- to 10-day intervals. They look for orange tortrix and evidence of parasitism mainly on the south and east quadrants of trees. If 15 larvae are found per hour of search on oranges, a chemical treatment may be warranted, depending on the level of parasitism.

CONTROLS

Cultural

There are no cultural practices used to target specifically orange tortrix.

Biological

Parasites. Several parasites and predators attack orange tortrix. The most common parasites are two wasps, *Apanteles aristolidae* and *Exochus* spp. These wasps lay their eggs in tortrix larvae and the parasites develop within. *Apanteles* pupates in a white cocoon outside the dead larvae, whereas *Exochus* pupates inside the larva and emerges through a round exit hole.

Chemical

***Bacillus thuringiensis* var. Aizawai or Kurstaki.** *Bacillus thuringiensis* (Bt) is the most common treatment for orange tortrix. Timing of applications is important because Bt has a short residual period. It should be applied only during warm weather to control young, actively feeding worms. *Bacillus thuringiensis* (Bt) insecticides, both the *aizawai* and *kurstaki* varieties, are specific to caterpillar pests. These insecticides are relatively nontoxic to parasites that attack the caterpillars and to beneficial insects and mites that feed on other citrus pests. Bt may be applied during bloom.

Cryolite. Cryolite (KRYOCIDE) is applied to citrus in the San Joaquin valley region but is rarely used on valley lemons and rarely used in any other growing region. It has a narrow range of activity (foliage feeders such as worms, katydids, and Fuller rose beetle), but is persistent unless washed off by rain. Higher application rates are used to treat larger worms and larger trees. Cryolite is a slow-acting stomach poison specific to foliage-feeding pests and may take several days of warm weather to kill worms. It is relatively nontoxic to parasites that attack the caterpillars and to beneficial insects and mites that feed on other citrus pests.

Chlorpyrifos. Chlorpyrifos (LORSBAN) is a broad-spectrum organophosphate insecticide intended for use on all varieties of citrus. As a broad-range insecticide, chlorpyrifos is used to treat several insect pests on citrus though rarely targeted to control orange tortrix.

Carbaryl. Carbaryl (SEVIN) is applied to citrus in the San Joaquin Valley region. Use of carbaryl is lower in the other regions.

Naled. Naled (DIBROM) is a broad-spectrum organophosphate that controls insects pests, as well as, beneficial mites.

Methomyl. Methomyl (LANNATE) is a broad-spectrum oxime carbamate that is applied to citrus in the San Joaquin Valley but rarely on citrus in any other region. Methomyl is a restricted use material that may only be applied by permit from a county agricultural commissioner. It kills beneficial insects, such as mites. It is toxic to bees and during bloom is applied from 1 hour after sunset until 2 hours before sunrise.

SCAVENGER CATERPILLAR
Pink Scavenger Caterpillar: *Pyroderces rileyi*
Black Scavenger Caterpillar: *Holocera iciryaceela*

Damage. Pink and Black Scavenger Caterpillars are occasionally pests of the Coastal-Intermediate Region but are rarely of economical significance in citrus. On orange and lemon trees, the caterpillar is mainly a scavenger, feeding on dry or decaying fruit, dead floral parts, and sooty mold. They are only occasionally a factor in the Coastal-Intermediate Region. The feeding is usually superficial and does not cause appreciable damage. In a few cases, serious damage has occurred similar to that caused by orange tortrix. A heavy infestation may result in fruit drop or decaying fruit during storage.

Description of Pest. The pink scavenger caterpillar occurs sporadically in the coastal areas of San Diego, Orange, and Ventura counties. When fully grown, larvae are much smaller than other orangeworms. Pink scavenger caterpillars have light brown heads, black mouthparts, a dark brown prothoracic shield, and a dark pinkish abdomen. The black scavenger caterpillar occurs occasionally on coastal citrus. It generally does not cause any significant damage. The larva is recognized by its black color.

CONTROLS

Chemical

Treatments specifically designed to control scavenger caterpillars are rarely needed. Chemical treatments, such as Bt, cryolite and chlorpyrifos, used to control other caterpillar pests will also control potential scavenger caterpillar infestations.

SIXSPOTTED MITE

Eotetranychus sexmaculatus

Damage. Sixspotted mite is a minor pest on citrus in some Coastal-Intermediate Region areas. It feeds along the midrib or larger veins on the underside of citrus leaves. The infested area may turn pale to yellow, and the leaves often become distorted. Leaf drop may occur with few mites present. Rarely seen.

Description of Pest. The Sixspotted mite is somewhat smaller than the twospotted mite, lemon yellow, and usually has three pairs of black spots. Typically, populations tend to be heaviest in spring and early summer when temperatures are cool. A generation takes 3 to 4 weeks to complete.

CONTROLS

Cultural

Dust Reduction. Growers minimize dust within the orchard by paving roads or using water trucks to wet dirt roads that are in high use. Trees may also be washed with water to remove dust though this is rarely practiced.

Biological

Predator Mites. A number of predators provide relative control of sixspotted mites. These include the sixspotted thrips, *Scolothrips sexmaculatus*, the spider mite destroyer, *Stethorus picipes*, minute pirate bugs, *Orius* spp., and the beneficial mite, *Euseius tularensis*.

Chemical

Wettable Sulfur. Wettable sulfur is applied to thoroughly cover foliage as soon as mites are detected. It is intended for use on all varieties of citrus. Applications are not made when temperatures are high or within 2 months of a previous oil spray.

Dicofol. Dicofol (KELTHANE) is an organochlorine applied at label rates to all varieties of citrus. It has a narrow range of activity, but is persistent. Applications are largely confined to the San Joaquin Valley region. Dicofol is of intermediate selectivity because it acts primarily against mites with minimal impact on beneficial insects such as lacewings, lady beetles, and *Aphytis melinus*, which help control worms, scale, thrips, and other pests. It is however, toxic to predaceous mites such as *Euseius tularensis*, because of its persistence.

TWOSPOTTED SPIDER MITE
Scientific Name: *Tetranychus urticae*

Damage. The twospotted spider mite is an occasional pest on citrus, particularly in the San Joaquin Valley Region. Its damage potential varies from year to year and is related to water stress and heat. Light infestations result in yellow or brown spots between leaf veins. Clusters of dried, brown leaves and profuse webbing indicate a heavy infestation, which if compounded by water stress, could result in leaf and fruit drop.

Description of Pest. Adults of the twospotted spider mite overwinter in protected places on the tree, such as the navel of navel oranges, under the button, and where fruit touch. Spider mites first appear on the underside of leaves and when heavy populations build up. A generation can be completed in 7 days.

Monitoring. In the San Joaquin Valley, growers monitor for twospotted mites when they monitor for citrus red mite in late winter and early spring. They look for yellow brown spots on foliage, particularly in the last growth flush, indicating feeding by twospotted spider mites. High populations in summer and fall may require treatments but thresholds have not been established.

CONTROLS

Cultural

Irrigation. Mites reproduce faster on water stressed trees. Adequate irrigation will reduce the impact of spider mite feeding.

Dust reduction. Dust, white wash, manure and other dry coatings on the leaves aggravate mite problems. Dust on the edges of orchards can be reduced by applying water to the roads.

Avoiding broad-spectrum insecticides. Certain broad-spectrum insecticides (especially carbamates and pyrethroids) can actually make the mites reproduce faster and so should be avoided if twospotted spider mites are present.

Biological

General Predators. A number of predators provide substantial control of twospotted spider mites. These include the sixspotted thrips, *Scolothrips sexmaculatus*, the spider mite destroyer, *Stethorus picipes*, minute pirate bugs, *Orius* spp., and the beneficial mite, *Euseius tularensis*.

Chemical

Narrow Range Oil. Narrow range spray oils can be effective against yellow scale if coverage is thorough. In orchards where resistance to organophosphate and carbamate insecticides is a severe problem, petroleum oil sprays can be a useful supplement together with other chemical treatments to control scale. Growers must take care when applying narrow range oil to avoid applying it at times when fruit and leaves can be damaged (phytotoxicity), when risk from frost damage can be increased, or natural enemies reduced. Narrow range 440 spray oil is preferred in the San Joaquin Valley region during warmer months because of greater persistence, but at some risk to enhanced phytotoxicity.

Propargite. Propargite (OMITE) is an organosulfur compound intended for use on citrus. Propargite should not be applied within 40 days of an oil application, but oil may be applied 30 days or more after propargite. Propargite is highly selective, more so than dicofol or oxythioquinox, because, when used at low rates, it is relatively nontoxic to beneficial mites. In southern California, propargite applications are allowed only under Special Local Needs permit. No more than 2 applications per year may be made and they must be at least 21 days apart. Omite has a 42 day REI.

Dicofol. Dicofol (KELTHANE) is an organochlorine which is applied at label rates to all varieties of citrus. It has a narrow range of activity, but is persistent. Dicofol is of intermediate selectivity because it acts primarily against mites with minimal impact on beneficial insects such as lacewings, lady beetles, and *Aphytis melinus*, which help control worms, scale, thrips, and other pests. It is however, toxic to predaceous mites such as *Euseius tularensis*, because of its persistence.

Fenbutatin Oxide. Fenbutatin oxide (VENDEX) has a narrow range of activity and the period of persistence is short. Fenbutatin oxide should not be applied during bloom. In hot weather, there is a potential of phytotoxicity. Higher rates may be used during cool weather periods. Fenbutatin oxide is highly selective and has little effect on natural enemies. It is typically applied in combination with a narrow range spray oil.

Pyridaben. Pyridaben (NEXTER) is toxic to predaceous mites. Multiple applications should be made at a minimum of 30 days apart.

APHIDS
Spirea Aphid: *Aphis citricola*
Cotton or Melon Aphid: *Aphis gossypii*

Damage. Aphids are a sporadic pest in the Coastal-Intermediate Region and rare pests in other regions of California citrus. Aphids feed on buds and on the underside of leaves (mainly feather growth), causing leaves to curl toward the stem. They are generally not an economic problem on citrus except on young trees. Occasionally heavy populations can cause fruit to become bumpy.

Description of Pest. The most common aphid on citrus in the coastal-intermediate region is the spirea aphid. The cotton or melon aphid occasionally feeds on citrus and can transmit the tristeza virus. The two species can be distinguished by color.

CONTROLS

Cultural

There are no cultural practices used to control aphids on citrus.

Biological

A number of predators, parasites, and fungal diseases usually keep aphid populations below damaging levels. A moderate aphid population (about 40% of growth flushes infested) can be considered beneficial on mature trees because aphids and their honeydew provide a good food source for many natural enemies of other pests early in the season when other hosts are not available.

Chemical

On newly established trees and on new growth flushes on mature trees, it is not uncommon for aphids to cause curling of leaves and produce honeydew. Natural enemies normally control aphid populations and a spray is rarely warranted. Treatment of the cotton aphid to prevent transmission of tristeza virus has not been shown to be effective.

GLASSY-WINGED SHARPSHOOTER
Homalodisca coagulata

Damage. The glassy-winged sharpshooter is a relatively new pest to California. It is a vector of various strains of the bacterium Xylella fastidiosa that causes diseases such as Pierce's Disease in grapes, almond leaf scorch, and oleander leaf scorch. There is concern that if citrus variegated chlorosis (CVC), a disease which has recently devastated citrus production in Brazil, were to enter California, this highly efficient vector would easily spread the disease in citrus. The glassy-winged sharpshooter causes significant damage in several commodities, though citrus is not economically affected to date with the exception of minimal losses to lemons due to egg mass scars in fruit rinds and some reduction of lemon fruit size in situations of heavy GWSS populations. Treatments are applied to lower overall densities to reduce the vectoring impact of Pierce's Disease in grapes and to disinfest fruit before shipping to uninfested areas of California.

Description of Pest. Sharpshooters are in the same insect family as leafhoppers. A large inset, almost ½ inch long, the glassy-winged sharpshooter is dark brown to black with a lighter underside. The upper parts of the head and back are stippled with ivory or yellowish spots; the wings are partly transparent with reddish veins. When feeding, it excretes copius amounts of watery excrement in a steady stream of small droplets. The sharpshooter has two generations per year.

Monitoring. In addition to visual observations, yellow sticky traps can be placed in areas adjacent to vineyards that serve as habitat for this insect. A treatment is warranted if after several successive warm days there is an increase in the number of sharpshooters trapped, or if more than an average of one sharpshooters is trapped per trap per week, or if visual inspections reveal more than one sharpshooter per tree.

CONTROLS

Cultural

There are no cultural practices, at this time, used to control sharpshooter on citrus.

Biological

A number of native (*Gonatocerus ashmeadi*) and introduced (*G. trigattatus*) egg parasitoids attack egg masses of the glassy-winged sharpshooters. However they are not very effective until the second generation of sharpshooter activity.

Chemical

Imidacloprid. (ADMIRE) is the most effective and longest lasting insecticide for GWSS control. It is about 85% effective in reducing nymphs and lasts for 6 months. It allows most natural enemies to survive, except vedalia beetles. It should not be used where cottony cushion scale is a problem.

Cyfluthrin. Cyfluthrin (BAYTHROID) is a broad- spectrum pyrethroid insecticide that is commonly used on oranges in the San Joaquin Valley region. The chemical is rarely used in any other region of the state, including the Desert Region, where citrus thrips are the major pest. Cyfluthrin is toxic to both beneficial mites and beneficial insects and disrupts biological control. Cyfluthrin is also used for katydids and citrus thrips. Cyfluthrin provides only one generation (2-3 months) of sharpshooter control.

Fenpropathrin. (DANITOL) was registered in 2001 in California for use on citrus. Fenpropathrin is applied to San Joaquin Valley Region oranges . Fenpropathrin is toxic to both beneficial mites and beneficial insects and disrupts biological control. It is also used for katydids. Fenpropathrin provides only one generation (2-3 months) of glassy-winged sharpshooter control.

Acetamiprid. (ASSAIL) Acetamiprid is broad-spectrum insecticide affecting all natural enemies. Acetamiprid exerts only one generation (2-3 months) of glassy-winged sharpshooter control. This insecticide should not be used where cottony cushion scale is a problem because it does not control that pest and it is toxic to vedalia beetle. This insecticide is also used for citricola scale control. It can be used to disinfest trees of glassy-winged sharpshooter just prior to harvest of citrus fruit because it has a short pre-harvest interval, short reentry interval, and several international maximum residue limits have been established.

Methomyl. Methomyl (LANNATE) is a broad-spectrum insecticide that is applied to San Joaquin Valley oranges, grapefruit, and lemons but rarely onto citrus in any other region. Methomyl is a restricted use material that may only be applied by permit from a county agricultural commissioner. It kills beneficial insects and predatory mites. It is toxic to bees and during bloom is applied from 1 hour after sunset until 2 hours before sunrise. It is used to disinfest trees of glassy-winged sharpshooter just prior to harvest of citrus fruit because it has a short pre-harvest interval, short reentry interval, and international maximum residue limits have been established.

CITRUS PEELMINER
Marmara gulosa

Damage: Citrus peelminer larvae attack sucker growth and the rind of citrus fruit in grapefruits, pummelos and susceptible navel varieties such as Fukumotos, Atwoods, and Tis. Citrus peelminer also attacks weeks, willows, oleander and crops including cotton, beans, grapes stone fruits, eggplant, squash, and peppers. It moves from host to host to maintain its population year round.

Description of Pest: Citrus peelminer is a small moth that lays its eggs on the outside surface of fruit. The eggs hatch and the larvae bore in and create a mine just under the top layer of the rind. The larvae molt 4-7 times over a two-week period and then the larva emerges and spins a pupal case.

Monitoring: Infestations in citrus occur beginning at the end of June and continue through harvest. Citrus trees can be monitored by examining fruit on the inside of the tree. All varieties of citrus can be attacked by peelminer but only susceptible varieties sustain damage of more than 3% of the fruit.

CONTROLS

Citrus peelminer has been a periodic pest in the Coachella and San Joaquin Valleys. Insecticides are not very effective.

Cultural controls

Susceptible varieties of citrus: Avoid growing susceptible citrus varieties such as Fukomotos, grapefruit, and pummelos. Locate plantings of these susceptible varieties away from neighboring crops such as cotton and grapes that could be a source of peelminer.

Bt Cotton: if cotton is grown next t o a susceptible citrus variety, then Bt cotton should be used.

Biological Control

There are many native miner parasitoids that attack it to a limited extent. Releases of the parasitic wasp *Cirrospilus* are being done in the SJV to improve biological control. Long-term control of this pest will be through natural enemies.

Chemical Control

There are no chemical treatments that have been found to be effective against Citrus peelminer.

CITRUS LEAFMINER
Phyllocnistis citrella

Damage: Citrus leafminer is a minor problem on mature trees because they can withstand heavy infestations with little effect on yield. In Florida, it is a vector of a number of diseases not yet found in California. Citrus leafminer is likely to be a pest of nurseries and new plantings because the growth of young trees is retarded by leafminer infestations.

Description of Pest: Citrus leafminer arrived in southern California in 2000. Similar to Citrus peelminer, leafminer is a small moth. However, it deposits its eggs in the leaf tissue, the eggs hatch, and larvae mine new flush growth. The pupal stage is found rolled up in the edge of leaves.

Monitoring: New foliage should be examined for mines whenever flush growth is evident. This pest is currently a B rated pest and movement of fruit with foliage is restricted. Growers in infested areas must remove foliage and have their fruit inspected to ensure that it is free of leafminers.

CONTROLS

Cultural

There are no known cultural controls at this time.

Biological

Leafminers are fairly well controlled by parasitic wasps. Many of the parasites that attack Citrus peelminer also attack citrus leafminer.

Chemical

Chemical control is limited to nurseries and new plantings.

Imidacloprid. (ADMIRE/GAUCHO) Imidacloprid allows most natural enemies to survive, except vedalia beetles. It exerts long-term suppression of citrus leafminer and will be a significant control tactic in new citrus plantings, as well as, nursery situations.

Nematode

CITRUS NEMATODE
Tylenchulus semipenetrans

SHEATH NEMATODE
Hemicycliophora arenaria

Damage. Citrus nematode attacks roots by burrowing its anterior end deep inside the root cortex while the posterior end remains outside in the soil.

Description of Pests. Damage caused by a citrus nematode infestation depends on the age and vigor of the tree, the nematode population, and susceptibility of the rootstock. Mature trees can tolerate a considerable number of these nematodes before showing lack of vigor and decline symptoms. The damage is greater when trees are predisposed by other factors such as Phytophthora root rot and water stress. Plant parasitic nematodes are microscopic, unsegmented roundworms that live in soil and plant tissues and feed on plant roots. The predominant species parasitic on citrus in California is the citrus nematode, *Tylenchulus semipenetrans*. This nematode is reported to be present in most citrus orchards and in all soil types.

The sheath nematode is less widespread than the citrus nematode; it has been found on citrus in the Coachella Valley. It has a broad host range and thrives well at high temperatures and at low moisture levels.

Monitoring. To make management decisions, growers need to identify the nematode species present within the orchard and the estimated population. Soil samples are sent to a diagnostic laboratory for identification.

CONTROLS

Cultural

Sanitation. Good sanitation practices are essential to avoid nematode infestations. Certified nematode-free planting material should be used. Growers use a resistant rootstock whether or not nematodes are present.

Resistant Rootstock. When replanting a citrus orchard, growers typically apply a preplant treatment even if a resistant rootstock is used. Trees planted on fumigated orchard sites are generally known to have improved growth and yields compared to those on nonfumigated sites. Troyer and Trifoliate rootstocks have resistance for the first years of tree life but biotypes of citrus nematode that develop to very high population levels can be expected after 20 years. There is need for rootstocks without the parentage of these two rootstocks where orchards are to be replanted.

Chemical

Preplant Fumigation

Methyl Bromide. Methyl Bromide is a broad-spectrum material that controls weeds, soil fungi, and soil insects as well as nematodes. Methyl bromide is being phased out in 2005 however except for growers/farms qualifying for a critical use exemption.

Metam Sodium. (VAPAM) Pre-application steps must be taken because metam sodium must be delivered uniformly across the field surface and moved as deep as 5 feet into the soil using water as the carrier. Before applying this material, the soil should be moist but drained. The delivery equipment can vary but must be adaptable to the existing irrigation system. Care must be taken to avoid off-gassing.

1,3-Dichloropropene. 1,3-Dichloropropene (TELONE II, TELONE C35, AND IN LINE) is a restricted use material that may only be applied with a permit from a county agricultural commissioner. InLine is a new emulsifiable formulation more suitable for citrus soils but drip emitters are needed on each square foot of soil surface. Six to 8-acre-inches of water would deliver the product to 4 or 5 feet deep. A tarp is also necessary.

Postplant

Oxamyl. (VYDATE) Oxamyl is applied by metering into drip irrigation systems or microsprinklers. This product is best delivered during a 4-hour irrigation to soil pre-moistened the day before.

Aldicarb. (TEMIK) Aldicarb 10G is applied to oranges, lemons, grapefruit and limes only. It is applied just before or during the spring flush of growth in a band along the drip line on both sides of tree row.

Fenamiphos. Fenamiphos (NEMACUR 3) may be applied by injections into microsprinkler or drip irrigation system to soil pre-wetted the day before. This product is only permitted as a 1-hr slug treatment which is a poor method where dispersion into soil is key. Nemacur will be unavailable after May 2005.

Diseases

Primary Diseases

PHYTOPHTHORA ROOT ROT
Phytophthora citriphthora
Phytophthora parasitica

Description of Disease. *Phytophthora* fungi are present in almost all citrus orchards. Under moist conditions, the fungi produce large numbers of motile zoospores, which are splashed onto the tree trunks. *Phytophthora citrophora* is a winter root rot that also causes fruit rot and gummosis. It is active during cool seasons when citrus roots are inactive and their resistance to infection is low. Additionally, it can cause trunk infections. *Phytophthora parasitica* is a warm weather root rot that is active when roots are growing. *Phytophthora* root rot destroys feeder roots of susceptible rootstocks causing a slow decline of trees. The leaves turn light green or yellow and may drop, depending on the severity of infection. The pathogen infects the root cortex, which turns soft and separates from the stele. If the destruction of feeder roots occurs faster than their regeneration, the uptake of water and nutrients will be limited. The trees will grow poorly and production decline.

Monitoring. Growers inspect the orchard several times a year for disease symptoms, digging up soil and checking feeder roots if a tree looks stressed. Symptoms are often difficult to distinguish from nematode, salt or flooding damage and can only be confirmed through laboratory analysis. When P*hytophthora* populations are greater than 15 to 20 propagules per gram of root zone soil, treatment may be warranted.

<u>CONTROLS</u>

Cultural

Drainage and Irrigation. Growers provide adequate soil drainage and avoid over-irrigation. If destruction of feeder roots is minimal, growers may take corrective actions by increasing irrigation intervals, switching to alternate middle row irrigation or mini-sprinklers. Ideally, for disease management water periods should be kept to a period of 24 hours.

Resistant Rootstock. When establishing new planting or replanting, growers choose resistant rootstocks, such as trifoliate orange, when possible.

Sanitation: Producing disease free plants for planting.

Non-ionic spreaders: Non-ionic spreaders have been shown to improve water penetration and soil tilth.

Chemical

Systemic fungicides can control Phytophthora. When planting or replanting in soil infested with *Phytophthora*, or when a susceptible rootstock has to be used, fumigation may be useful.

Preplant Fumigation

Methyl Bromide. Methyl Bromide is injected into the soil at 7 to 8 inch intervals. The site is tarped immediately following application and is not planted for at least 1 month. Lower rates are applied to sandy loam and the higher rates are applied to heavier soils with a high clay content. Methyl bromide is being phased out by 2005except for growers/ farms who qualify for a critical use exemption.

Chloropicrin. Chloropicrin is applied as a pre plant fumigant by means of injections. The site is tarped immediately after treatment. The treated site is not planted for at least 3 months. Lower rates are applied on sandy loam and higher rates are used on heavier soils with high clay content. Chloropicrin is typically applied in combination with methyl bromide treatments. Chloropicrin does not provide consistent control of soil borne pathogens and is weak on several weed species.

Metam Sodium. Metam Sodium (VAPAM) is a pre plant fumigant that is minimally applied to citrus orchards in California, with most applications being made in the San Joaquin Valley District to oranges, in the Coastal-Intermediate District to Lemons and in the Desert Valley Regions to grapefruit. The site may not be planted for at least 45 days after application. Metam sodium alone does not provide long term, deep control of nematodes. Movement in the soil profile is limited to the wetted front of the fumigation zone.

Basamid: Difficult to achieve uniform application of this material because it is in a granular form and the dissolution rate, as well as, soil penetration are not consistent.

1,3-Dichloropropene. 1,3-Dichloropropene (TELONE) is a restricted use material that may only be applied with a permit from a county agricultural commissioner. Township caps are in place for this material. 1,3-D generally controls nematodes in shallow, light soils and does not control nematodes effectively unless the soil moisture is less than 12%. Soils this dry are difficult to achieve in heavy soils.

Nonbearing Trees

Fosetyl-aluminum. Fosetyl-aluminum (ALIETTE) is applied to nursery trees only. Trees are treated at the time of planting and are sprayed to wet.

Mefenoxan. Mefenoxan (RIDOMIL GOLD) is applied as a soil drench or a surface spray with sufficient water for soil penetration. For citrus trees in nurseries, mefenoxan is applied as a drench at planting and at 3 month intervals to coincide with root growth flushes during the growing season. This product replaces metalaxyl, which has recently been phased out.

Bearing Trees

Fosetyl-aluminum. Fosetyl-aluminum (ALIETTE) is applied as a foliar treatment sprayed to wet. Four application per year may be made.

Mefenoxan. Mefenoxan (RIDOMIL GOLD) is applied in the spring followed by 1 to 2 applications at 3-month intervals to coincide with root flushes, depending on the tree size. The orchard is irrigated with 0.5-1 inch water after application. This product replaces metalaxyl, which has recently been phased out.

Sodium Tetrathiocarbonate. Sodium tetrathiocarbonate (ENZONE) is generally considered to be less efficacious than the other registered alternatives as it is a poor root penetrant. It is most suitable to post plant treatments. Product needs further testing.

ARMILLARIA ROOT ROT
Armillaria mellea

Description of Disease. Armillaria root rot, also known as oak root fungus, can damage and kill citrus trees. The fungus requires cool, moist soil conditions for development and spread; it is therefore rarely a problem in desert valley regions. Symptoms may not develop until after the disease is well established. The first symptoms of Armillaria root rot are poor growth or dieback of shoots, small yellowing leaves, and premature leaf drop. The fungus spreads by root contact or through rhizomorphs, which can grow short distances through the soil and contact and penetrate citrus roots. The pathogen invades the roots and crown, eventually girdling the crown region and destroying the entire root system. The fungus can survive for many years in dead or living roots of fruit and nut trees. Very localized.

Monitoring. Evidence of infection is seen at the base of the tree trunk. Identifying infection centers in previous plantings before establishing a new orchard.

CONTROLS

Cultural

Prevention of Infection. Management of Armillaria root rot relies primarily on preventing infection of new trees. Growers avoid planting in a site likely to be infested with Armillaria. If there are infected trees in the orchard, they are completely removed, including the roots. Neighboring, apparently healthy trees are also removed as it is likely that their roots are also diseased but the trees are not yet showing symptoms.

Biological

There are no effective biological control agents against Armillaria.

Chemical

To prepare infested sites for replanting, roots larger than 1 inch in diameter are removed, dried and destroyed and the site is then fumigated.

Methyl Bromide. Methyl bromide is a pre plant fumigant injected into the soil at 7 to 8 inch increments. The treated area is tarped. Growers wait at least one month before planting. Lower rates are used on sandy loam soils and higher rates are used on heavier soils with high clay content. Methyl bromide is a restricted use material applied only be permit from a county agricultural commissioner. Methyl bromide is being phased out and should no longer be available by 2005.

Metam Sodium. Metam sodium (VAPAM) requires pre-application steps because metam sodium does not penetrate plant roots very well and is very difficult to get 4-5 feet down from the surface. Before applying this material, growers must thoroughly cultivate the area to be treated to break up clods and deeply loosen the soil. Metam sodium alone does not provide long term, deep control of nematodes. Movement in the soil profile is limited to the wetted front of the fumigation zone.

Sodium Tetrathiocarbonate. Sodium tetrathiocarbonate (ENZONE) is generally considered to be less efficacious than the other registered alternatives as it is a poor root penetrant. It is most suitable to post plant treatments. Product needs further testing.

Chloropicrin. Chloropicrin is applied as a preplant fumigant by means of injections. The site is tarped immediately after treatment. The treated site is not planted for at least 3 months. Lower rates are applied on sandy loam and higher rates are used on heavier soils with high clay content. Chloropicrin is typically applied in combination with methyl bromide treatments. Chloropicrin does not provide consistent control of soil borne pathogens and is weak on several weed species.

BROWN ROT
Phytophthora spp.

Description of Disease. Brown rot is caused by Phytophthora fungi when conditions are cool and wet. It develops mainly on fruit growing near the ground when Phytophthora spores from the soil are splashed onto the tree skirts during rainstorms. Brown rot is often seen in the northern Coastal-Intermediate district on lemons and occasionally in the Desert Valley regions after summer rains. Infections develop under continued wet conditions. Fruit in the early stage of the disease may go unnoticed at harvest and infect other fruit during storage.

Monitoring. Symptoms appear primarily on mature or nearly mature fruit. Initially, the firm, leathery lesions have a water-soaked appearance, but they soon turn soft and have a tan to olive brown color and a pungent odor. Occasionally, twigs, leaves, and blossoms are infected, turning brown and dying.

<u>CONTROLS</u>

Cultural

Pruning Skirts. Brown rot management relies on prevention. Tree skirts are pruned 24 or more inches above the ground to prevent infection from Phytophthora spores that are splashed up from the soil during rain storms.

Sanitation: Exclude affected fruit zone from harvest (do not harvest crop on the skirts of the canopy).

Biological

There are no biological controls of Phytophthora**.**

Chemical

Zinc Sulfate - Copper Sulfate - Hydrated Lime. Applied to citrus from October through December, or just after the first rain. Where danger of copper injury is severe, these products are modified to make them safer by adding 0.33-1 lb of hydrated lime/lb of dry copper fungicide.

Copper Sulfate. Copper sulfate (BORDEAUX MIXTURE) is applied to citrus where there is no history of copper injury. Tree skirts are sprayed about 4 feet above ground, which does not harm natural enemies. Spraying the ground underneath the trees also reduces Brown rot infections.

Basic Copper (COPPER HYDROXIDE, COPPER OXIDE): Basic coppers minimize potential phytotoxicity and are effective treatments for managing diseases.

Fosetyl-aluminum. Fosetyl-al (ALIETTE) is applied to all susceptible citrus varieties. It is applied when conditions favor disease development. Fosetyl-al is not applied within 30 days of harvest. Tree skirts are sprayed about 4 feet above ground. The maximum number of applications per year is four.

SEPTORIA SPOT
***Septoria* spp.**

Description of Disease. The Septoria fungus causes spotting of Valencia oranges and occasionally of lemons and grapefruit. It occurs in the San Joaquin Valley and interior districts of southern California during cool, moist weather. Infections begin when Septoria spores are spread throughout the tree in dew or rainwater. Symptoms of Septoria spot appear as small, light tan to reddish brown pits on fruit. On lemon, the small spots develop into large, brown blotches during storage. Septoria may cause similar spotting on leaves or twigs that are weakened by frost or pests.

CONTROLS

Cultural

There are no cultural practices employed at this time to control Septoria.

Chemical

Zinc Sulfate - Copper Sulfate - Hydrated Lime. Applied to citrus as a preventative spray from October through December, or just after the first rain. In years with heavy rainfall, respraying may be necessary. Where danger of copper injury is severe, these products are modified to make them safer by adding 0.33-1 lb of hydrated lime/lb of dry copper fungicide.

Copper. Copper is applied at label rates as a paint or spray on the trunk and crown right after excision of diseased bark. It is also applied as a protectant on trees where risk of gummosis is high.

Copper Sulfate. Copper sulfate (BORDEAUX MIXTURE) is applied from October through November, before the first rains. On mandarin trees, applications are made after the fruit is picked to avoid undesirable residue.

STUBBORN DISEASE
Spiroplasma citri

Description of Disease. Stubborn disease is endemic in the warm inland growing areas, where it affects primarily sweet orange, grapefruit, and tangelo trees. Because hot, dry weather favors the development and spread of the stubborn pathogen, it has become a problem in the San Joaquin and Desert Valley regions. The disease is more of a problem in young orchards than in mature groves. The pathogen is a mycoplasma, which is spread by leafhopper (primarily beet leafhopper) feeding, and by grafting and budding. Treatment of leafhoppers in the field does not prevent the spread of the mycoplasma. Stubborn disease is often difficult to diagnose. Stubborn disease does not kill trees, but stunts growth and inhibits fruit production.

CONTROLS

Cultural

Prevention of Infection. Management of stubborn disease focuses on preventing the disease and avoiding its spread. Preventative measures mainly apply to nursery practices, such as maintaining stubborn-free mother trees for budwood. In an established orchard, trees are observed carefully for any signs of stubborn disease in late fall or early winter. A sparse crop, which is an indicator of this disease, becomes apparent as fruit color changes to orange. Growers map or flag the trees suspected of being infected and recheck the orchard several times during the year to confirm the diagnosis.

TRISTEZA DISEASE COMPLEX
Tristeza Virus

Description of Disease. Tristeza is widespread throughout coastal-intermediate and interior regions but limited in the San Joaquin and desert valley regions. Tristeza virus is spread through budding and grafting or by aphids feeding on citrus. The melon aphid is the vector for all tristeza isolates (types) found in California. Trees infected with tristeza show light green foliage, poor growth flushes, and some leaf drop.

CONTROLS

Cultural

Prevention of Infection. Management of the tristeza complex depends largely on preventative measures, such as using tolerant rootstocks and tristeza-free propagation material. Quarantine restrictions are in place. No plants or plant parts are shipped from infected southern California districts to areas where tristeza is not present or is localized, such as the San Joaquin Valley or desert valley regions.

Virus-Free Budwood. Only certified, virus-free budwood are used when grafting or topworking. The Citrus Clonal Protection Program (CCPP) provides virus-free and true-to-type bud lines to nurseries and growers in California. In southern California, where tristeza is widespread, growers remove infected trees only when they become unproductive.

Chemical

There are no chemical controls available for tristeza.

Secondary Diseases

BOTRYTIS ROT
Botrytis cinerea

Description of Disease. Botrytis Rot is mainly a problem on lemon fruit but the fungus may also infect twigs and small branches of lemon trees. The fungus infects through injuries and forms gray, velvety mats of fruiting bodies on infected tissue, causing the surface of fruit to be bumpy. Infected twigs may die back several inches. Generally regionalized with higher incidence in coastal regions.

CONTROLS

Cultural

Infection Prevention. Preventative measures are taken to reduce the incidence of infection. Mechanical injury is avoided. Growers protect against frost and Brown rot, and prune regularly.

Chemical

Fungicide applications are usually rotated during the season, with fungicides of different chemical classes being applied in sequence. Use of repeated applications of the same or related fungicide is avoided. Tank mixing of fungicides is also common, lowering the application techniques require less active ingredient per acre and are allowed under

FIFRA.

PHYTOPHTHORA GUMMOSIS
Phytophthora spp.

Description of Disease. *Phytophthora* fungi are present in almost all citrus orchards. Under moist conditions, the fungi produce large numbers of motile zoospores, which are splashed onto the tree trunks. The *Phytophthora* species causing gummosis develop rapidly under moist, cool conditions. Hot summer weather slows disease spread and helps drying and healing of the lesions. Secondary infections often occur through lesions created by *Phytophthora*. These infections kill and discolor the wood deeper than gummosis itself. An early symptom of Phytophthora gummosis is sap oozing from small cracks in the infected bark. Decline may occur rapidly within a year, especially under conditions favorable for disease development, or may occur over several years.

Monitoring. Late stages of Phytophthora gummosis are distinct, but early symptoms are often difficult to recognize. Growers inspect the orchard several times a year for disease symptoms looking for signs of gumming on the lower trunk and crown, and for soil buildup around the crown.

CONTROLS

Cultural

Management of Phytophthora gummosis focuses on preventing conditions favorable for infection and disease development .

Propagation: Bud union should be 6-8 inches above soil line.

Irrigation Management/Good Drainage: Avoid standing water near trunk of tree.

Resistant Rootstock: Avoid lemon-type rootstocks such as Rough Lemon.

Berm Planting. Trees are planted on a berm or high enough so that the first lateral roots are just covered with soil and bud unions well above the soil. During irrigation, care is taken not to spray the scion with water. Correcting any soil or water problems is essential for a recovery.

Chemical

Copper sprays (see below) can be used to protect against infection. When planting or replanting in soil infested with *Phytophthora*, or when a susceptible rootstock has to be used, fumigation may be useful.

Preplant Fumigation

Methyl Bromide. Methyl Bromide is injected into the soil at 7 to 8 inch intervals . The site is tarped immediately following application and is not planted for at least 1 month. Lower rates are applied to sandy loam and the higher rates are applied to heavier soils with a high clay content. Methyl bromide is being phased out by 2005.

Chloropicrin. Chloropicrin is applied as a pre plant fumigant that is injected into the soil. The site is tarped immediately after treatment. The treated site is not planted for at least 3 months. Lower rates are applied on sandy loam and higher rates are used on heavier soils with high clay content. Chloropicrin is typically applied in combination with methyl bromide treatments. Chloropicrin does not provide consistent control of soil borne pathogens and is weak on several weed species.

Metam Sodium. Metam sodium (VAPAM) is a pre plant fumigant minimally applied to citrus orchards in California, with most applications being made in the San Joaquin Valley District to oranges, in the Coastal-Intermediate District on Lemons and in the Desert Valley Regions on grapefruit. The site is not planted for at least 45 days after application. Metam sodium alone does not provide long term, deep control of nematodes. Movement in the soil profile is limited to the wetted front of the fumigation zone.

1,3-Dichloropropene. 1,3-Dichloropropene (TELONE) is a restricted use material that may only be applied with a permit from a county agricultural commissioner. Township caps are in place for this material. 1,3-D generally controls nematodes in shallow, light soils and does not control nematodes effectively unless the soil moisture is less than 12%. Soils this dry are difficult to achieve in heavy soils.

Postplant Treatments

Copper. Copper is applied at label rates as a paint or spray on the trunk and crown right after excision of diseased bark. This is not a curative treatment, but is intended as a preventative measure to help prevent reinfection. It is also applied as a protectant on trees where risk of gummosis is high.

Fosetyl-aluminum. Fosetyl-aluminum (ALIETTE) is sprayed or painted on trunks when disease occurs or conditions favor disease development. If no lesion is present, wet the trunk from the ground up to a height of 2 feet. The higher rate is used when trunk lesions are present. The lesions are thoroughly treated. Applications should not exceed 4 applications of per year.

Mefenoxan. Mefenoxan (RIDOMIL GOLD) is applied by spraying on the surface of trunks to cover lesions thoroughly. This product replaces metalaxyl, which has recently been phased out. It is applied when the disease occurs and can be applied up to 3 times/ year in the same orchard, but not to the same tree in the same cropping season.

Sodium Tetrathiocarbonate. Sodium tetrathiocarbonate (ENZONE) is generally considered to be less efficacious than the other registered alternatives as it is a poor root penetrant. It is most suitable to post plant treatments. Product needs further testing.

DRY ROOT ROT
Fusarium spp.

Description of Disease. Dry Root Rot damage usually starts in larger roots and spreads into the crown. Patches or large areas of bark on the underground portion of the crown show a moist, dark decay, which later dries and adheres to the wood. In some cases, dry bark may also be seen above ground. Unlike Phytophthora gummosis, dry root rot does not produce gumming, and the lesion extends deep into the wood. Once the crown region is girdled, the tree collapses.

Although the disease is normally a chronic problem affecting only a few scattered trees in a grove, it can develop into an epidemic in some orchards. The exact cause of dry root rot has not been established, but a Fusarium solani is most often isolated from diseased wood. All common rootstock including trifoliate and Troyer citrange are susceptible to dry root rot.

Monitoring. Growers check regularly for signs of Phytophthora root rot or vertebrate damage that may provide entry sites for dry root rot.

CONTROLS

Cultural

Irrigation Control. Good orchard management, especially careful irrigation, is essential for preventing dry rot. If the soil around the tree crowns and roots is saturated for long periods of time, the chances for injury and subsequent fungal infection increase. When establishing furrows, growers

provide berms along the trees so that the crowns are protected from the water. Sprinklers are adjusted so that water does not hit the trunks.

Protection of Trunk and Crown. During cultural operations, care is taken to avoid injury to the lower trunk, crown and/or feeder roots in the top soil, especially during the cool and wet season. Care is taken to avoid overdosing the trees and burning root tissue when applying fertilizers, herbicides, and nematicides.

Aeration of Disease. When the disease is present, growers may expose the crown region allowing it to dry which may slow the progress of the disease. Tree skirts are pruned to allow the circulation of air around the crown region.

Tree Removal. Trees that have become unproductive because of severe infection are removed from the orchard.

Chemical

No effective chemical treatments are available.

EXOCORTIS
Exocortis viroid

Description of Disease. Exocortis is widespread in older plantings, but it is a mild disease that causes only moderate stunting and some loss of production. Exocortis is of minor importance in California today because strict regulations on budwood sources have kept new plantings largely free of this viroid disease. Infected trees rarely die, but growth is retarded and productivity slowly declines. The viroid kills the bark, which dries, cracks, and may lift in thin strips.

CONTROLS

Cultural

Removal of Infected Trees. Infected trees are removed from the orchard because pruning clippers and saws can transmit exocortis unless thoroughly disinfected with hypochlorite (bleach); heat does not kill the viroid. For planting or replanting, viroid-free budwood is grafted onto rootstock.

Chemical

There are no chemical treatments for exocortis.

PSOROSIS

Description of Disease. Psorosis is a graft transmissible disease, caused by a virus, most often found in old citrus plantings. Infected trees, mostly orange and grapefruit, slowly decline. It is transmitted in infected budwood or possibly with contaminated grafting tools. During early stages, patches of bark on the trunk or scaffold branches show small pimples or bubbles. In advanced stages, deep layers of bark and the wood become impregnated with gum and die.

CONTROLS

Cultural

Prevention. As with other graft transmissible diseases, the use of disease-free budwood is the major method for preventing damage from psorosis. The Citrus Clonal Protection Program provides budwood free of major diseases to nurseries and growers. Generally, a psorosis-infected tree will produce less, and replacement is the best option.

Removal of Infected Trees. Infected trees are removed from the orchard because pruning clippers and saws can transmit the disease unless thoroughly disinfected with hypochlorite (bleach); heat does not kill the viroid. For planting or replanting, viroid-free budwood is grafted onto rootstock.

BACTERIAL BLAST
Pseudomonas syringae

Description of Disease. Bacterial blast, also known as citrus blast and black pit, is restricted mainly to citrus growing areas in the Sacramento Valley (a small growing region north of the main San Joaquin Valley region) where wet, cool, and windy conditions during winter and spring favor development and spread of the blast bacterium. Leaves and twigs of oranges and grapefruit and the fruit of lemon are most susceptible to infection. The bacterium infects small injuries caused by thorn punctures, wind abrasions, or insect feeding.

Infections usually start as black lesions in the leaf petiole and progress into the leaf axil. Once the petiole is girdled, leaves wither, curl, and eventually drop. Entire twigs may die back. The damage is most severe on the south side of the tree, which is exposed to the prevailing winter winds. Diseased areas are covered with a reddish brown scab. Infections result in small black spots on the fruit.

CONTROLS

Cultural

Cultural practices can help to reduce the incidence of bacterial blast.

Windbreaks. Growers plant windbreaks using bushy cultivars with relatively few thorns to help prevent wind injury.

Pruning. Dead or diseased twigs are pruned out in spring after the rainy period reduces the spread of the disease. Fertilization and pruning are scheduled during spring or early summer to prevent excessive new fall growth, which is particularly susceptible to blast infection.

Biological

There are no biological control agents against bacterial blast.

Chemical

Preventative treatment against bacterial blast alone is generally not economical, but sprays against Brown rot or Septoria may provide some protection against bacterial blast. In the Sacramento Valley where blast is an annual problem, yearly treatments are common.

Copper Sulfate. Copper sulfate (BORDEAUX MIXTURE) is generally applied from October through November, before the first rains. On mandarin trees, applications are made after the fruit is picked to avoid undesirable residue.

Post-Harvest Diseases

Some diseases are of specific concern following the harvest of California citrus. The post-harvest treatments of these diseases are the subject of this section.

GREEN MOLD and BLUE MOLD

Green Mold: *Penicillium digitatum*
Blue Mold: *Penicillium italicum*

Damage. Green mold and blue mold are primarily problems during the post-harvest handling and storage of citrus. They are the most common post-harvest disease for the industry. The diseases are not easily detected. Infections appear as soft, circular, water-soaked areas termed "clear rot". Later, a whitish mycelium with either green or blue spores develops. Therefore, preventative treatments are often performed during post-harvest processing of citrus to control these diseases. Often, blue and green mold occur together though the effectiveness of treatments for these two diseases can differ. Fruit picked under wet conditions are more vulnerable to the disease and may be selected for preventative treatment during post-harvest processing.

Monitoring. Though monitoring for green mold and blue mold during post-harvest processing and storage is performed on a continual basis, by the time these diseases can be observed, the infestation typically is beyond stages that can be eradicated feasibly. The most effective control methods are preventative and, therefore, not directly applicable to monitoring. Monitoring is ongoing for resistant strains to both Penicillium species to the registered post-harvest fungicides.

CONTROLS

Cultural

Dry Fruit. Growers avoid picking fruit under conditions where the fruit will be wet prior to processing and/or storage since these conditions favor the onset of green and blue mold infestation.

Fruit Handling: Fruit should be handled to minimize injuries to the fruit.

Sanitation. Processing equipment and facilities and materials that come in contact with post-harvest fruit such as transport and storage bins are kept clean to minimize contaminant levels. Steam, hot water, or chemical sanitizers, such as sodium hypochlorite or quaternary ammonium compounds, are used to minimize green and blue mold spore populations.

Biological

There is one FIFRA-registered biological control agent that has been available for about 5 years to control post-harvest infestations of green or blue mold. This control agent has been found to have very limited applicability. Applications must be made at the time wounds occur (harvest), a timing that is not practical with the following products.

***Pseudomonas syringae* .** This microbial pesticide (BIOSAVE) is a wound colonizer that is intended to establish itself, out-compete green and blue mold spores for the wound site, and result in limited infestation by removing the host. However, the requirements for effective establishment of this colonization of the wounds sites are so difficult to meet, the product has limited effectiveness in the field. There is very little use of this product at this time.

Chemical

Several techniques are used to treat for green and blue mold. Fruit are treated directly by spraying, drenching or flooding, incorporating the fungicide into storage or shipping waxes, or dipping the fruit in tanks. In addition, the facilities are also treated to minimize the possibility of contamination.

Direct Applications to Fruit

The following products are effective in controlling green and blue mold under post harvest conditions though all three have increasing levels of resistance building up. All are capable of controlling infections initiated up to a day before treatment.

Ortho Phenylphenol. Ortho-phenylphenol (OPP) and sodium phenylphenate (SOPP, DOWICIDE) are applied as an overhead non-renewing spray or in a dip tank. OPP can also be incorporated into shipping wax that is applied to the fruit during post-harvest processing though this active ingredient is most effective when applied as a washer sanitizer in aqueous solutions. OPP is potentially phytotoxic, particularly in tanks, so application rates and solution pH must be closely monitored.

Thiabendazole (TBZ). Thiabendazole (TBZ) is applied in dip tanks and overhead non-recovery sprayers as well as a component of shipping wax. Aqueous TBZ solutions often contain hypochlorite and sometimes sodium bicarbonate. Thiabendazole is often applied as an overhead spray where the ingredient is combined with waxes. Residues from aqueous applications are more easily removed by rinsing or handling than those in waxes.

Imazalil. Imazalil uses are similar to those of thiabendazole. The product is typically used as a component of storage or shipping wax, occasionally as an aqueous bin drench, non-recomver spray, or as a drench or dip where it is sometimes heated. Because waxes reduce its activity substantially, imazalil is used at higher rates in waxes than in aqueous applications. It is effective in retarding blue and green mold sporulation, which makes the fruit preferable for product intended for retail sale. Aqueous imazalil cannot be mixed with hypochlorite, so tanks of imazalil require filtration or periodic heating to prevent resistant spores from accumulating in them. Sometimes imazalil and TBZ are added together in the shipping wax but this can exacerbate resistance problems.

The following products are also direct fruit treatments but they are less effective than the above products, in protecting newly formed wounds following applications.

Lime Sulfur. Lime sulfur can be effective in treating blue and green mold post-harvest and does not build up resistance in the pest. However, lime sulfur is less effective than the organic alternatives (OPP, TBZ and imazalil) and can be quite corrosive to equipment.

Applications to Equipment and Facilities

The following products are used to sanitize the materials, equipment, and environment that post-harvest citrus are in contact with, reducing the potential for infestations by blue and green mold.

Formaldehyde. Formaldehyde is used as a fumigant to decrease the level of mold that can be a source of inoculation for post-harvest fruit. Fumigations treat all surfaces, including equipment and storage/transportation bins. The product is effective against resistant varieties of green and blue mold and is relatively inexpensive to use but is highly restricted in its use and must be applied by remote control.

Quaternary Ammonia Compounds. Quaternary ammonia compound or (QUATS) are used to disinfect equipment and other materials that come in contact with the harvested fruit or may be a source of inoculum. There are many quats that can accomplish this type of disinfection.

SOUR ROT
Geotrichum citri-aurantii

Damage. Sour Rot is fairly common as a post-harvest infestation in citrus. The disease results in severely decayed fruit that often has an unpleasant odor associated with it, reducing the value of the fresh market produce significantly.

Monitoring. Most treatments against sour rot are preventative though careful monitoring for onset of the disease is performed to limit the spread of the disease.

<u>CONTROLS</u>

Cultural

Sanitation. Processing equipment and facilities and materials that come in contact with post-harvest fruit such as transport and storage bins are kept clean to minimize contaminant levels. Often, chemical control methods and facilities fumigation are performed to ensure sufficient minimization of sour rot.

Delay of Senescence: Gibberellic Acid (GA3). As citrus fruits senesce, they become more susceptible to sour rot. Use of the plant growth regulator Gibberellic Acid (GA3) provides a modest delay of senescence which gives a modest degree of sour rot control for lemons.

Biological

There are no biological control methods that are specifically designed to impact sour rot.

Chemical

Fewer chemicals are available to treat sour rot than green and blue mold. Several techniques are used including direct applications onto post-harvest fruit, incorporation into shipping wax, and facility applications.

Direct Applications to Fruit.

The following product can be used against sour rot but are only marginally effective.

Lime Sulfur. Lime sulfur is only 50% effective against sour rot. No resistance has been noted but sour rot is difficult to prevent and/or control. Currently it is not used much due to corrosivity.

Ortho Phenylphenol. Ortho-phenylphenol (OPP) and sodium phenylphenate (SOPP, DOWICIDE) are only partially effective against sour rot (10% control) are rarely targeted towards this pest.

Applications to Equipment and Facilities

The following products are used to sanitize the materials, equipment, and environment that post-harvest citrus are in contact with, reducing the potential for infestations by sour rot.

Formaldehyde. Formaldehyde is used as a fumigant to decrease the level of sour rot that can be a source of inoculation for post-harvest fruit. Fumigations treat all surfaces, including equipment and storage/transportation bins. The product is effective against resistant varieties of sour rot and is relatively inexpensive to use but is highly restricted in its use and must be applied by remote control.

Quaternary Ammonia Compounds. Quaternary ammonia compounds or (QUATS) are used to disinfect equipment and other materials that come in contact with the harvested fruit or may be a source of inoculum. There are many quats that can accomplish this type of disinfection.

ALTERNARIA ROT
Alternaria citri

Description of Disease. Alternaria rot is a fungal disease that affects mainly navel oranges and lemons. Fruit infected with alternaria change color prematurely. The decay is softer on lemons than on oranges and develops mostly during storage. On navel oranges, the disease is also called black rot, and results in dark brown to black, firm spots or areas at the stylar end or in the navel. When infected fruit are cut in half, you can see the rot extending into the core.

<u>CONTROLS</u>

Cultural

Limit Stress and Damage. Healthy, good quality fruit are more resistant to Alternaria rot than stressed or damaged fruits, especially oranges with split navels. Preventing stress can reduce the incidence of splitting and Alternaria rot.

Chemical

2,4-D Isopropyl Ester. (2,4-D) For lemons, the primary port of entry of this pest is via the detachment of the button. Because this plant growth regulator delays the abscission of the button, post-harvest application of 2,4-D reduces the incidence of Alternaria decay.

Other Post-Harvest Diseases

Diplodia: *Diplodia citri*
Phomopsis
Cottony Rot: *Scerotinia sclerotiorum*
Trichoderma
Botrytis

Several other diseases are occasional problems for post-harvest citrus production. These include the following:

Cottony Rot, Trichoderma and Botrytis Post-harvest pests for coastal grown lemons during storage. Though difficult to control, the fungicides used for blue and green mold can be helpful and sanitation procedures can reduce the risk of infestation.

Diplodia and Phomopsis are minor problems that can impact desert region citrus. Thiabendazole (TBZ) can be effective against these post-harvest diseases.

Plant Growth Regulators

Overview. Several plant growth regulators are registered for pre-harvest use on citrus crops. Two are also registered for post-harvest application. 2,4-dichlorophenoxyacetic acid (2,4-D) is used primarily to delay and reduce abscission (drop) of mature fruit. Naphthaleneacetic acid (NAA) may be used as a fruit thinning agent or a separate concentrated formulation may be used to control sprouting. Gibberellic Acid is used primarily to delay senescence or over-ripening. For growth regulators to be effective they must be absorbed by the plant tissue. Good spray coverage is essential and climatic conditions that favor absorption (warm and humid conditions) are desirable. With the exception of NAA used for sucker control, these chemical treatments are sprayed uniformly over the fruiting canopy.

2,4-D ISOPROPYL ESTER

The isopropyl ester of 2,4-D is a compound used extensively to reduce the drop of mature navel orange and grapefruit and to a lesser extent, other citrus fruit. It is applied before fruit drop becomes a problem, but sufficiently ahead of flowering to reduce undesirable effect on the spring cycle of growth. For navel oranges, sprays are commonly made from October through December. For mature grapefruit and Valencia oranges, 2,4-D may be applied in the spring to control fruit drop or as a dual purpose spray to control mature fruit drop and to improve fruit size of the new crop. 2,4-D may also be used in pesticide oil sprays to counteract leaf and fruit drop caused by the oil and with Gibberellic Acid. Care is taken not to apply 2,4-D shortly before or during a flush of growth as vegetative or reproductive growth may be damaged resulting in lower production. For Pre-harvest application, the restricted entry is 12 hours. As indicated in the Alternaria Rot section, 2,4-D is applied post-harvest to delay the abscission of the button of lemons and thereby reduce the incidence of alternaria decay.

GIBBERELLIC ACID

In California, Gibberellic Acid may be applied at label rates to navel orange, Valencia orange, lemons, limes, and tangerine hybrids to delay senescence, the over ripening of fruit. It is also applied to navel orange trees after oil treatments to reduce rind breakdown (water spotting). It should not be used in solutions with a pH higher than 8. Solutions with a pH of 8 or lower provide better stability and better absorption by the plant tissue. For Pre-harvest application, the restricted reentry interval for Gibberellic Acid is 12 hours. Gibberellic Acid may be applied post harvest to citrus fruit to delay senescence. See the Sour Rot section.

Weeds

Overview. Weeds within the orchard compete with citrus trees for water, nutrients, and sunlight and contribute to insect infestations and disease pressure. They also interfere with cultural operations and increase frost hazards. In young orchards, weed competition may be strong resulting in stressed young trees that grow slower and are less tolerance to insect and disease pressure. In mature orchards, tree skirts and canopies shade part of the orchard floor and reduce weed growth. Most weed species found in citrus orchards are either annual or herbaceous perennial plants.

Annuals. Winter annuals germinate in the fall, grow during the winter, and flower and produce seed in the spring before dying in early summer. Common winter annuals include bluegrass, cupgrass, chickweed, common groundsel, foxtails, henbit, miner lettuce, fiddleneck, filaree, little mallow (cheeseweed), mustards, shepherds-purse, and wild barley. Summer annuals germinate in the spring or early summer and flower and produce seed in the fall before dying in the winter. Major species include barnyardgrass (watergrass), crabgrass, common lambsquarter, flax-leaved fleabane, marestail, lovegrass, pigweeds, puncturevine, spotted spurge, purslane, sprangletop, nightshades, turkey mullein, vinegar weed, and witchgrass.

Perennials. Perennials, which can live 3 years or longer, may be herbaceous or woody plants. Some herbaceous perennials die back during the winter but regrow during the spring or early summer from underground rhizomes, tubers, bulbs or crowns on tap roots. Common herbaceous perennials include Bermuda grass, dallisgrass, field bindweed, Johnson grass, and nutsedges.

Monitoring. Growers must know the weed species present in the orchard, their abundance and locations. A survey is conducted twice a year, in summer and late winter.

CONTROLS

Cultural

Water Management. Growers prevent the spread of weeds by making sure that irrigation ditches are free of weeds. Screens are sometimes installed to keep out dislodged weeds and weed seeds. Water management is important in weed control. To discourage the establishment of seedlings, the top 2 to 3 inches of soil is allowed to dry completely between furrow or sprinkler irrigations. Weeds are not allowed to mature and produce seeds around the orchard perimeter.

Ground Cover and Cover Crops. A ground cover is maintained in some orchards, especially in northern California and on hilly terrain. Ground cover of resident vegetation or a sown cover crop prevents soil erosion and improves water penetrations and soil structure. Spotted spurge can provide a good cover crop since it is low growing, does not require mowing and is not a strong competitor for nutrients and water.

Mowing. Weeds are mowed throughout the orchard. Repeated mowing, however, favors the establishment of perennials which are deep rooted and more competitive with citrus than annuals like spotted spurge or clovers.

Cultivation. Growers sometimes manage weed problems with cultivation, by shallowly tilling or disking of weeds. This practices is not routinely practiced, however, because tillage destroys the layer of feeder roots which absorb nutrients, water and oxygen in the top soil. The injury to the trees root system may also provide entry sites for disease organisms.

Biological

Weed control by plant pathogens and insects within the orchard provides some control.

Chemical - Preemergent Herbicides

Diuron. Diuron (KARMEX) is the most common pre emergent herbicide used in citrus. It is applied to emerging and young broadleaf and grass weeds, as well as mosses, but not perennial weeds. It controls most broadleaf weeds, except henbit, Russian thistle, surge, speedwell, and turkey mullein. It also effective against most species of grass weeds except for sprangletop and wild oat.

Simazine. The 1,3,5-triazine compound controls most broadleaf weeds and some grassy weeds. It is effective against most broadleaf weeds, except filaree, spurge, and turkey mullein. It is only partially effective on some grassy weeds and not effective on others. It does not control perennial weeds.

Bromacil. Bromacil is applied prior to irrigation or rain for the control of broadleaf, grassy and some perennial weeds. It controls most weeds except sprangletop.

Oryzalin. Oryzalin (SURFLAN) is a 2,6-dintroaniline compound that is applied to citrus for the control of grassy weeds and some broadleaf weeds. It is very effective against grassy weeds and certain broadleaf weeds such as chickweed, fiddleneck, goosefoot, knotweed, lambsquarter, miners lettuce, pigweed, popcorn flower, purslane and redmaids.

Trifluralin. Trifluralin (TREFLAN) is a 2,6-dintrioaniline compound applied to control grassy weeds, some broadleaf weeds and some perennials. It controls grassy weeds, and certain broadleaf weeds such as chickweed, fiddleneck, goosefoot, knotweed, lambsquarter, miners lettuce, pigweed, popcorn flower, purslane and redmaids.

EPTC. EPTC (EPTAM) is applied for the control of grasses and some broadleaf weeds. It controls most grasses, except sprangletop, as well as most broadleaf weeds, except cocklebur, cudweed, fiddleneck, mustard, puncture vine, spurge, speedwell, turkey mullein, and wild radish.

Napropamide. Napropamide (DEVRINOL) is applied for the control of broadleaf and grassy weeds. It controls most grass weeds and provides good control over some broadleaf weeds, but not flax-leaved fleabane, ground cherry, marestail, nightshade, popcorn flower, redmaids, shepherds purse, spurge, turkey mullein or wild radish. It is more expensive that other pre emergent herbicides.

Norflurazon. Norflurazon (SOLICAM) is applied for the control of broadleaf and grassy weeds. It is somewhat effective against most of these species, and only partially effective against perennial weeds, except field bindweed for which it is not effective. Applications are made with caution as there is a potential to contaminate groundwater with norflurazon.

Chemical - Postemergent Herbicides

Glyphosate, isopropylamine salt. Glyphosate (ROUNDUP) is the most commonly used post emergent herbicide in citrus. It is typically applied for effective control of most broadleaf weeds (except malva, filaree and panicle mallow herb), grassy weeds and perennial weeds. Although it is one of the most effective tools, it must be used with care to prevent drift.

MSMA. . MSMA is a selective, post emergent herbicides. It controls a few grassy weeds

(annual bluegrass, crabgrass and Johnson grass). It also partially controls other grassy weeds and perennial weeds.

Paraquat Dichloride. Paraquat dichloride (GRAMOXONE) is applied for effective control of most broadleaf and seedling grassy weeds.

Vertebrate Pests

Overview. A number of vertebrate species may live within or move into citrus orchards for food or shelter. The potential for damage by vertebrates varies from orchard to orchard and region to region. Orchards located near rangeland, wooded areas or other uncultivated areas are more likely to be invaded or re-invaded by certain vertebrates. Predators, diseases and food sources all may influence a vertebrate populations. Predators such as coyotes, foxes, snakes, hawks and owls feed on rodent and rabbit species. Growers cannot, however, rely on predators to prevent rodents or rabbits from becoming agricultural pests.

POCKET GOPHER
***Thomomys* spp.**

Description of Pest. Pocket gophers are important vertebrate pests. They gnaw on the root systems and girdle young trees below the soil line. Their burrows run through the orchard, diverting water and contributing to soil erosion.

Monitoring. Growers monitor for gophers by looking under tree skirts especially near the border of the orchard where gophers may move in from adjacent fields or orchards. Weeds and cover crops in the orchard may make detection more difficult. Gophers should be controlled as soon as they are detected.

CONTROLS

Cultural

Trapping. Trapping or baiting by hand are the most effective control mechanisms. Traps are placed in the main tunnel between two fresh mounds. Growers check the traps daily. Pocket gophers are classified as non-game mammals and can be eliminated at any time if injuring crops.

Chemical

Strychnine. Strychnine bait is applied at label rates to control gophers. Baiting by hand is one of the most effective control mechanisms. Single dose baits can also be placed at intervals in the main tunnel.

Diphacinone. Diphacinone is a rodenticide bait intended to control gophers. It is applied at labeled rates. Baiting by hand is one of the most effective control mechanisms. Single dose baits can also be placed at intervals in the main tunnel. Diphacinone is a restricted use material that may only be applied with permit from a county agricultural commissioner.

Aluminum Phosphide. Aluminum phosphide (PHOSTOXIN) is a phosphide fumigant that is used to control burrowing rodents. Fumigation of burrows does not work well with gophers because the burrow systems are extensive and gophers can quickly seal tunnel when they detect poisonous gas.

Zinc Phosphide. Zinc phosphide is a bait used to treat gophers and ground squirrels. Baiting by hand is one of the most effective control mechanisms. Single dose baits can also be placed at intervals in the main tunnel.

CALIFORNIA GROUND SQUIRREL
Spermophilus beecheyi

Description of Pest. Ground squirrels are a pest of citrus orchards digging burrows under the trees, gnawing on polyethylene irrigation hoses and eating fruit. Ground squirrels typically dig their burrows along ditches, fence rows and on uncultivated land, but may also establish burrows beneath trees in an orchard.

Monitoring. Growers monitor for ground squirrels by checking the perimeter of the orchard about once per month for animals or their burrows. If monitoring indicates that a squirrel population is moving into the orchard, they can be controlled with traps, fumigants, or toxic bait.

CONTROLS

Cultural

Trapping. Trapping ground squirrels works well in small areas or for a small number of squirrels. Growers check the traps daily.

Chemical

Strychnine. Strychnine bait is applied at label rates to control ground squirrels. Baiting by hand is one of the most effective control mechanisms.

Aluminum Phosphide. Aluminum phosphide (PHOSTOXIN) is a phosphide fumigant that is used to control burrowing rodents. It works best in early spring when moist soil helps retain a high toxic gas level in the burrows. The burrows are checked after about three days.

Diphacinone. Diphacinone is an anticoagulant rodenticide bait intended to control ground squirrels. It is applied at labeled rates to traps or in bait stations. Baiting by hand is one of the most effective control mechanisms. Single dose baits can also be placed at intervals in the main tunnel

Zinc Phosphide. Zinc phosphide is a bait used to treat ground squirrels.

TREE SQUIRREL
Eastern Gray Squirrel: *Sciurus carolinenis*
Eastern Fox Squirrel: *Sciurus niger*
Western Gray Squirrel: *Sciurus griseus*

Description of Pests. Eastern gray squirrel is more localized and rarely causes damage to citrus. The Eastern fox squirrel is more common than the gray squirrel and is well established in city parks, residential areas, and adjacent agricultural lands. It feeds on ripe citrus fruit, nuts, mushrooms and on bird eggs and insects.

CONTROLS

Cultural

Trapping. A modified packet gopher box trap can be used for tree squirrels. It is fastened onto horizontal limbs in a tree where feeding damage has occurred. It is baited with pieces of nut meat for several days to establish feeding, prior to setting the trap. Tree squirrels are classified as game mammals by the California Fish and Game and a permit from the local game warden is required for control of the eastern gray squirrel. Poisoning of this species is illegal. The eastern fox squirrel may be killed in any manner if it is causing crop damage, but a permit is still required.

MEADOW MICE
***Microtus* spp.**

Description of Pest. Meadow mice, which are also referred to as voles or field mice, inhabit roadsides, meadows, canal banks, fencerows and many field crops. They are rarely a problem in weed-free citrus orchards. Meadow mice feed on young or mature trees, sometimes girdling the trees close to the soil line.

Monitoring. Growers monitor the orchard in the fall or winter checking for signs of mouse activity. If treatment is necessary, treatments are most efficient before the spring breeding season.

CONTROLS

Cultural

Weeding. Preventative measures may be taken by growers to make the orchard less favorable to invasion by meadow mice and their survival. Growers clear weeds and thick mulches around tree trunks to discourage infestation by meadow mice. Weeds are also cleared from fencerows or ditch banks. If a groundcover is grown in the orchard, growers keep weeds at least 3 feet from tree trunks.

Tree Wrappers. Tree wrappers used for sunburn and frost protection offer some protection, although these wrappers sometimes offer shelter for the deer mouse or house mouse. Meadow mice are classified as non-game mammals and may be eliminated in any manner at any time if they are injuring crops.

Chemical

Diphacinone. Diphacinone is an anti-coagulant rodenticide bait applied at labeled rates. Baiting by hand is one of the most effective control mechanisms. Single dose baits can also be placed at intervals in an active runway, burrow entrance or at several spots around the trunks of trees.

Zinc Phosphide. Zinc phosphide is a bait used to treat meadow mice at labeled rates.

BLACK-TAILED JACKRABBIT
Lepus californicus

Description of Pest. The black-tailed jackrabbit is a common pest that may feed on the bark of young trees, and gnaw on low volume irrigation hoses. Jackrabbits cause little damage to mature citrus trees; however they may use the orchard as shelter during the day then move our to forage on field crops during the night.

CONTROLS

Cultural

Tree Wrappers. Tree wrappers used for sunburn and frost protection offer some protection, although these wrappers sometimes offer shelter for the deer mouse or house mouse. Wire guards, 3 feet high, around tree trunks also help protect young trees from potential jackrabbit damage.

Trapping. Jackrabbits are classified as game mammals by the California Fish and Game Code. The hunting season is year round with no bag limit. When injuring crops, jackrabbits may be killed in any manner, but traps must comply with Fish and Game regulations and state law.

RAT
Roof Rat: *Rattus rattus*
Wood Rat: *Neotoma* spp
Cotton Rat: S*igmodan hispidus*

Description of Pests. Roof rats are most common around dwellings, but also occur in orchards. It is a problem in some coastal-intermediate and interior regions. Roof rats build nests in citrus trees and eat the pulp out of mature oranges or lemons. They may also chew the bark of scaffold limbs. Wood rats are also called pack rats. They normally live in wooded or brushy areas. They feed on fruit or bark and cut twigs for their nests. Wood rats build their nests in trees within the orchard.

The cotton rat rarely causes damage to citrus orchards. It has limited distribution in southern California and is typically found on grassy ditch banks.

CONTROLS

Cultural

Trapping. Trapping is effective for a small number of rats. Rat snap traps attached to limbs and baited with citrus, raisins, prunes or nut meats. After feeding at the trap has been established, traps are set. Rats are classified as nongame mammals and can be eliminated in any manner at any time if injuring crops.

Pruning. Growers prune trees reducing secluded habitat for rats.

Chemical

Diphacinone. Diphacinone is an anti-coagulant rodenticide bait applied at labeled rates. Baiting by hand is one of the most effective control mechanisms. Single dose baits are place in bait boxes.

Zinc Phosphide. Zinc phosphide is a bait used to rats at labeled rates.

DEER

Description of Pest. Deer occasionally damage newly planted trees that are located near their natural habitats, such as woods and thickets. They feed at night on young tree foliage and rub their antlers on limbs in the spring.

CONTROLS

Cultural

Repellants. Foliar repellants may offer some protections, although fencing offers a more permanent solution.

Trapping. Deer are classified as game mammals by the California Department of Fish and Game. A depredation permit is needed for shooting deer that are damaging crop. Poisoning deer is illegal in California.

COYOTE
Canis latrans

Damage. Coyotes are a pest in citrus orchard causing damage to low volume irrigation hoses. Coyotes can eat the irrigation tubing and structures.

CONTROLS

Cultural

Foliar Repellant. Foliar repellants may offer some protections, although fencing offers a more permanent solution.

Elimination. A permit is needed for shooting coyote that are damaging crops.

Research

There are several areas of focus for ongoing and future research on pest management in California citrus. Focuses include the development of alternate and reduced risk pesticides, development of cultural practices, demonstration and education projects and pest-specific research.

Pesticide replacement research is focusing on new, reduced-risk pesticides and biochemical and microbial pesticides. These products are being developed to offer lower risk chemicals for agricultural workers and food residues.

Research efforts need to further focus on techniques to improve the effectiveness of ant baits to control Argentine Ants and Red Imported Fire Ants. Control methods also need to be further developed against pests of increasing concerns such as Citricola Scale, Katydids, and Cottony Cushion Scale and the development of new chemicals for these pests. Another pest of increasing concern is the Bud Mite, the number one pest of concern in the coastal growing regions. Further research into the control of nematodes on citrus is needed.

New restrictions on the export of California citrus have triggered the need for research into a higher level of control of Bean Thrips and Fuller Rose Beetle.

New insect pests to California such as the Glassy-winged Sharpshooter and Red Imported Fire Ants are triggering research efforts to characterize these pests on citrus and develop appropriate control programs.

Diseases of particular concern where research efforts are needed include Phytophthora, where research into cultural control methods such as mulching and biological control methods, as well as the use of antagonistic fungi are underway.

Cultural practices, many of them listed and discussed in this Pest Management Strategic Plan, are also being continually developed and revised. Emphasis is needed to introduce these cultural techniques to the grower community. Demonstration plots and education are essential to the adoption of improved pest management systems by growers. As an example, research and demonstrations are ongoing into the impacts that weed control techniques have on the integrated management of insect pests.

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