Western IPM Center

Western Integrated Pest Management Center

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30 September 2016

USDA/Office of Pest Management Policy
1400 Independence Avenue, S.W.
Washington, DC 20250-0314

Dear Teung, David, and Elizabeth,

I've compiled information on uses of carbaryl in California on behalf of the Western Integrated Pest Management Center. The Center will also send information for the Southwest, Pacific Northwest, and Hawaii under separate cover.

This information comes from the California Department of Pesticide Regulation's pesticide use reporting database, Pest Management Strategic Plans, University of California Pest Management Guides, a report compiled by the California Department of Pesticide Regulation on critical uses of carbaryl, industry representatives, and information provided by University of California professors, extension specialists, and farm advisors.

I've also attached information from the University of California Integrated Pest Management Program, data tables from the pesticide use reporting database, a presentation given on carbaryl use in citrus, and a draft of an investigation from California's Department of Pesticide Regulation.

If you have any further questions, please let me know.

Sincerely,

Amanda Crump, director
Western Integrated Pest Management Center

INFORMATION REQUESTED:

1) What are the benefits for the use of carbaryl?
    a) What crops is carbaryl used on in your region, and for control of which pests?
        i) In California, carbaryl is used in more than 100 crops and non-crops (i.e. landscapes, turf). For some specialty crops like cactus pear, carbaryl is one of the only chemistries registered to control important pests. For other crops, carbaryl is used in rotation with other chemistries.
            (1) Colusa and Sutter Counties (located just north of Sacramento): Carbaryl is used on both tomatoes and cucurbits to control armyworms, cutworms, tomato fruitworm,

hornworms, darkling beetles, flea beetles, cucumber beetles, grasshoppers, crickets, earwigs, and beet leafhoppers. It is used as both a broad-spectrum spray and 5% bait for more specific control. In Colusa county 2014, 2,796 lbs of carbaryl (AI) per acre was used on tomatoes and 59 lbs AI/acre on cucurbits. In Sutter county 2014, 1,295 lbs AI/acre on tomatoes and 580 lbs AI/acre on cucurbits. Heavier use on tomatoes is apparent. (PUR data)

(2) Yolo and Solano counties (located just west of Sacramento): Darkling ground beetles (mostly) and for some cutworm activity.

(3) Olives: Used for black scale control.

(4) Monterey, San Benito, and Santa Cruz counties (California's Central Coast):
   (a) Cactus pear – used for scale (only thing registered for this industry)
   (b) Used on strawberries and occasionally caneberries. . It is used to control cochineal scale in cactus. This problem is increasing over years. Carbaryl is also used in ditches and canals adjacent to vegetable fields for earwig problems.

(5) Carrots: used for grasshoppers and salt marsh caterpillars but used very little.

(6) Pears: Carbaryl is one of the most cost-effective products on russet mite and pear blister mite control. If used as a fall cleanup in mid-October, the impact on beneficials has been proven negligible.

(7) Citrus: Please see attached presentation from Beth Grafton Cardwell, UC Riverside. For citrus, carbaryl is important because (1) carbaryl is broad spectrum and controls multiple pests simultaneously– reducing the number of applications, which in turns minimizes costs, compaction, fruit damage, VOCs, risks for workers. (2) Relatively short REI (12 hours or 3 days for >5lbs/acre) and PHI (5 days) (3) Provides a product that has international MRLs established – some new chemistries do not have MRLs (4) Controls some new/difficult to control pests such as glassy-winged sharpshooter, Asian citrus psyllid, Fuller rose beetle. (5) Utilized in the California red scale eradication program in portions of S. California (6) Provides a chemistry that could potentially help with resistance management – a rotational chemical for California red scale

(8) Pistachio: used for darkling beetles, a pest for young, non-bearing trees.

(9) Almonds: The use is typically for borers (which there are no other effective products) or dormant treatments (which there are other effective products).

(10) Turfgrass: Limited efficacy against grubs feeding on shallow surface roots. Carbamate chemistry is an effective non-pyrethroid for adult bluegrass billbug control only. Used as a bait for grasshoppers.

b) What are the typical application rate(s) (may be less than the maximum label rate) for the crops of interest? Are higher rates used occasionally for specific purposes?

(1) Colusa and Sutter Counties (located just north of Sacramento):
   (a) In tomatoes (according to Pest Management Guidelines): Sevin XLR Plus is recommended at 0.66-1.25 lbs/acre for flea beetles and beet leafhopper and 1-2 qt/acre for hornworm control. Sevin Bait 5% is recommended at 30-40 lbs/acre for cutworms
   (b) In cucurbits (according to Pest Management Guidelines): Sevin 5 Bait is recommended at 20 lbs/acre for grasshoppers, earwigs, darkling beetles, cutworms,

and crickets. Sevin 4F is recommended at 1 qt/acre for cucumber beetles. Sevin XLR Plus is recommended at 1 qt/acre for cucumber beetles and flea beetles.

(c) All Sevin products have a 12-hour REI and 3 days PHI according to Pest Management Guidelines. These rates are at or below label rates.

(2) Yolo and Solano counties (located just west of Sacramento): Typically, the application method would be by granular bait boxes with 5% carbaryl on some type of attractant bait. Application might be 5 to 10 lbs per acre of product scattered along the seed line. Some application at near full label rates when applied by airplane.

(3) Monterey, San Benito, and Santa Cruz counties (California's Central Coast): Maximum rates. At issue is the long7 day PHI of this material, so if it is used at all, it would be before crops are harvested.

(4) Central Valley processing tomatoes and melons: used to reduce damage due to darkling ground beetle and cutworm.

(5) Pears: Growers usually go with 5-7 pts of Sevin XLR +5 gal. 440 oil and spray dilute at 500 gal./acre targeting pear psylla and the mites. Sevin is off patent and very economical, and has been in the growers' program for over 30 years.

(6) Pistachio: Treatments typically end after year 3 once the tree has enough size to withstand feeding. These granular baits are applied once, in-season when the risk of rain is minimal.

c) If multiple applications are needed, how many applications are usually needed (do particular pests/thinning regimes typically require multiple applications) what are the usual application intervals?

(1) Colusa and Sutter Counties (located just north of Sacramento): Generally, only one application is needed or spot applications rather than the entire field.

(2) Yolo and Solano counties (located just west of Sacramento): Single application typical, with only a second application made under severe and unusual conditions (for the bait).

(3) Monterey, San Benito, and Santa Cruz counties (California's Central Coast): No multiple applications. Typically applied when the pest is detected in large numbers.

2) Management Options

a) What other management (pesticide/non-pesticide) options are available if carbaryl was not available?

(1) Colusa and Sutter Counties (located just north of Sacramento): Carbaryl and other chemicals are rated in the Pest Management Guidelines for their greatest IPM value: most effective and least harmful to natural enemies, honey bees, and the environment. Carbaryl should not be applied to blooming plants. Chemicals ranked as better IPM value compared to carbaryl, a carbamate:

(a) Beet leafhopper control (tomatoes)-neonicotinoids (imidacloprid, dinotefuran, thiamethoxam), systemic insecticides are useful

(b) Cutworms (tomatoes)- Bacillus thuringiensis, spinosad, Cultural: tillage to destroy plant residue 2 weeks before planting, weed management

(c) Flea beetles (tomatoes)-neonicotinoids (dinotefuran, clothianidin, thiamethoxam), pyrethroids (esfenvalerate, lambda-cyahalothrin, pyrethrin), Cultural: rotate with a non-host crop, maintain healthy plant canopy
(d) Hornworms (tomatoes)-diamides (chlorantraniliprole, flubendiamide), methoxyfenozide, spinosyns (spinetoram, spinosad), Bacillus thuringiensis, novaluron, emamectin-benzoate, indoxacarb, pyrethroids (esfenvalerate, fenpropathrin), wasp parasitoids are also available: Trichogramma and Hyposoter exiguae, Cultural: post-harvest discing, non-host crop rotations
(e) Flea beetles (cucurbits)-neonicotinoids (acetomiprid and clothianidin)
(f) Earwig (cucurbits)-carbaryl is only chemical option listed, Cultural: keep bed tops dry, remove old leaf material on soil surface (senescent leaves)
(g) Darkling beetles (cucurbits)-carbaryl is listed as best option compared to malathion, ---Cultural: weed management, water barriers, reducing organic matter by fallowing
(h) Cutworms (cucurbits)-indoxacarb, diamides (flubendiamide, chlorantraniliprole), buprofezin, lambda-cyahalothrin, diazinon, Cultural: weed management is key
(i) Cucumber beetles (cucurbits)-acetamiprid
(j) Crickets (cucurbits)-carbaryl is ranked as best option, followed by pyrethroids (bifenthrin and lambda-cyahalothrin)

(2) Yolo and Solano counties (located just west of Sacramento): other insecticides are available, but would be sprays at higher active ingredient rates.
(3) Monterey, San Benito, and Santa Cruz counties (California's Central Coast): Many, but the key would be to have the shorter PHI's. Carbaryl is a very effect broad spectrum insecticide. Pyrethroids and other carbamates are the alternatives. Pyrethroids are also under scrutiny. Carbaryl is needed if there is an "out-of-control" situation.
(4) Pistachios: Losing carbaryl for pistachio would be problematic for many farmers as there is no other effective product.

b) How do these alternative options compare with carbaryl in terms of efficacy, cost and compatibility with current season-long pest management considerations, including resistance management?

(1) Colusa and Sutter Counties (located just north of Sacramento): Baits are effective control measures. Most of these insects attack seedlings and transplants and from conversations with some of my growers, baits are always applied to control darkling beetles. Broad-spectrum sprays are used later in the season when armyworms and cutworms begin feeding on foliage and fruit. It seems that neonicotinoids and pyrethroids are a better option for systemic broad-spectrum control than a carbamate in terms of IPM values.
(2) Yolo and Solano counties (located just west of Sacramento): Low dosage bait application makes economic sense, less likely drift and presumably a more effective interval of efficacy.
(3) Monterey, San Benito, and Santa Cruz counties (California's Central Coast): There are some good, what makes Sevin so useful is the lack of exposure of the pests (most lygus and thrips) to this material and subsequent susceptibility. That said, it is not often used because of the long PHI and use restrictions.

3) Economic Importance
   a) What are the estimated yield impacts if carbaryl was not available and there are no other efficacious alternatives?
      (1) Yolo and Solano counties (located just west of Sacramento): Plant population reductions and lower yields. In some cases, replanting necessary.
      (2) Monterey, San Benito, and Santa Cruz counties (California's Central Coast): Carbaryl is not used often, so the impact would not be great. That said, it's nice to have as an option and should not be removed as an option.
   b) What are the estimated yield impacts on a per acre basis if carbaryl was not available and the next best alternative, assuming one, is available? What is the next best alternative?
      (1) Monterey, San Benito, and Santa Cruz counties (California's Central Coast): Yield impacts would not be great.
   c) How would the chemical costs per acre change? Please list by each active ingredient alternative.
      (1) Monterey, San Benito, and Santa Cruz counties (California's Central Coast): Alternatives are about $70/application/acre.
   d) Would there be additional costs when using the next best alternative, such as the need for additional field passes, different equipment needs, or additional labor needs?
      (1) Colusa and Sutter Counties (located just north of Sacramento): The formulations would be similar for any other chemical baits or sprays. The equipment needs would be similar, but the rates per acre may be different. Also, pyrethroids and neonicotinoids may require more than one application.
      (2) Monterey, San Benito, and Santa Cruz counties (California's Central Coast): No

4) Periodic or invasive pests
   a) What are the periodic or invasive pests of concern for which carbaryl is a control option and for which crop(s)?
      (1) Colusa and Sutter Counties (located just north of Sacramento): Every year is different when it comes to what insects will be present or which insects will be a problem. Adjacent crops to tomatoes or cucurbits also play a role in the presence of pest insects. Carbaryl is an insecticide option for most of the pests that attack both tomatoes and cucurbits, especially with armyworm or cutworm outbreaks in a given year.
      (2) Yolo and Solano counties (located just west of Sacramento): Darkling ground beetles and cutworms for tomatoes and other seeded crops where plant population is relatively low.
      (3) Monterey, San Benito, and Santa Cruz counties (California's Central Coast): Only for lygus, which is a native pest.
   b) What are the alternatives if carbaryl is not an option? Are there any yield or quality losses when using these alternatives instead of carbaryl? How would the costs per acre change?
      (1) Colusa and Sutter Counties (located just north of Sacramento): The alternatives are various other insecticides, generally pyrethroids, neonicotinoids, and diamides.
   c) If there are no alternatives, what are the associated yield or quality losses resulting from these pests?

(1) Colusa and Sutter Counties (located just north of Sacramento): Depending on what stage the insects attack and whether they are in large enough numbers plays a role in the yield impact. Many of the insects such as cutworms and darkling beetles attack seedlings and transplants which could impact stand establishment. Later in the season cutworms and armyworms can feed on foliage and fruit rendering it unmarketable. The same is true for cucumber beetles.
(2) Yolo and Solano counties (located just west of Sacramento): Clearly, there are years when more acres are treated (as well as cycles where treatment is less necessary).

UNIVERSITY OF CALIFORNIA AGRICULTURE & NATURAL RESOURCES
UC IPM
Statewide Integrated Pest Management Program

How to Manage Pests

Pesticide Information

| About Pesticide Information |

Active ingredient: Carbaryl

Pesticide type: insecticide (carbamate)

Synonym: sevin
See example products below.

Potential Hazard[1] to				
			People and Other Mammals	
Water quality[2] (aquatic wildlife)	Natural enemies (beneficials)	Honey bees[3]	Acute[4]	Long Term[5]
☐ M	☐ MH	☐ VH	☐ M	CA Prop 65

Acute Toxicity to People and Other Mammals[4]

- Toxicity rating: **Moderately Toxic**

Long-Term Toxicity to People and Other Mammals[5]

- **On US EPA list:** Not listed;
- **On CA Proposition 65 list:** **Listed**

Water Quality Rating[2]

- Overall runoff risk rating: **Moderate**
- Source: *Pesticide Choice: Best Management Practice for Protecting Surface Water Quality in Agriculture*. UC ANR Publication 8161.

Impact on Natural Enemies

- Overall toxicity rating: **Moderate To High**
- Specific impacts: predatory mites (**Moderate**), parasitoids (**Moderate**), general predators (**High**)

Impact on Honey Bees[3]

- Toxicity category: **I - Do not apply to blooming plants**
- Notes: carbaryl baits less toxic to bees than sprays.

Pests for which it is mentioned in Pest Notes

Asian Citrus Psyllid • Bark Beetles • Biological Control and Natural Enemies • Carpenterworm • Codling Moth • Earwigs • Elm Leaf Beetle • Goldspotted oak borer • Grasshoppers • Hoplia Beetle • Lawn insects • Roses in the Garden and Landscape: Insect and Mite Pests and Beneficials • spider mites • Snails and Slugs

Application Tips

Foliar sprays with emulsifiable concentrate (EC) formulation:
Pests are killed by consumption, so good coverage of consumed surfaces is required. Compressed air or backpack sprayers are desirable for good coverage on trees; other sprayers are acceptable on smaller plants.

Squash bugs:
Apply dusts or sprays especially to the base of plants when eggs are laid and bugs aggregate. Repeat application about 2 weeks later. Do not apply to blossoms.

Trunk sprays:
Purchase a product labeled for bark treatments and apply at the rate recommended for trunk treatments. Carbaryl applied at foliar rates will not control borers. Timing is critical. For elm leaf beetle, sprays must kill mature larvae as they crawl down the trunk. For borers, sprays must kill adults before they lay eggs and be applied to cover the trunk, crotches, and lower limbs. Keep carbaryl off foliage as much as possible to prevent killing natural enemies and inducing mite problems. Keep sprinklers directed away from the trunk to avoid washing off the spray.

Precautions and Safety Equipment

Minimize your exposure to pesticides. Avoid contact with eyes. Wear eye protection, long pants, a long-sleeved shirt, and a hat that can be washed after each use. Always read label of individual product for additional directions.

Always check the label before purchasing or applying a pesticide product for a specific pest on a specific plant to be sure it can be applied. Follow label directions precisely.

WARNING ON THE USE OF CHEMICALS

Example home, garden or landscape use products[6]

GardenTech Sevin Concentrate Bug Killer • GardenTech Sevin Lawn Insect Granules • Gardentech Sevin Ready-To-Use • GardenTech Sevin RTS Bug Killer • Gardentech Sevin-5 Ready-To-Use 5% Dust

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Footnotes

1. Potential Hazard Rating: VL=Very low, L=Low, LM=Low to Moderate, M=Moderate, LH=Low to High, MH=Moderate to High, H=High, VH=Very High, N=None, NKR=No Known Risk, —=No data
2. Water quality ratings from *Pesticide Choice: Best Management Practice (BMP) for Protecting Surface Water Quality in Agriculture*, ANR Publication 8161, or the USDA-NRCS WIN-PST database—see *Pesticides: Water-Related Toxicology of Active Ingredients*.
3. Honey bee ratings are: (Very High) I-Do not apply to blooming plants; (High) II-Apply only during late evening; (Moderate) III-Apply only during late evening, night, or early morning; and (Low) IV-Apply at any time with reasonable safety to bees. For more information, see *How to Reduce Bee Poisoning From Pesticides* (PDF), Pacific Northwest Extension Publication PNW591.
4. Acute oral toxicity ratings for people and other mammals based on LD50 and US EPA Acute Toxicity Ratings system: H = Highly Toxic (LD50 <50), M = Moderately Toxic (LD50: 50-500), L = Slightly Toxic (LD50: 500-5000), VL = Not Acutely Toxic (LD50 >5000)
5. Long term ratings indicate whether the active ingredient is on the California Prop 65 list, which indicates if materials are known to cause cancer or reproductive toxicity, or whether the US EPA has classified the pesticide as "likely to be carcinogenic to humans", "Group B-Probably Human Carcinogen", or "Group C-Possible Human Carcinogen."
6. These products were registered for home and garden use in California in July 2013. Professional use products are not included. If no example products are listed, this active ingredient may be available only for professional use. Individual products are registered for specific uses on specific sites. Read the label to determine if the product is registered for your use. Note that some products may be formulated with additional pesticides.

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chemical	Acres Treated: Carbaryl (105; 63-25-2)									
year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
site										
Alfalfa (23001)	865.58	557	484	704	76.3		93	298	832	407
Almond (3001)	242.01	357.11	224	225	33	978.92	1,484.50	70	106	281.4
Animal Premise (61001)										
Apple (4001)	7,315.90	5,958.04	4,787.15	4,818.05	5,522.24	3,719.02	2,694.96	3,902.01	3,172.25	3,570.71
Apricot (5001)	126.25	110	99.25	16	31.21	10	10	91.25	2	
Asparagus (16002)	1,416.94	1,608.46	1,584.83	123.8	851.03	1,624.26	40	2,143.55	1,522.22	935.2
Avocado (28000)										
Barley (29103)					44					
Bean, Dried (15001)	508	85	95	114	182	250		146	74.5	
Bean, Succulent (15003)	336.5	234.5	464	152	182	218	50			0.25
Bean, Unspecified (28001)	10			16	10					
Beet (29109)	22.32		3			6.66				
Bermudagrass (22017)		72								
Blackberry (1002)	2.5				0.84	16.54	28	12	16	
Blueberry (1009)		4			52	4	4			
Bok Choy (13502)	7.5	2.5						3	10	5
Boysenberry (1003)	46									
Broccoli (13005)	62.06	5.3	367	237.3	461	567.35	147.83	12.5	113.82	21
Brussels Sprout (13006)		10					120	16.6		
Cabbage (13007)	9.56	31.65	12	2.2	44.51	51.23	39	3.8		129.44
Cactus Leaf (13048)							16			29.8
Cactus Pear (6028)	239.3	459.6	737.45	1,143.80	634.7	626.9	344.3	1,217.30	1,417.50	1,077.40
Cantaloupe (10002)	8,029.50	9,593.90	13,071.48	8,849.68	8,562.86	4,650.03	5,677.40	7,839.15	6,997.48	5,507.77
Carrot (29111)	1,916.55	40		20		91	2		60	86.32
Cauliflower (13008)	6				100	23.49	12	10	12	46
Celery (29113)	54.9	33.4		68.35	533.51	471.98	517.8	240.05	63.5	14
Cherry (5002)	1,669.00	1,167.56	767.33	697	1,014.77	998.47	266.57	651.18	367.46	271.8
Chinese Cabbage (Nappa) (13010)	3.65	10.5	10.9	2.4	50.33	263.62				5
Chinese Greens (13999)	4									
Christmas Tree (30005)	20	15.5			18					
Citrus (2000)		16.9	74	20	0.02	0.04	0.03	1.57	7	4.41
Clover (23003)										18

chemical	Acres Treated: Carbaryl (105; 63-25-2)									
year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
site										
Collard (13009)	7.97		3.5							
Corn (Forage - Fodder) (22005)	5,574.42	2,908.70	2,909.55	1,486.30	2,084.50	2,712.58	223	733	1,232.00	204
Corn, Human Consumption (29119)	718.13	714.65	637.5	693.75	667	700	523	566	685.6	
Cotton (29121)	76				172	75	106	37.8		1
Cucumber (10010)	276	172.28	84	121	184.06	120.8	25.2	19		0.06
Daikon (14023)								3		
Eggplant (11001)	16.1	18	10			2	8	8.1		
Endive (Escarole) (13015)										
Forage Hay/Silage (22000)	773.2			20	225					1,230.20
Forest, Timberland (30000)			867		514	142				
Garlic (14007)										76
Grape (29141)	1,724.43	332.7	123.77	82.47	250.48	48.61	232.8	9.17	4.2	118.7
Grape, Wine (29143)	2,977.29	2,414.97	561.03	558.5	163.6	1,576.60	289.48	612.86	69.75	37
Grapefruit (2002)	88.2	33.2	117.4	95.1	150.8	100.2		57	25	149
Kale (13011)			1			4.5				
Kohlrabi (13012)										
Landscape Maintenance (30)	2	30	28.68	621	31		25		2	
Lemon (2004)	294.14	594.6	323.95	504.91	279.5	54.15	128.96	16.7	97.72	20
Lettuce, Head (13045)	1,847.53	819.1	635.3	1,337.40	1,459.60	223.3			22	4.9
Lettuce, Leaf (13031)	161.05	18.2	0.8	392.1	481	345.1		5		6.5
Melon (29122)	12,893.14	13,699.09	7,060.02	3,561.18	2,878.40	2,055.75	2,670.29	3,200.99	4,201.98	1,863.98
Mustard (29123)	6.16	4.26	16.34	15		3.52		4.28	13.94	17.86
N-Grnhs Flower (151)	1.5				0.89				2.53	
N-Grnhs Plants In Containers (153)	61.05	21.47	23.56	108.86	27.05	63.06	60.24	178.64	54.75	32.03
N-Grnhs Transplants (155)	10.76	62.95		4.8	33.92	8.8		1.03	1.21	
N-Outdr Flower (152)	112.1	61.72	351.35	33	91.18	460.09	217.51	100.38	85.07	70
N-Outdr Plants In Containers (154)	774.1	300.09	1,380.26	1,862.92	1,755.26	1,667.49	1,099.84	964.78	2,675.11	625.4
N-Outdr Transplants (156)	423.89	135.03	17.85	33.25	306.79	118.68	45.4	50.01	175.98	0.8
Nectarine (5003)	447.85	697.64	653.45	885.5	335.19	105	32.25	29.75	8	12
null				140	52.1	270			278.67	
Oat (29125)										
Olive (28014)	3,127.60	684.2	607	590.5	1,512.30	3,700.80	2,456.77	3,439.30	2,525.40	1,578.27

chemical	Acres Treated: Carbaryl (105; 63-25-2)									
year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
site										
Orange (2006)	5,570.78	2,635.03	2,797.03	2,220.90	2,428.49	1,177.32	765	1,827.39	1,628.43	3,349.35
Parsley (13022)							6			
Pastureland (28035)	178.4	60	31		160		18	55	44	
Peach (5004)	2,476.49	1,517.72	1,165.94	1,057.65	462.68	222.2	65.93	83.5	207.71	788.6
Peanut (29126)								1		
Pear (4003)	2,944.90	2,543.90	3,899.80	1,990.70	1,614.30	1,670.50	1,518.00	1,883.00	1,339.90	2,160.40
Peas (29127)								11		
Pecan (3008)	20			20						
Pepper, Fruiting (11003)	1,622.80	514.8	1,523.60	1,548.25	1,338.06	707.65	487.6	873.86	866	1,021.60
Pepper, Spice (8050)	204.9	55		75.4		20				
Pistachio (3011)	2,651.95	6,623.65	4,342.66	8,215.26	3,959.15	5,632.76	1,309.75	3,419.35	8,355.97	8,176.70
Plum (5005)	821.86	403.34	244.94	775.92	420.33	72.45	0.25	74.75	7.5	
Potato (14013)	1,064.50	604.9	1,830.99	717.1	890.8	1,935.00	3,388.70	1,399.30	1,835.50	788.7
Prune (5006)	62	64	70							
Pumpkin (10011)	73	249.5	119	49	20.2	28	24	280.5	111	56.5
Radish (14014)	2	0.07		10	11	74		155.05		
Rangeland (28045)		1,120.00			10	10	633	310.5	42	9
Raspberry (1006)		4					12		11	
Recreation Area (67002)							38			
Regulatory Pest Control (100)		6								
Research Commodity (99)	0.33	18.06		40	80	20	77.53	0.17	50.25	47.25
Rice (28072)	2,313.80	1,245.30	370.7	931.5	530.5	247.75	465	265	285	1,216.00
Rights Of Way (40)								40		
Safflower (29129)										54
Soil Fumigation/Preplant (40008)										70
Sorghum (Forage - Fodder) (22004)										
Sorghum/Milo (29131)		1,418.97								
Soybean (28023)	15.8									
Spinach (13024)			4.1		20					
Squash (10012)	173.87	53.5	141	16	143.5	57	12.08	51.58	28.5	2
Squash, Summer (10013)	23									
Squash, Winter (10014)										

chemical	Acres Treated: Carbaryl (105; 63-25-2)									
year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
site										
Squash, Zucchini (10015)									4	
Stone Fruit (5000)							0.5			0.5
Strawberry (1016)	2,007.00	1,853.50	1,653.84	569.75	2,033.94	1,222.15	2,013.75	1,744.75	722.7	599.34
Sudangrass (22011)					17		82			40
Sugarbeet (29135)	4,597.70	2,149.60	931		50					
Sunflower (29133)		103.7	40			105				
Sweet Potato (14018)					17	17	15			
Swiss Chard (13025)	1.88		1.5		4.77					
Tangelo (2007)			5			31				
Tangerine (2008)	333.88	166.68	41	170.1	66.4	56		119.9	2,306.16	1,522.05
Timothy (22029)		65								998.5
Tomato (11005)	5,147.54	2,904.29	3,459.81	4,702.37	1,611.40	1,340.61	2,070.67	1,152.15	4,113.70	3,208.29
Tomato, Processing (29136)	7,149.08	12,215.88	28,132.90	34,770.06	55,844.98	30,929.85	27,802.10	50,978.19	47,004.73	63,845.88
Turf/Sod (33008)	3						30			
Turnip (29137)										
Uncultivated Ag (66000)		148				5		1,545.74	150	289.52
Uncultivated Non-Ag (67000)		5	6		10			77.5	1	
Vegetable (28024)							1	0.1		
Vertebrate Control (80)										
Walnut (3009)	187.2	81	124	86	24	189	102	58	44	166
Watermelon (10008)	1,010.19	311.12	942.53	1,697.45	1,594.54	170	610	331.52	259.74	615.9
Wheat (29139)			310							
Wheat (Forage - Fodder) (22007)										49
Totals	95,966.47	83,237.29	91,383.03	90,020.54	105,422.98	75,069.78	61,238.98	93,433.55	96,353.45	107,533.28

chemical	Pounds Active Ingredient: Carbaryl (105; 63-25-2)								
year	2006	2007	2008	2009	2010	2011	2012	2013	2014
site									
Alfalfa (23001)	813.67	557.11	742.2	92.98		23.65	286.78	840.67	403.53
Almond (3001)	294.76	695.63	45.06	65.76	1,599.05	1,239.10	163.6	298.78	408.4
Animal Premise (61001)									
Apple (4001)	11,491.43	8,304.29	9,339.41	10,308.02	8,195.23	5,320.22	7,335.69	6,031.55	6,145.07
Apricot (5001)	866.46	159.3	30.84	61.49	9.89	9.89	612.13	2.25	
Asparagus (16002)	1,979.44	2,515.47	247.59	906.21	2,708.81	81.7	4,291.58	1,544.18	935.7
Avocado (28000)									
Barley (29103)				44					
Bean, Dried (15001)	48.5	71.25	114	94.5	110.75		147.86	114.12	
Bean, Succulent (15003)	207.82	405.33	98.75	227.75	182.88	23.75			0.02
Bean, Unspecified (28001)			120	20					
Beet (29109)		6			8.11				
Bermudagrass (22017)	90								
Blackberry (1002)				1.6	31.79	48.72	23.99	31.83	
Blueberry (1009)	4.09			103.97	3.98	5.93			
Bok Choy (13502)	5						3	19.7	5
Boysenberry (1003)									
Broccoli (13005)	6.36	592.51	174.48	118.19	421.53	286.62	9.8	171.25	38.98
Brussels Sprout (13006)	10					51.59	33.03		
Cabbage (13007)	59.35	23.99	4.4	44.87	92.26	81.61	1.74		185.61
Cactus Leaf (13048)						24			50.15
Cactus Pear (6028)	938.78	1,506.34	2,208.01	1,296.44	1,280.51	703.27	2,306.39	2,745.46	2,120.91
Cantaloupe (10002)	5,200.27	6,539.19	4,243.59	5,108.12	2,576.08	3,551.82	4,753.03	4,891.52	2,963.35
Carrot (29111)	30		25		103.5	1.5		71.07	15.95
Cauliflower (13008)				52	28.89	13.84	12	11.96	16
Celery (29113)	48.92		83.76	952.57	806.37	840.07	431.49	88.72	27.99
Cherry (5002)	3,106.53	2,136.44	1,705.42	5,958.30	3,012.87	549.06	2,940.44	1,240.99	835.4
Chinese Cabbage (Nappa) (13010)	21	15.04	2.44	32.43	413.55				5.04
Chinese Greens (13999)									
Christmas Tree (30005)	2.98			18					
Citrus (2000)	94.95	486.78	80	64.18	1.05	1.52	6.85	3.29	6.15
Clover (23003)									27.15

chemical	Pounds Active Ingredient: Carbaryl (105; 63-25-2)								
year	2006	2007	2008	2009	2010	2011	2012	2013	2014
site									
Collard (13009)		7							
Corn (Forage - Fodder) (22005)	2,322.76	2,256.11	854.67	1,289.74	1,956.24	63.85	369.82	867.3	253
Corn, Human Consumption (29119)	1,236.24	1,261.77	1,225.97	1,222.72	1,204.09	1,053.22	1,114.64	1,195.38	
Cotton (29121)				92.45	0.75	203.5	3.31		0.99
Cucumber (10010)	72.45	63.5	59.55	174.06	62.9	25.26	14.55		0.01
Daikon (14023)							0.77		
Eggplant (11001)	22.5	9.85			1.99	12.24	8.42		
Endive (Escarole) (13015)									
Forage Hay/Silage (22000)			15	225					1,844.27
Forest, Timberland (30000)		514.99		294.59	539.2				
Garlic (14007)									76
Grape (29141)	458.18	106.3	89.04	63.5	46.95	313.58	16.76	4.97	21.7
Grape, Wine (29143)	4,308.32	864.75	245.32	173.88	1,479.81	316.45	923.41	57.01	62.84
Grapefruit (2002)	265.36	1,197.80	1,006.20	1,436.83	733.54		413.9	147.47	1,479.39
Kale (13011)		1.6			4.52				
Kohlrabi (13012)									
Landscape Maintenance (30)	28	21.5	195.88	130.89		1.18		1.18	
Lemon (2004)	5,372.49	2,664.73	4,760.53	2,827.15	257.55	617.82	20.52	486.97	100.28
Lettuce, Head (13045)	1,213.41	604.55	985.05	424.02	352.3			44.12	9.76
Lettuce, Leaf (13031)	30.3	1.6	111.21	101.6	399.08		10		6.5
Melon (29122)	9,153.85	4,740.08	2,587.87	1,966.36	1,221.09	1,791.52	2,200.28	3,059.37	1,215.59
Mustard (29123)	8.29	33.31	10.18		5.86		4.26	13.96	17.65
N-Grnhs Flower (151)				0.04				0.05	
N-Grnhs Plants In Containers (153)	14.64	19.15	44.52	60.09	42.17	18.64	510.53	104.88	60.83
N-Grnhs Transplants (155)	115.73		8.8	65.28	16.7		1.49	1.11	0.67
N-Outdr Flower (152)	27.11	258.32	17.87	76.96	143.42	147.02	76.91	53.11	55.2
N-Outdr Plants In Containers (154)	313.93	716.73	870.74	1,391.91	1,444.11	734.34	998.3	811.11	491.11
N-Outdr Transplants (156)	173.08	23.04	23.57	159.73	179.13	183.92	128.55	131.74	0.8
Nectarine (5003)	2,570.99	2,427.57	3,335.62	997.26	362.69	98.06	86.46	31.22	36.1
null			140	20.84	135			557.86	
Oat (29125)									
Olive (28014)	3,940.21	2,948.04	1,811.58	5,938.32	16,179.89	9,542.48	11,250.76	9,224.00	6,293.76

chemical	Pounds Active Ingredient: Carbaryl (105; 63-25-2)								
year	2006	2007	2008	2009	2010	2011	2012	2013	2014
site									
Orange (2006)	26,235.89	27,624.44	22,476.34	21,591.27	14,685.45	3,769.26	10,775.29	13,636.67	34,394.42
Parsley (13022)						4.8			
Pastureland (28035)	60.06	30.01		80		27	55	66	
Peach (5004)	5,264.97	4,056.87	4,083.33	1,519.38	760.69	137.82	221.54	615.26	2,860.95
Peanut (29126)							2.04		
Pear (4003)	5,084.45	9,214.84	4,871.86	3,906.70	3,790.26	3,330.30	4,171.02	3,302.53	5,393.37
Peas (29127)							11		
Pecan (3008)			80.08						
Pepper, Fruiting (11003)	565.78	1,682.38	1,467.54	879.29	539.84	717.33	659.42	562.8	594.39
Pepper, Spice (8050)	47		113.1		40				
Pistachio (3011)	14,003.52	6,366.01	6,637.19	5,405.23	6,862.05	1,723.84	2,890.07	8,185.41	8,978.48
Plum (5005)	1,341.07	927.76	2,803.12	1,111.50	293.09	0.8	235.82	27.46	
Potato (14013)	627.81	1,833.07	722.73	1,057.49	2,201.83	3,853.05	1,699.44	2,093.11	945.52
Prune (5006)	68.45	137.9							
Pumpkin (10011)	206.95	78.19	37.26	15.61	19.96	22	280.69	98.07	56.48
Radish (14014)	0.06		9.94	10.94	200.19		152.36		
Rangeland (28045)	1,519.22			342.5	10	301.45	221.42	20.43	8
Raspberry (1006)	4					23.86		21.88	
Recreation Area (67002)						988.78			
Regulatory Pest Control (100)	2.58								
Research Commodity (99)	10.06		30	80	20	46.52	1.61	9.09	7.21
Rice (28072)	1,483.97	420.7	988.96	477.54	371.44	654.01	262.46	426.28	1,054.36
Rights Of Way (40)							40.85		
Safflower (29129)									30.25
Soil Fumigation/Preplant (40008)									35
Sorghum (Forage - Fodder) (22004)									
Sorghum/Milo (29131)	2,837.95								
Soybean (28023)									
Spinach (13024)		0.1		4					
Squash (10012)	51.62	140.98	10.95	135.45	56.98	12.1	51.61	28.51	1.99
Squash, Summer (10013)									
Squash, Winter (10014)									

chemical	Pounds Active Ingredient: Carbaryl (105; 63-25-2)								
year	2006	2007	2008	2009	2010	2011	2012	2013	2014
site									
Squash, Zucchini (10015)								5	
Stone Fruit (5000)						3.96			4.01
Strawberry (1016)	2,564.35	2,689.04	1,054.18	2,879.46	1,775.32	3,514.44	3,005.21	1,293.45	1,036.63
Sudangrass (22011)				1.28		113.1			80.08
Sugarbeet (29135)	1,246.90	999.5		50					
Sunflower (29133)	4.49	80			75				
Sweet Potato (14018)				45	20.39	18			
Swiss Chard (13025)		3		0					
Tangelo (2007)		60			337				
Tangerine (2008)	663.84	364	1,527.06	710.96	426.99		739.16	12,335.79	6,024.19
Timothy (22029)	97.62								1,498.26
Tomato (11005)	1,433.31	2,014.23	4,056.22	1,809.16	1,579.67	1,772.12	1,160.17	2,906.67	1,945.86
Tomato, Processing (29136)	10,289.98	25,205.49	27,256.95	39,479.64	18,607.55	16,531.32	32,922.28	26,756.49	35,772.74
Turf/Sod (33008)						128.05			
Turnip (29137)									
Uncultivated Ag (66000)	147.14				9.89		790.47	2,988.92	182.15
Uncultivated Non-Ag (67000)	0.56	4.99		20			77.5	1.75	
Vegetable (28024)						0.5	1.25		
Vertebrate Control (80)									
Walnut (3009)	265.64	505.56	264.26	41.96	293.34	106.89	85.6	224.13	282.89
Watermelon (10008)	70.29	431.85	973.23	1,058.02	169	309.26	195.89	222.06	342.54
Wheat (29139)		465							
Wheat (Forage - Fodder) (22007)									21.5
Totals	133,167.65	130,092.90	117,128.41	127,417.00	101,501.98	66,091.52	102,222.23	110,727.87	127,768.07

	Pounds Active Ingredient: Carbaryl (105; 63-25-2)
year	2014
Aerial Applications	8,104.87
Ground Applications	119,654.95
Other	8.25
Totals	127,768.07
	Acres: Carbaryl (105; 63-25-2)
year	2014
Aerial Applications	5,997.60
Ground Applications	101,496.18
Other	39.5
Totals	107,533.28

	Acres Treated: Carbaryl (105; 63-25-2)
year	2014
Formula	
Dust/Powder	107
Emulsifiable Concentrate	1,360.83
Flowable Concentrate	3,883.14
Granular/Flake	7,098.60
Impregnated Material	2.25
Liquid Concentrate	4,043.37
Microencapsulated	0.2
Other (Dry)	8,881.01
Pellet/Tablet/Cake/Briquet	67,517.72
Soluble Powder	0.1
Solution/Liquid (Ready-To-Use)	615.62
Suspension	14,018.19
Wettable Powder	5.25
Totals	107,533.28
	Pounds Active Ingredient: Carbaryl (105; 63-25-2)
year	2014
Formula	
Dust/Powder	25.23
Emulsifiable Concentrate	8,652.37
Flowable Concentrate	7,875.95
Granular/Flake	3,670.39
Impregnated Material	0.19
Liquid Concentrate	16,330.20
Microencapsulated	0.02
Other (Dry)	4,500.95
Pellet/Tablet/Cake/Briquet	41,701.69
Soluble Powder	0.12
Solution/Liquid (Ready-To-Use)	1,995.44
Suspension	43,007.11
Wettable Powder	8.43
Totals	127,768.07

Department of Pesticide Regulation

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Director

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Governor

M E M O R A N D U M

TO: Lisa Ross, Ph.D.
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Via: Kevin Solari
Environmental Program Manager I
Worker Health and Safety Branch

FROM: Michael Zeiss, Ph.D.
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DATE: May 19, 2016

SUBJECT: CRITICAL USES OF CARBARYL WITHIN CALIFORNIA

Contents

1. Summary

During 2015-2016, the Department of Pesticide Regulation (DPR) conducted fact-finding about why and how the insecticide carbaryl is used within California. The goal of the fact-finding was to learn about stakeholders' needs regarding critical uses of carbaryl, to help DPR select among several mitigation options that would all be equally protective. This document uses the term "critical use" as meaning a current legal use of carbaryl that addresses an important need and for which there are few or no feasible alternatives to the use of carbaryl.

To make most efficient use of its resources, DPR intentionally limited its fact-finding to seven crops or use categories in which carbaryl use is relatively high. Fact-finding indicated carbaryl critical uses in five use categories:

- **Apple production**: chemical fruit thinning (liquid formulations of carbaryl);
- **Melon production**: control of soil-dwelling insect pests (granular formulations);
- **Non-production plantings of ornamental plants:** eradication of incipient infestations of glassy-winged sharpshooter (GWSS), under the direction of quarantine officials of the California Department of Food and Agriculture (CDFA) (liquid formulations);
- **Ornamental-plant production**: prophylactic control of GWSS on shipments from GWSS-infested counties in southern California to uninfested California counties, as required by quarantine regulations (liquid formulations); and
- **Tomato production**: control of soil-dwelling insect pests shortly after planting (granular formulations).

Though not meeting this document's definition of "critical", the following carbaryl uses are valued by industry or CDFA quarantine officials and should be carefully considered when selecting among mitigation options:

- **Citrus production**: no critical uses per se, though carbaryl is a valuable tool for late-season control of red scale, for helping prevent resistance, and for control of multiple insect species with a single application, and is one of several pesticides effective against Asian citrus psyllid (liquid formulations); and
- **Olive production**: no critical uses per se, though carbaryl is a useful rotation insecticide for scale control to help prevent resistance (liquid formulations).

Critical uses that involve granular formulations, namely those within melon and tomato production, produce lower foliar residues and thus may be simpler to mitigate than those involving liquid formulations.

2. Purpose

This memorandum summarizes fact-finding by DPR about carbaryl use within California. Carbaryl is a broad-spectrum carbamate insecticide used in production of fruits, nuts, field crops, and ornamental plants. In addition, carbaryl is used on non-production plantings including turf, landscaping, and home gardens. As of April 2016, there are 21 carbaryl products with active California registrations. Summaries of those products are included in Zeiss (2015).

In June 2014, DPR completed an assessment of human health risks associated with carbaryl use (Rubin 2014). The resulting Risk Characterization Document (RCD) concluded that estimated risks include Margins of Exposure (MOEs) less than 100 or cancer risks greater than 10^{-6} for many of the carbaryl exposure scenarios that involve:

- occupational handlers;
- occupational re-entry by workers, *primarily of concern for planted areas treated with liquid formulations* (not granular bait formulations);
- residential handlers and residential re-entry; and
- bystanders (Rubin 2014).

Risk managers within DPR currently are evaluating the RCD to determine whether any of the estimated risks will require mitigation.

To help prepare for the possibility of mitigation action, during 2015-2016 DPR conducted fact-finding about why and how carbaryl is used within California. The goal of the fact-finding was to learn about stakeholders' needs regarding critical uses of carbaryl, to help DPR select among several mitigation options that would all be equally protective. DPR's mission is, "to protect human health and the environment by regulating pesticide sales and use, and by fostering reduced-risk pest management" (DPR 2013b). In cases when any one of several mitigation options would serve to achieve this mission, DPR considers stakeholders' needs when selecting among equally-protective mitigation options. This memorandum summarizes the findings of DPR's fact-finding.

3. Definition of "critical use"

During fact-finding about carbaryl uses, DPR scientists seldom used the phrase "critical use". Instead, DPR scientists asked open-ended questions about which carbaryl uses were important, and what non-carbaryl alternatives (if any) were available.

Nonetheless, for convenience, this document will use the term "critical use" as meaning ***a current legal use of carbaryl that addresses an important need and for which there are few or no feasible alternatives to the use of carbaryl***. For carbaryl, "important need" can include controlling economically-important insect pests, or achieving economically-important fruit characteristics via carbaryl's direct effect on fruit-tree growth patterns. In previous assessments of other pesticides, some experts have recommended also including longer-term needs such as managing the evolution of pests' resistance to alternative pesticides (UCIPM 2014a). In this document, needs such as resistance management are considered and discussed, but are not included within "critical use".

For additional perspectives on the "critical use" concept, see the 2014 report on critical uses of chlorpyrifos (UCIPM 2014a), and the 1997 decision on critical-use exemptions for methyl bromide (UNEP 1997).

4. Scope of DPR's carbaryl fact-finding

4.1 Use categories

Carbaryl insecticide products are registered in California for use on more than 45 distinct crops or use categories (Zeiss 2015). To make most efficient use of its resources, DPR intentionally limited its fact-finding to the following seven use categories:

- apple production;
- citrus production;
- melon production;
- non-production plantings of turf or other ornamental plants (distinct from production of ornamental plants);
- olive production;
- ornamental-plant production; and
- tomato production (both processing and fresh-market).

DPR selected those use categories because they had the highest total quantity of reported carbaryl use (pounds of active ingredient), or had the highest number[1] of reported carbaryl applications, within California during recent years (Zeiss 2015). Though this was a logical decision, it might inadvertently have excluded certain use categories with small but critical carbaryl uses. If DPR receives information about carbaryl critical uses within additional use categories, DPR will consider those additional uses when selecting mitigation options.

4.2 Information sources

During fact-finding, DPR scientists contacted selected University of California staff, County Agricultural Commissioner staff, and private-sector companies and organizations associated with the selected use categories (for example, the California Landscape Contractors Association and California Citrus Mutual). Information collection included telephone discussions, email correspondence, written questionnaires, in-person meetings, and field visits to observe selected crop-production practices. Representative examples of the questionnaires are shown in Appendix 1 and 2.

For each of the selected use categories, DPR has received information from at least four independent sources. Information collection is essentially complete, though surveys from one industry association are still pending as of April 2016. Names and affiliations of individual experts are intentionally excluded from this memorandum. Experts' views and opinions

[1] California regulations define production agriculture as the production for sale of agricultural commodities as defined in 3 CCR 6000. For production-agriculture use categories, California regulations require that pesticide use reporting be location-specific and time-specific. Thus for production-agriculture use categories, it is straightforward to count the actual number of unique applications such that each application has a unique combination of location and date. In contrast, for non-production and non-agricultural use categories, pesticide use reporting is via a monthly summary of total quantity used of each pesticide. Therefore, it is not possible to count the number of unique applications. Instead, for non-production and non-agricultural use categories, DPR estimated the number of applications by counting the number of monthly-summary reports submitted per use category.

summarized in this memorandum are solely those of the experts contacted, and do not necessarily represent the views of DPR. Mention of commercial products is not to be construed as either an actual or implied endorsement, nor as an indication that DPR considers one product to be more efficacious than another.

Independent of DPR's fact-finding, a team managed by CDFA's Office of Pesticide Consultation and Analysis (OPCA) also has been assessing carbaryl critical uses. DPR scientists have communicated and shared information with OPCA, and DPR will consider any findings reported by the OPCA team.

5. Findings: critical uses of carbaryl within California

In summary, fact-finding indicated carbaryl critical uses in five use categories:

- **Apple production**: chemical fruit thinning (liquid formulations of carbaryl);
- **Melon production**: control of soil-dwelling insect pests (granular formulations);
- **Non-production plantings of ornamental plants:** eradication of incipient infestations of glassy-winged sharpshooter (GWSS), under the direction of CDFA quarantine officials (liquid formulations);
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- **Tomato production**: control of soil-dwelling insect pests shortly after planting (granular formulations).

Though not meeting this document's definition of "critical", the following carbaryl uses are valued by industry or CDFA quarantine officials and should be carefully considered when selecting among mitigation options:

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- **Olive production**: no critical uses per se, though carbaryl is a useful rotation insecticide for scale control to help prevent resistance (liquid formulations).

Detailed findings are presented below, in alphabetical order by use category.

5.1 Apple production

Includes a critical use of carbaryl: **fruit thinning**. Certain liquid-formulation carbaryl products are labeled for fruit thinning on apple. Chemical fruit thinning intentionally removes a portion of the immature fruits from the tree. Fruit thinning can help improve fruit yield and quality for the current year, and improve bloom for the following year (Grant et al. 2006).

For fruit thinning, liquid carbaryl formulations are applied via airblast sprayer, usually one or two applications in April (Figure 1). Exact timing varies with apple variety and annual weather patterns. All experts contacted agreed that chemical thinning would become more difficult if carbaryl mitigation required changes to application method (airblast), timing, or application rate for carbaryl. The following are representative examples of experts' comments:

> "Good coverage is extremely important, very difficult to penetrate tree canopy without air[blast]." "Thorough and uniform coverage of all flowers/fruitlets is important. The thinning effect is very localized."

> "The timing of carbaryl applications for thinning is very time sensitive. Applications outside the optimal window for each variety are ineffective and the results are very difficult to predict."

> "The rate of carbaryl is dependent on variety, tree condition and weather dependent. Using a rate lower than those dictated by the specific conditions would result in sub-optimal effects (less thinning)."

Regarding alternatives, several other plant growth regulators commonly are used for apple thinning, but all are typically used *in combination with carbaryl*. As one expert put it:

> "Other products are usually based around the use of [carbaryl] as the main thinning agent. NAA [1-naphthaleneacetic acid] and NAD [1-naphthaleneacetamide] both can cause pigmy fruit in California; Ethrel [ethephon] can over thin, MaxCel [6-benzyladenine] needs [carbaryl] to thin properly."

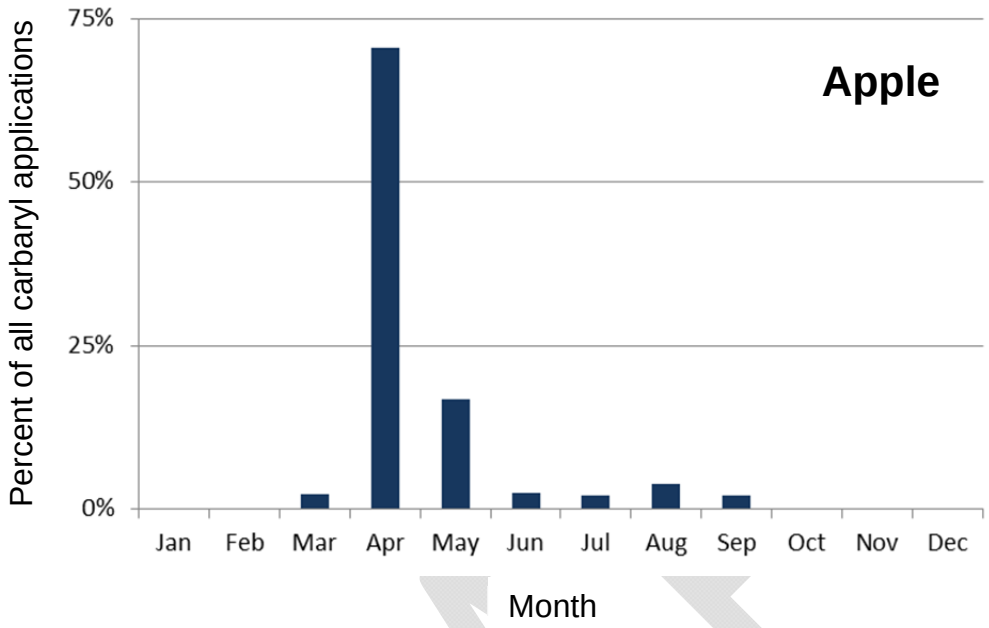
This is consistent with UCIPM guidelines, which specify carbaryl as part of the tank mix for each of the apple varieties mentioned (Grant et al. 2006).

A second expert added:

> "Carbaryl has at least one especially desirable thinning capability that I have not found on other tested PGRs [plant growth regulators]. It has the ability to 'singulate' fruitlet clusters. All the other thinners I have trialed reduce fruit load by removing the entire flower or fruitlet clusters. The ideal effect, more or less unique to Sevin, is the removal [of] the lateral fruitlets, leaving the 'king' fruitlet which has greater sizing potential than the lateral ones."

Figure 1. Timing of carbaryl applications to California apple fields, 2009 – 2013

Source of data: DPR Pesticide Use Report database (DPR 2015b).



5.2 Citrus production

Citrus does not include any carbaryl critical uses, per se. However, it does include several uses that are valued by industry or CDFA quarantine officials and that should be carefully considered when selecting mitigation options. These are listed below, in approximate order of importance. All uses described below use liquid formulations.

5.2.1 Asian citrus psyllid (ACP)

This sucking insect vectors the bacterium that causes the devastating citrus disease huanglongbing, also known as citrus greening (UCIPM 2016a). The Plant Health and Pest Prevention Services of the California Department of Food and Agriculture (CDFA) administers California's ACP quarantine. ACP quarantine regulations do not restrict movement of citrus fruits, but do require pesticide treatments of regulated citrus nursery stock[2] (CDFA 2015a). However, carbaryl is merely one of four active ingredients approved by CDFA for foliar treatment of nursery stock moving within an ACP quarantine area. In contrast, for nursery stock that will be moved interstate, CDFA does not approve carbaryl, and instead approves five other foliar active ingredients (CDFA 2015a).

[2] For the list of plant species regulated under the State Interior Quarantine for Asian Citrus Psyllid, see California Code of Regulations, title 3, section 3435(c), available at: http://pi.cdfa.ca.gov/pqm/manual/htm/420.htm

In areas where ACP has become established, citrus growers must manage ACP populations in their production orchards. However, in UCIPM guidelines for citrus, carbaryl is merely one of eight broad-spectrum foliar insecticides recommended for ACP control. Of the eight, carbaryl is listed last, whereas "pesticides having the greatest IPM value [are] listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top" (UCIPM 2016a).

There is no question that ACP and the pathogen it vectors have the potential to cause severe economic damage to the California citrus industry (UCIPM 2016a). Nonetheless, given the availability of alternative pesticides and their formal approval by CDFA, the use of carbaryl for ACP management does not meet this document's definition of "critical use". However, I recommend that DPR consider ACP management in citrus when designing any future mitigation.

5.2.2 Fuller rose beetle

This flightless beetle causes only minor direct damage to California citrus, but nonetheless is important because of quarantine prohibitions against its eggs by key citrus-fruit importing countries such as Korea (UCIPM 2015b). Some citrus experts stated that Fuller rose beetle is not adequately controlled by alternative insecticides. In addition, some fruit-importing countries reportedly have not established Maximum Residue Limits (MRL's) for some alternative insecticides, but do have MRL's in place for carbaryl.

However, at a 2016 meeting of citrus experts, consensus was that several other active ingredients have good efficacy against Fuller rose beetle. This is consistent with UCIPM guidelines, which list a total of eight active ingredients (UCIPM 2015b). Korea currently has MRLs for seven of those eight active ingredients; the only exception is cryolite (Bryant Christie, Inc. 2016).

5.2.3 California red scale

This armored scale is a key pest of California citrus. Reasons why carbaryl can be important for managing red scale include:

- Few alternatives for mature scales. Several citrus experts stated carbaryl is the only effective option during mid to late season (July-August), when scales are too mature for insect growth regulators (IGRs). As one expert put it, "Once scale survives a May application, it explodes in July and August." This may be exacerbated by changing weather patterns. Since first California registration in 1998, insect growth regulators (IGRs) typically have provided good control if applied in June-July, when crawlers (immature scales) had emerged from nearly all red scales (UCIPM 2015c). However, a 2016 meeting of citrus experts reported that in recent years, unusually warm weather has enabled red scale populations to continue development even during the winter. This reportedly has resulted in overlapping generations, which reduces IGR effectiveness because less-susceptible life stages are now present throughout the year. Systemics such as spirotetramat are active against all scale stages (UCIPM 2015c), but the 2016 meeting of citrus experts stated systemics did not give adequate control of populations on older woody branches. As one expert put it, "What worries me about systemics is, they leave an untreated hole in the center of the tree that's like

a mini-insectary." Chlorpyrifos has good efficacy against most scale stages on most plant parts, but has an inconveniently long restricted entry interval (REI) of 5 days (UCIPM 2015c) and is being considered by U.S. EPA for regulatory action (USEPA 2015). Carbaryl avoids all these limitations: it is effective against a wide range of scale life stages, even on mature wood, and has an REI of only 3 days even if used at the highest rate (12 lbs carbaryl / acre) that labels allow for red scale.

- Resistance management. Several citrus experts mentioned the importance of including carbaryl in a rotation of insecticides to help prevent red scale from developing resistance to IGRs and systemics.

These management challenges are real, but do not meet this document's definition of "critical uses". The availability of narrow-range oil, IGRs, systemics, and chlorpyrifos (UCIPM 2015c) provides alternatives for managing both mature scales and resistance. Nonetheless, I recommend that DPR consider the need to manage red scale on citrus when designing any future mitigation.

5.2.4 Secondary or occasional pests, especially simultaneous control of multiple species

"Secondary" or occasional pests of citrus include soft scales such as black scale, brown soft scale, and cottony cushion scale, as well as some of the pest species previously discussed. Although these are occasional pests, they do require control in some orchards and some years. Reasons why carbaryl can be important for managing these pests include:

- Some experts stated that these pests are not adequately controlled by alternative insecticides. However, UC IPM guidelines for soft scales list several alternative insecticides, many of which are classified as having greater IPM value[3] than carbaryl (UCIPM 2015a). Further, several citrus growers reported they have not used carbaryl for any purpose during the past 10 years.
- Some experts stated that fruit-importing countries have not established MRLs for some alternative insecticides, but do have MRL's in place for carbaryl. However, all of the pesticides recommended by UCIPM for soft scales (UCIPM 2015a) currently have MRLs in Korea (Bryant Christie 2016). This is comparable to the situation for Fuller rose beetle, already discussed in section 4.2.2 above. Korea MRLs may become more problematic for the citrus industry in 2019, when Korea will switch to using only Korean national MRLs for commodities including citrus (Lantz 2016). However, the California citrus industry already is working with U.S. trade representatives to prepare for this transition (J. Cranney, California Citrus Quality Council, personal communication).
- Carbaryl can control multiple species of insect pests that can all be present within a single orchard. A 2016 meeting of citrus experts pointed out that controlling multiple pests with a single application, "minimizes costs, compaction, fruit damage, VOCs [from machinery engines], and risks for workers". It can also reduce water used as a carrier. While real, these benefits also are true for any broad-spectrum insecticide.

[3] IPM value is described as follows: "pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table" (UCIPM 2016a).

In summary, citrus has several carbaryl uses that are valued by the citrus industry or CDFA quarantine officials and that should be carefully considered when selecting mitigation options. Carbaryl can be a valuable tool for late-season control of red scale, for helping prevent resistance, for control of multiple insect species with a single application, and is one of several pesticides useful for controlling ACP. However, none of the citrus uses meet this document's definition of "critical use".

5.3 Melon production

Includes a critical use of carbaryl: use of granular bait formulations to control soil-dwelling insects, both at planting and during fruit development (Figure 2). In contrast, use of liquid carbaryl formulations to control cucumber beetles is not a critical use because there are more alternatives.

5.3.1 Baits for soil-dwelling insects

Every melon expert contacted (10 of 10) reported that insecticidal-bait application was a common and important pest management intervention to control soil-dwelling insect pests. The pests mentioned most often were cutworms[4] and darkling beetles, but also included wireworms[5], crickets and earwigs. This group of pests can cause three types of damage in melons:

1) Chewing the stems of young plants shortly after planting, when even a small amount of feeding can kill a plant;
2) Chewing into drip-irrigation tape, causing leaks that disrupt irrigation; and
3) Later in the season when fruits are maturing, chewing into fruits from below, directly damaging fruits and indirectly enabling microbes to rot the fruits.(UCIPM 2012a, 2012b). Even a small area of damage makes a fruit unmarketable (UC Davis 2016). A separate type of insect, cucumber beetles, also damage fruits in the same way (discussed in section 4.3.2 below).

Experts explained that bait is the most effective formulation for soil-dwelling insects because soil shields these insects from most contact insecticides. For early-season application, bait can be banded along the row of plants, or applied in a band over the top of drip tape to protect the tape. For later applications to protect fruit, bait is broadcast either via ground equipment or air.

Carbaryl is the only bait recommended by UCIPM to control either darkling beetle (UCIPM 2012a) or cutworms (UCIPM 2012b). Carbaryl is not the only bait formulation labeled for melons. There are at least two alternative active ingredients, permethrin and spinosad[6], that are available in bait formulations labeled for outdoor production-agriculture use on melon. None of the melon experts contacted mentioned the spinosad bait, which was first registered in California

[4] Cutworms refers to a group of caterpillar pests within the Order Lepidoptera.

[5] Wireworms are a group of beetle larvae pests within Order Coleoptera.

[6] The insecticidal bacterium *Bacillus thuringiensis* f. sp. *kurstaki* also is available in bait formulation, but has efficacy only against caterpillars in the Order Lepidoptera, and thus would not be expected to control darkling beetles, wireworms, crickets, or earwigs.

in 2010. For a separate crop, tomato, one expert's experience with spinosad bait is summarized in section 5.7 of this memo. A search of DPR's Pesticide Data Index (DPR 2016) indicated that DPR has received three studies on spinosad efficacy against cutworms in field crops including cucurbits, and one study of efficacy against darkling beetles in poultry-rearing facilities. Review of those studies is beyond the scope of this memo, but may be appropriate before DPR selects mitigation options.

Regarding the second bait alternative, permethrin, one melon expert stated that permethrin bait actually provided better control than did carbaryl bait, and that there was no substantial cost difference. However, the majority of melon experts (7 of 10) stated that carbaryl bait provides better control, and is cheaper. As one expert put it:

> "the [carbaryl] bait is more effective than the [permethrin] bait we have replaced it with. We band these materials over the plant row when the melons begin to emerge. Because it's in a small area (10-15% of the area) to use less material, it needs to be active longer for the pests to find it. I think the carbaryl is active longer than the permethrin."

The small number of alternatives, and reports that they are less effective than carbaryl, justifies classifying bait applications for soil insect control in melon as a critical use of carbaryl.

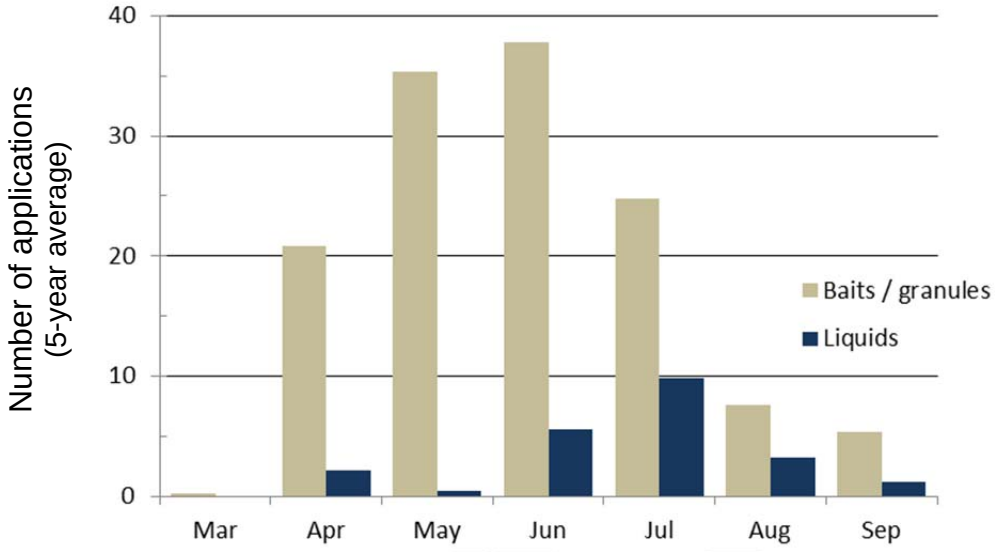
5.3.2 Liquid formulations for cucumber beetle

Developing melon fruits are susceptible to damage by both soil-dwelling insects (discussed above) and adult cucumber beetles. In the upper San Joaquin Valley and lower Sacramento Valley areas, cucumber beetle damage to melon fruits has increased in recent years, perhaps because of changes to agronomic practices including reduced tillage (UC Davis 2016). Several experts stated that carbaryl was an important tool for controlling cucumber beetle, including both bait and liquid formulations. The timing of reported use (Figure 2) suggests that most liquid is applied for late-season cucumber beetles. However, carbaryl is merely one of four active ingredients recommended for cucumber beetle (UCIPM 2012c). Therefore, the use of liquid[7] carbaryl formulations to control cucumber beetle in melons is not a critical carbaryl use. Likewise, use of liquid carbaryl formulations to control other melon pests such as flea beetles is not a critical use because several alternative pesticides are available (UCIPM 2012d).

[7] The conclusion about cucumber beetles has more significance for mitigation of liquid carbaryl formulations. It's a moot point for baits. Section 5.3.1 already concluded that late-season bait applications *to control soil insects* is a critical use, and such bait applications would simultaneously control cucumber beetles.

Figure 2. Timing of carbaryl applications to California melon fields, 2009 – 2013

Source of data: DPR Pesticide Use Report database (DPR 2015b).



5.4 Non-production plantings of turf and ornamental plants

Non-production plantings include:

- turf or other ornamental plants planted for the purpose of landscaping, recreation, or other uses outside the definition of production agriculture[8]; and
- food plants in home gardens or other locations from which the harvest is not sold (DPR 2014).

Thus, this use category is distinct from ornamental-plant production (section 5.6, below), in which a commercial enterprise produces plants for sale.

Most experts reported that carbaryl was seldom needed in non-production plantings. For example, in a survey conducted by California Landscape Contractors Association, 78% of respondents reported that they did not use any carbaryl in their businesses; and of those who did use carbaryl, 56% rated it as only "slightly important". Similarly, UC Advisors whom we contacted all stated there were effective alternatives to carbaryl. However, non-production plantings do include one carbaryl critical use: eradication of incipient GWSS infestations. In addition, use of carbaryl to control ACP is valued by CDFA quarantine officials and should be considered when selecting mitigation options. All major quarantine uses are listed below, in approximate order of importance. All use liquid formulations of carbaryl.

[8] California regulations define production agriculture as the production for sale of agricultural commodities as defined in 3 CCR 6000.

5.4.1 Glassy-winged sharpshooter (GWSS)

GWSS is economically important primarily as a vector of the bacterium that causes Pierce's disease, which can cause scorching, wilting, and death in various ornamental plants as well as grape (Varela et al. 2007). In recent years, CDFA and the County Agricultural Commissioners have used ground applications of carbaryl, cyfluthrin, and especially imidacloprid to control GWSS in several counties (DPR 2013a). Current guidance from UCIPM states:

> "The main material used to protect [GWSS]-susceptible plants in both commercial agriculture and urban landscapes is imidacloprid, which is registered for home and professional landscape use on nonfood crops. Imidacloprid is sold in two formulations: one for soil application and one for foliar application" (Varela et al. 2007).

Similarly, CDFA's Pierce's Disease Control Program (PDCP) stated the following in its 2015 report to the Calfornia legislature (the report did not mention carbaryl):

> "Imidacloprid has proven very effective against the GWSS. It is used in treatment programs in urban and residential settings and can be used for both foliar and soil treatment applications" (CDFA 2015c).

Although imidacloprid has proven to be an effective alternative to carbaryl, imidacloprid is currently under reevaluation in California and registration review at the Federal level (DPR 2015a). In addition, in response to DPR's request for input about carbaryl critical uses, CDFA's Plant Health and Pest Prevention Services informed DPR:

> "We'd like to keep the ACP and GWSS uses. . . . For the Urban/Residential side of the PDCP, including right-of-ways, carbaryl was a key product used that has helped us eradicate GWSS in multiple incipient infestations within the program"

Both because of the small number of proven alternatives, and because of the specific request from CDFA, I consider carbaryl use under the direction of CDFA quarantine officials to eradicate incipient infestations of GWSS on non-production plantings to be a critical use of carbaryl.

5.4.2 Asian citrus psyllid (ACP)

Carbaryl is one of several insecticides recommended by UCIPM for managing ACP in landscapes and home gardens (Grafton-Cardwell and Daugherty 2013). In contrast, the Residential Treatment Program for ACP control that is carried out by CDFA does not rely on carbaryl. Instead:

> "When a psyllid is found in these areas, all citrus and other known ACP host plants on a property and nearby properties receive a combination of two insecticides. These are a foliar pyrethroid insecticide to quickly kill adults and immature psyllids it comes in direct contact with, followed by a systemic

> (ground drench application) insecticide to provide sustained control of nymphs tucked inside young leaves" (Grafton-Cardwell and Daugherty 2013)

Another indication of the availability of alternative pesticides is CDFA's approval of several pesticides other than carbaryl for treatment of nursery stock within the ACP quarantine program (CDFA 2015a), as previously discussed in section 5.2.1. Nonetheless, CDFA's Plant Health and Pest Prevention Services informed DPR, "we'd like to keep the ACP and GWSS uses."

There is no question that ACP and the pathogen it vectors have the potential to cause severe economic damage to the California citrus industry (UCIPM 2016a). Nonetheless, given the availability of alternative pesticides and their formal approval by CDFA, the use of carbaryl for ACP management does not meet this document's definition of "critical use". However, I recommend that DPR consider ACP management in non-production plantings when selecting mitigation options.

5.4.3 Japanese beetle (JB)

Though common in the eastern U.S., this polyphagous pest is not established in California (CDFA 2016). CDFA and CAC staff conduct annual detection trapping, and when JB adults are detected, CDFA implements pesticide applications to eradicate the infestation (CDFA 2016). In recent years, CDFA eradication programs sometimes used carbaryl to kill adult JB on fruiting plants (e.g., CDFA 2015b). However, CDFA's Plant Health and Pest Prevention Services informed me, "We are moving away from it [carbaryl] on JB" (S. Brown, CDFA Plant Health and Pest Prevention Services, personal communication).

5.5 Olive production

Olive production does not include any carbaryl critical uses, per se. Black scale is one of the key pests of olive in California. Most olive experts contacted stated that liquid carbaryl formulations are an inexpensive and effective control for black scale. However, carbaryl is merely one of several pesticides recommended by UCIPM for black scale control on olive (UCIPM 2014b). Recommended alternatives include narrow range oil[9], methidathion, and pyriproxyfen, an insect growth regulator (IGR). The UCIPM recommendations are supported by comments from several olive experts such as the following:

> " for scale control there are potential alternatives, at least one alternative would be the IGRs, that have worked for scale pests and there are a number of systemics – such as neonicotenoids and lipid biosynthesis inhibitors that should also be investigated."

Because alternative pesticides are available and widely recognized as effective, scale control on olive is not a critical carbaryl use. Nonetheless, the number of proven alternatives is relatively

[9] Narrow range oil is highly-refined petroleum oil that kills certain pests primarily by smothering. Synonyms include crop oil and horticultural oil (UCIPM 2016b).

small, and several olive experts stated that carbaryl was a useful rotation insecticide to help prevent resistance. As one expert put it:

> "Resistance management: although IGRs work well against scales, growers should avoid using IGRs year after year, to avoid the risk of resistance to IGRs. Crop oil, by itself, does not adequately control scales in olive."

An additional limitation of the alternatives is that they are primarily for application after olive harvest (dormant or delayed dormant applications). Although pyriproxyfen product labels do allow "in-season cover spray" on olive, UCIPM recommends pyriproxyfen and methidathion only postharvest (UCIPM 2014b). This is supported by comments from several olive experts, including the following:

> "Only options for scale control in olives in season (July – harvest) are narrow range oil, or narrow range oil + carbaryl. Post-harvest, there are different options ([methidathion])."

> "Growth regulators usually take time to control the scale and are most effective applied in the Fall."

Therefore, although it is not a critical carbaryl use, I recommend that DPR consider the need to manage resistance for olive scales when selecting mitigation options.

5.6 Ornamental-plant production

Includes a critical use of carbaryl: prophylactic control of GWSS on shipments of nursery stock from GWSS-infested counties in southern California to uninfested California counties, as required by quarantine regulations. CDFA's Nursery Stock Approved Treatment Program requires the originating nursery to treat such shipments with an approved insecticide prior to shipment. Only two insecticides are approved: carbaryl and fenpropathrin (CDFA 2011). In response to DPR's request for input about carbaryl critical uses, CDFA's Plant Health and Pest Prevention Services informed DPR:

> "fenpropathrin also plays a critical role in the Approved Treatment Program, but its more restrictive label (i.e. on food crops, open flowers) often makes carbaryl the only option for these nurseries. In addition, fenpropathrin has a 24 hour REI, while carbaryl has a 12 hour REI. This additional 12 hours can have an impact on a rush sale or the ability to deliver the shipment to its destination prior to the expiration of the treatment (5 days). Due to these main factors, over 90% of the shipments in the Approved Treatment Program are treated with carbaryl. Researchers have tested multiple chemicals over the years for consideration as candidate replacement compounds in the Approved Treatment Program and none have provided adequate levels of control."

Most nursery experts contacted emphasized the importance of carbaryl's 12-hour REI. The following is one example:

> "With the 12 REI it allows us to be more competitive with other nurseries shipping into GWSS non-infested counties. If the REI is increased we would lose days that we will be able to ship into GWSS-non-infested counties and lose our customer base in these counties. [Our nursery] fully understands DPR's concern about [carbaryl] having a higher risk than thought. We want our employees to have a safe environment to work in. We would like to have DPR increase PPE for applicators (which we are doing now as you saw) and maybe have some type of increase of PPE for [re-entry] workers (like Long sleeved shirts Etc…) But keep the REI the same."

Given that treatment is mandatory under quarantine regulations, and that there is only one approved alternative, prophylactic GWSS control on shipments of nursery stock from GWSS-infested counties is a critical carbaryl use.

5.7 Tomato production

Includes a critical use of carbaryl: use of granular bait formulations to control soil-dwelling insects. This group of pests, and the usefulness of baits to control them, were already discussed for melons in section 5.3.1.

In tomato production, soil-dwelling insects chew the stems of young plants shortly after planting, when even a small amount of feeding can kill a tomato plant. Several experts reported darkling beetle damage to young tomato plants has increased in recent years, due to a reduction in tillage. Nearly every tomato expert contacted stated that early-season application of carbaryl bait was common and essential. For example:

> "Immediately following transplanting, the only effective tool on the market is carbaryl. The pests live in the soil surface, at night they chew the stems in half. 10 – 50% losses have occurred if not applied immediately. . . . We have tried many different products. Some have bee restrictions and some are just not effective on the pests."

> "Carbaryl is the only means of control for the pest spectrum listed above. There are no other registered effective alternative means of control for the target pest spectrum. All of the pests [for which we use carbaryl bait] are either soil dwelling or highly mobile. This makes it nearly impossible to control the listed pests with conventional spray applications of other insecticides. In processing tomatoes, carbaryl is applied as bait to the soils surface. Target insects will feed on the bait instead of transplanted tomato seedlings."

Carbaryl is the only bait recommended by UCIPM to control cutworms in tomato (UCIPM 2013). UCIPM lists darkling beetles as a tomato pest during seedling growth, but does not present control recommendations (UCIPM 2014c). As in melon, there are at least two alternative

active ingredients, permethrin and spinosad[10], that are available in bait formulations labeled for outdoor production-agriculture use on tomato. One tomato expert provided this assessment of the alternative baits:

> "Spinosad bait is more effective on earwigs but is a lot more expensive. . . . [and] less effective on ground beetles. . . . Permethrin bait [provides] fair control on ground beetles – but not as effective as [carbaryl] – weaker on cutworms. Have not seen control on earwigs."

The small number of alternatives, and reports that they are less effective than carbaryl, justifies classifying bait applications for soil insect control in tomato as a critical use of carbaryl.

[10] The insecticidal bacterium *Bacillus thuringiensis* f. sp. *kurstaki* also is available in bait formulation, but has efficacy only against caterpillars in the Order Lepidoptera, and thus would not be expected to control darkling beetles, wireworms, crickets, or earwigs.

6. Implications for risk management

Risk managers within DPR currently are evaluating the carbaryl RCD (Rubin 2014) to determine whether any of the estimated risks will require mitigation. For an overview of DPR's risk management process, see DPR (2011).

Carbaryl critical uses that involve granular formulations, namely those within melon and tomato production, produce lower foliar residues than those involving liquid formulations. Thus, if mitigation is determined to be necessary, it may be simpler to mitigate the critical uses that involve granular formulations. Table 1 shows the relationship between carbaryl critical uses identified in this memorandum, and scenarios with MOEs less than 100 or cancer risks greater than 10^{-6} , as reported in the RCD (Rubin 2014).

Table 1. Overlap between carbaryl critical uses and estimated risks reported in the RCD

X = Scenarios with MOEs less than 100 or cancer risks greater than 10^{-6} are expected to occur within this critical use

? = Scenarios with MOEs less than 100 or cancer risks greater than 10^{-6} might occur within this critical use

Critical uses identified in this memorandum	Scenarios for which RCD risk estimates include MOEs less than 100 or cancer risks greater than 10^{-6} (Rubin 2014):			
	Occupational handler[a] (RCD Table IV-7a)	Occupational re-entry[b] (RCD Table IV-7b)	Residential handler & re-entry[c] (RCD Table IV-8)	Bystander[d] (RCD Table IV-11)
Apple (liquids for fruit thinning)	**X**	**X**		
Melon (baits for soil insects)	**X**	**?**		
Non-production plantings (liquids for GWSS)	**X**	**X**	**?**	
Ornamental production (liquids for GWSS)	**X**	**X**		
Tomato (baits for soil insects)	**X**			

Notes for Table 1:

a For occupational handlers, RCD risk estimates include MOEs less than 100 or cancer risks greater than 10^{-6} for most carbaryl formulations and most application methods.

b Regarding occupational re-entry, fieldworkers entering **tomato** fields previously treated with carbaryl granules are not expected to have substantial contact with soil or baits. In contrast, scouts entering **melon** fields treated late in the season reportedly would have high contact with soil (and thus potentially with carbaryl bait) when evaluating fruit maturity. Scouting for melon fruit maturity reportedly involves crawling along a row to cut open fruits. For **ornamental production**, retail workers who unload trucks of ornamental plants treated for GWSS with liquid carbaryl formulations would be expected to have high contact with foliar residues, comparable to the scenario "Ornamental plant hand harvesting" in the RCD (Eric. Kwok, DPR Human Health Assessment Branch, personal communication).

c Residential re-entry might be an issue if GWSS control requires CDFA quarantine officials to treat ornamental plantings around residences.

d Bystander risks are not expected to be unacceptably high for any carbaryl critical uses, because carbaryl critical uses do not involve aerial applications. RCD bystander risk estimates include MOEs less than 100 or cancer risks greater than 10^{-6} only for aerial applications.

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Questions about carbaryl use and fieldworker activities in apple

to help CDPR understand how and why growers use carbaryl,
and what activities fieldworkers do within fields previously treated with carbaryl

October 28, 2015

Contact:

Mike Zeiss, Worker Health and Safety Branch
California Department of Pesticide Regulation (CDPR)
Email: Michael.Zeiss@cdpr.ca.gov
Phone: 916-323-2837

Background: carbaryl use and products

Carbaryl is a broad-spectrum insecticide used in production of fruits, nuts, field crops, and ornamental plants. In addition, carbaryl is used on non-production plantings including lawns, landscaping, and home gardens. For production agriculture, carbaryl products[11] registered in California include both liquid and bait formulations:

- Carbaryl 4L
- Carbaryl Cutworm Bait
- Drexel Carbaryl 4L
- Drexel Carbaryl 5% Bait
- First Choice Carbaryl Cutworm Bait
- Sevin 5 Bait
- Sevin Brand 4F Carbaryl Insecticide
- Sevin Brand XLR Plus Carbaryl Insecticide
- Sevin SL Carbaryl Insecticide
- The Andersons Professional Turf Products 8% Granular Insecticide With Carbaryl

Questions (total of 15):

1. In apple, what are the main uses for carbaryl? In other words, to control which insect pests, or for which horticultural reason such as chemical fruit thinning?

2. Why do growers choose carbaryl products over other pesticide alternatives, or other chemicals such as plant-growth regulators? Possible answers might include less effective, higher cost, insect pests are resistant to other insecticides, etc.

3. Are there any uses for which carbaryl is the **only** suitable tool (in other words, for which there is no suitable alternative to carbaryl)? If so, which use or uses, and why?

(continued next page)

[11] Mention of commercial products is not to be construed as either an actual or implied endorsement.

4. The timing of carbaryl applications is shown in Figure 1 (following the questions). Why is carbaryl applied at that particular time (that particular month or growth stage)? Would it be practical to move the application date:
   - 3 to 4 weeks earlier? Or
   - 3 to 4 weeks later?

   Why or why not?

5. When carbaryl is applied, what type of application equipment is usually used?

   /__/ Aircraft (fixed-wing or helicopter)

   /__/ Airblast (a large motorized fan that usually is pulled behind a tractor)

   /__/ Motorized ground sprayers other than airblast (e.g., boom sprayers)

   /__/ Motorized ground equipment for applying granule or bait formulations

   /__/ Hand-held equipment such as wands, hose-end "guns", or hand-held equipment for applying granule or bait formulations

6. If carbaryl is usually applied via aircraft or airblast, would it be practical to apply it via motorized ground sprayers (e.g., boom sprayers)? Why or why not?

7. The range of carbaryl application rates is shown in Figure 2 (following the questions). Are there situations where using a lower rate of carbaryl would be practical? If so, which situations and why? If not, why not?

8. How many times during each cropping cycle is carbaryl usually applied? If more than once, would it be practical to reduce the number of applications per cropping cycle? Why or why not?

9. During the months when carbaryl is usually applied (Figure 1), what crop management activities do fieldworkers usually carry out in apple fields? Possible answers might include manipulating irrigation equipment, pruning branches, manual thinning of fruit, harvesting, etc.

10. Why do fieldworkers carry out those crop management activities at that particular time (that particular month)? Would it be practical for fieldworkers to do that activity:
    - 3 to 4 weeks earlier? Or
    - 3 to 4 weeks later?

    Why or why not?

(continued next page)

11. When carrying out those crop management activities, which of the following apparel do fieldworkers usually wear? Check all that are worn by most fieldworkers:

    Clothes:
    /__/ Long pants
    /__/ Long-sleeved shirt
    /__/ One-piece coveralls with long sleeves and long pants legs
    /__/ Jacket or coat that is not waterproof (for example, made of cotton or wool)
    /__/ Jacket or coat that is waterproof (for example, a raincoat or nylon poncho)

    Head covering:
    /__/ Head covering that is not waterproof (bandana, hat, or hood of a jacket that is not waterproof)
    /__/ Head covering that is waterproof (bandana, hat, or hood of a jacket that is waterproof)

    Shoes:
    /__/ Open-toed shoes such as sandals
    /__/ Closed-toe shoes or boots that are not waterproof (for example, made of leather)
    /__/ Closed-toe shoes or boots that are waterproof (for example, made of rubber)

    Gloves:
    /__/ Gloves that are not waterproof (for example, made of leather or cloth)
    /__/ Gloves that are waterproof

12. Is there ever a need for fieldworkers to enter a carbaryl-treated field while the Restricted Entry Interval is still in effect (called "early-entry fieldworkers")? If so, what crop management activities are those early-entry fieldworkers usually doing? Would it be practical to postpone those activities until after the Restricted Entry Interval has expired? Why or why not?

13. Is there anything else that would be helpful for us to know about carbaryl use or fieldworker activities?

14. If there were any questions for which you were unsure about the answer, could you recommend a person or organization that might be able to provide the answer?

15. Would you have preferred to answer these questions via some other method (for example, via an in-person interview, or via an online survey such as SurveyMonkey)? If so, please tell us what method you would have preferred.

Thank you for your help! Learning how growers manage pests and crops helps DPR plan its pesticide guidelines to fit growers' needs as much as possible.

Figure 1. Timing of carbaryl applications to California apple fields, 2009 – 2013
Source of data: CDPR Pesticide Use Report database, queried via Cal-PIP

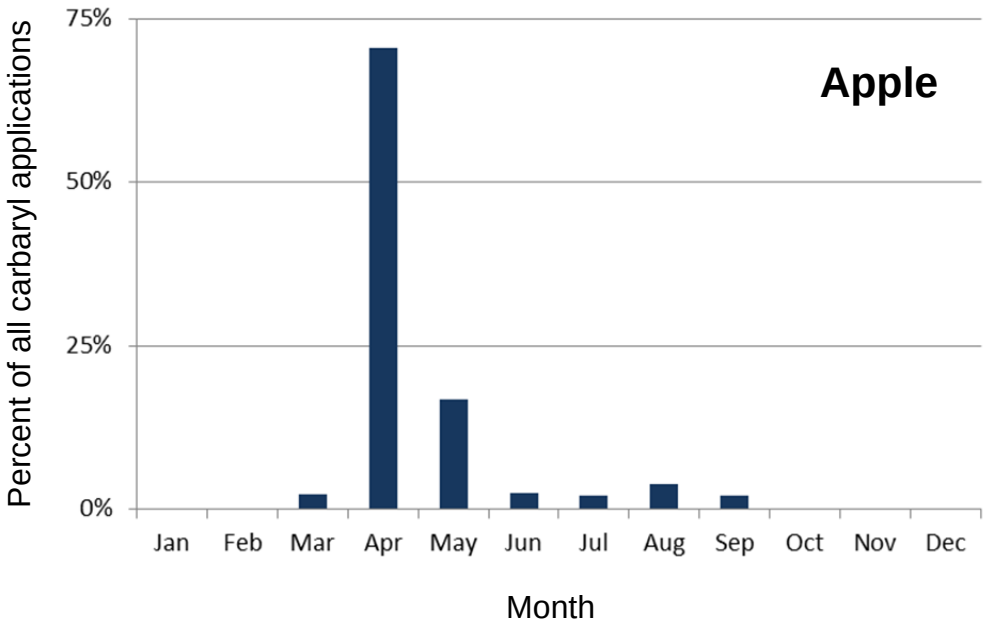
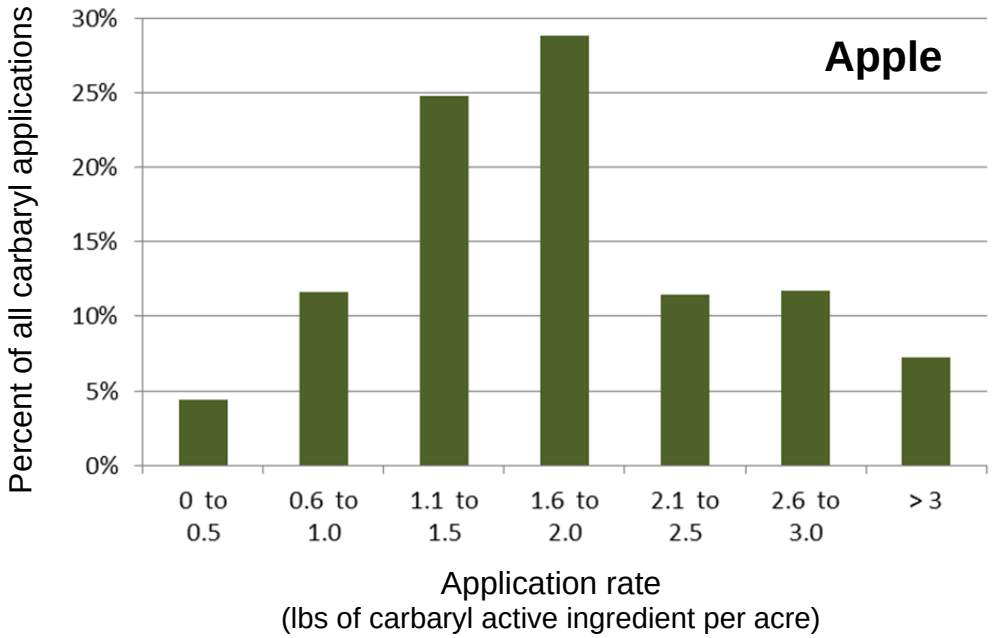


Figure 2. Rate of carbaryl applied to California apple fields, 2009 – 2013
Source of data: CDPR Pesticide Use Report database, queried via Cal-PIP



Appendix 2: Representative short questionnaire

Carbaryl factfinding: Short questionnaire for apple growers

WHS Branch, California Department of Pesticide Regulation (DPR)
December 29, 2015

1) Do you use carbaryl? (Most carbaryl products have "Carbaryl" or "Sevin" in their name. For your convenience, the names of some carbaryl products are listed on the back of this questionnaire.)

2) If you use carbaryl, for what purpose do you use it? In other words, to control which insect pests, or for which horticultural reason such as changing the growth pattern of the plant?

_____

_____

_____

3) If you use carbaryl, how important is it for your production:
   /__/ Slightly important (I have alternatives that are as good or better)
   /__/ Important (carbaryl is one of my go-to tools)
   /__/ Very important (it would be difficult for me to produce without carbaryl)

4) Would you or your PCA be willing to discuss how and why you use carbaryl with DPR? If so, please provide contact information so DPR could send you some additional questions, or meet with you in person if you prefer:

_____

_____

_____

Background: carbaryl use and products

The California Department of Pesticide Regulation (DPR) is gathering information about how the apple industry uses carbaryl, because recent analyses by DPR indicate that health risks for some carbaryl uses appear to be higher than DPR's usual risk targets. Therefore, DPR is evaluating what steps we need to take, if any. Learning how apple growers manage pests and workers helps DPR plan its pesticide guidelines to fit growers' needs as much as possible.

(continued on next page)

Appendix 2: Representative short questionnaire

Carbaryl is a broad-spectrum insecticide used in production of fruits, nuts, field crops, and ornamental plants. In addition, carbaryl is used on non-production plantings including lawns, landscaping, and home gardens. For production agriculture, carbaryl products[12] registered in California include both liquid and bait formulations:

- Carbaryl 4L
- Carbaryl Cutworm Bait
- Drexel Carbaryl 4L
- Drexel Carbaryl 5% Bait
- First Choice Carbaryl Cutworm Bait
- Sevin 5 Bait
- Sevin Brand 4F Carbaryl Insecticide
- Sevin Brand XLR Plus Carbaryl Insecticide
- Sevin SL Carbaryl Insecticide
- The Andersons Professional Turf Products 8% Granular Insecticide With Carbaryl

Contact:

Mike Zeiss, Worker Health and Safety Branch
California Department of Pesticide Regulation (DPR)
Email: Michael.Zeiss@cdpr.ca.gov
Phone: 916-323-2837

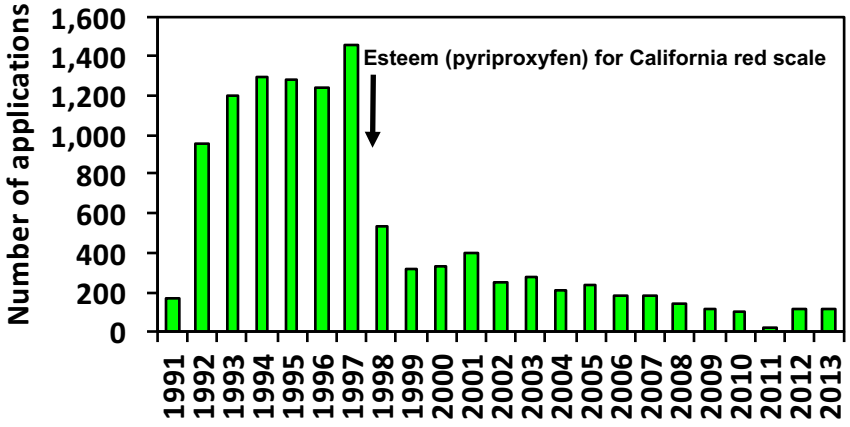
[12] Mention of commercial products is not to be construed as either an actual or implied endorsement. Some products may not be approved for apple production. Read and follow label instructions and restrictions.

Carbaryl Use in California Citrus

Beth Grafton-Cardwell, Citrus IPM Specialist
Department of Entomology, UC Riverside
Director of Lindcove Research and Extension Center

University of California
Agriculture and Natural Resources

Carbaryl Use in the San Joaquin Valley



Insects controlled by carbaryl

Pest	Rate applied	Time of year	Water volume
California red scale	5-12 lb	May-Sep	≥750 gpa
Black scale	3-5 lb	May-Oct	≥750 gpa
Cottony cushion scale	3-5 lb	Jul-Sep	≥750 gpa
Citricola scale	3-5 lb	Jun-Sep	300-500 gpa
Fuller rose beetle	3-5 lb	Jun-Aug	300-500 gpa
Worms (amorbia, cutworm, others)	3-5 lb	Apr-Jun	100-200 gpa
Asian citrus psyllid	3-5 lb	May-Oct	100-200 gpa
Grasshopper	1 lb	May-Oct	Bait applied to rangeland

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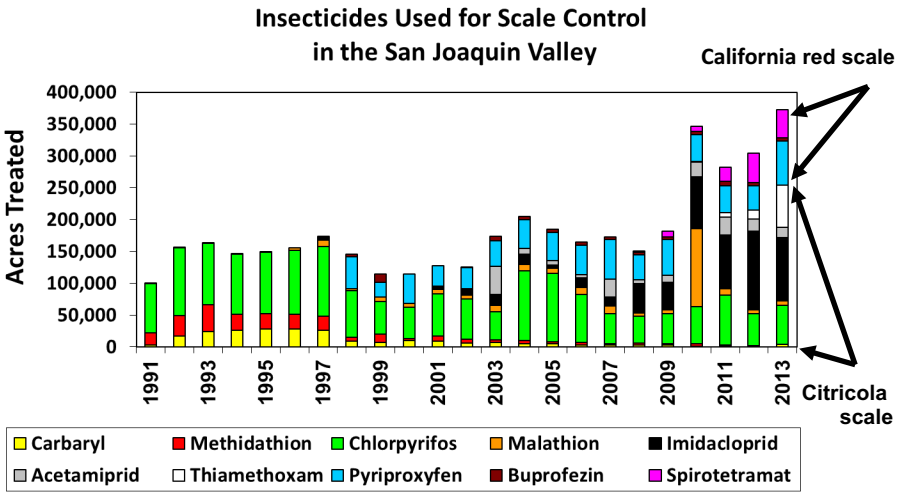
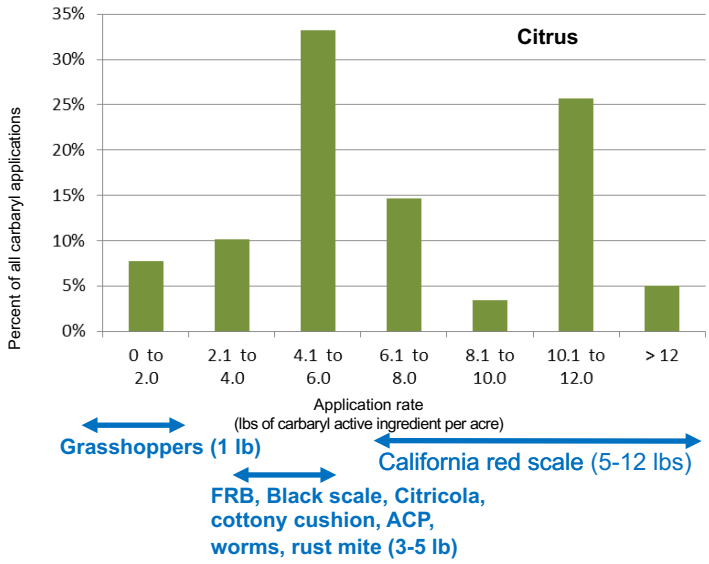
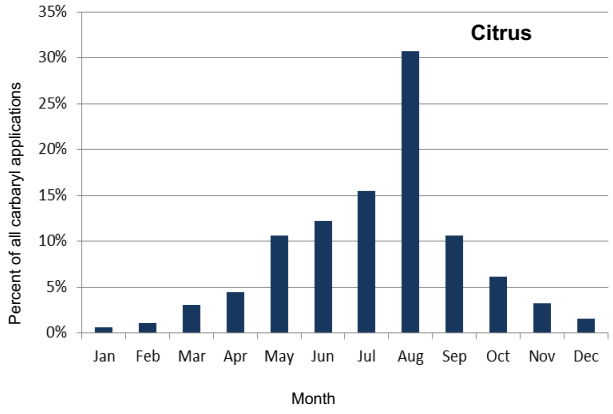


2009-2013 applications of carbaryl



2009-2013 applications of carbaryl



Reasons for carbaryl (Sevin) use in California citrus

1. **Carbaryl is broad spectrum and controls multiple pests simultaneously– reducing the number of applications, which in turns minimizes costs, compaction, fruit damage, VOCs, risks for workers**
2. Relatively short REI (12 hours or 3 days for ≥5lbs/acre) and PHI (5 days)
3. Provides a product that has international MRLs established – some new chemistries do not have MRLs
4. Controls some new/difficult to control pests such as GWSS, ACP, Fuller rose beetle
5. Utilized in the California red scale eradication program in portions of S. Calif
6. Provides a chemistry that could potentially help with resistance management – a rotational chemical for California red scale

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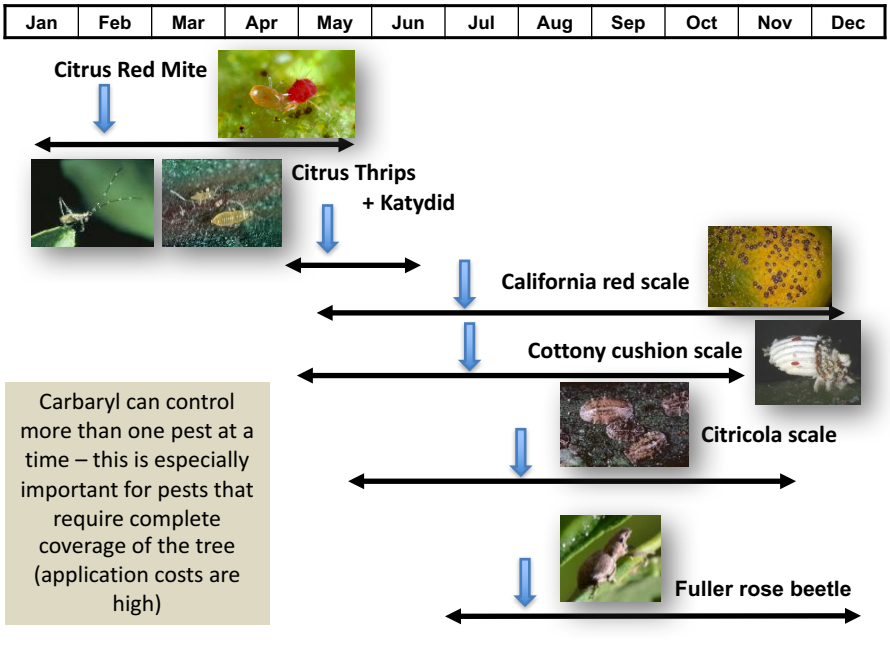
San Joaquin Valley Citrus IPM



Carbaryl can control more than one pest at a time – this is especially important for pests that require complete coverage of the tree (application costs are high)

Reasons for carbaryl (Sevin) use in California citrus

1. Carbaryl is broad spectrum and controls multiple pests simultaneously– reducing the number of applications, which in turns minimizes costs, compaction, fruit damage, VOCs, risks for workers
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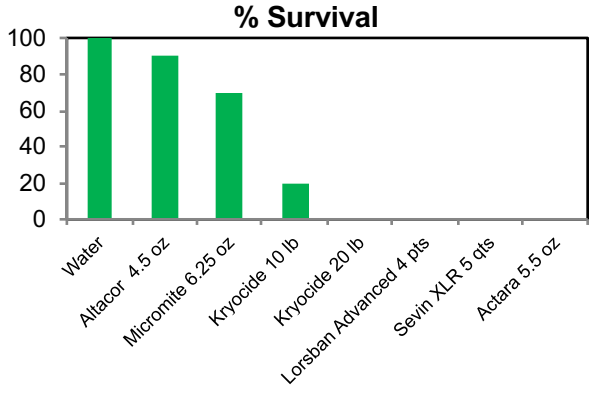
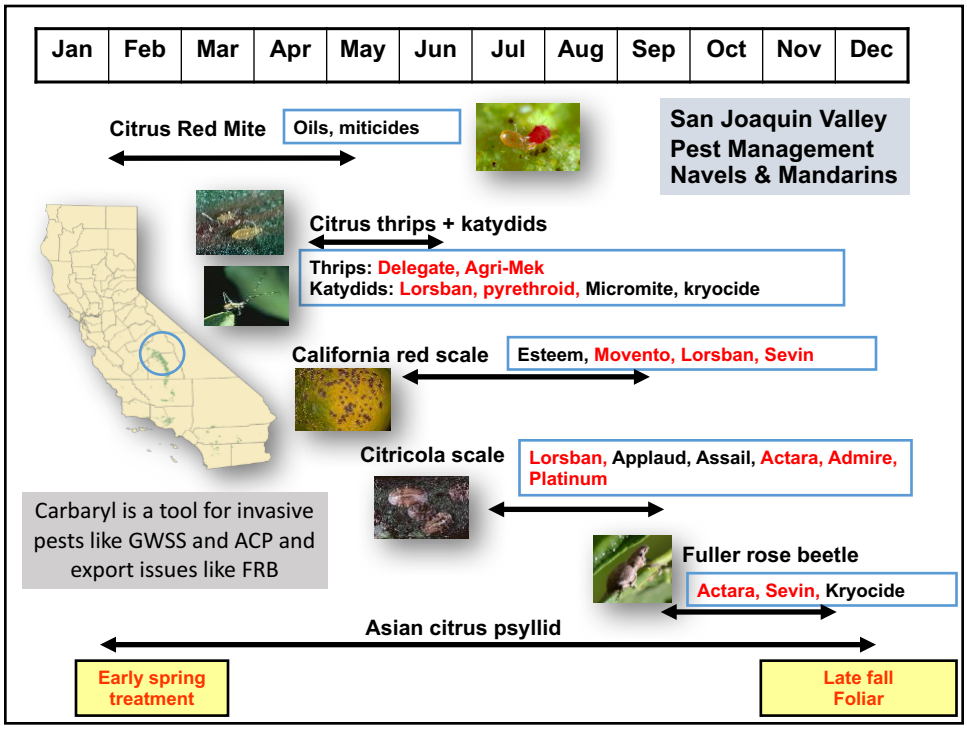
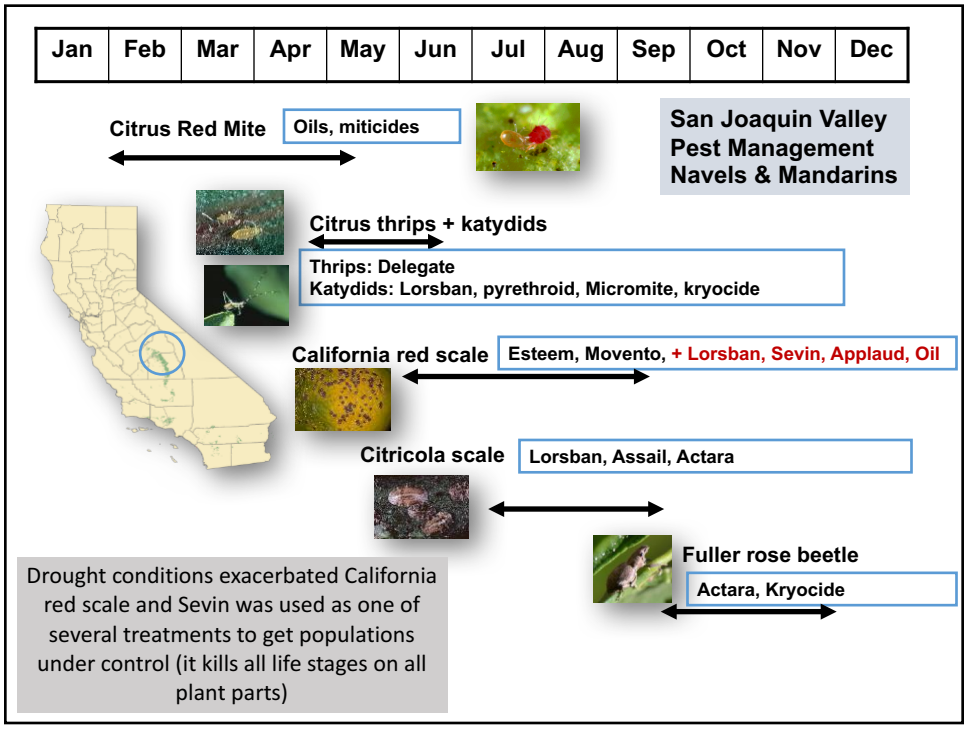
Laboratory Bioassays of Fuller rose beetle adults - 14 DAT



	US MRL (PPM)	Korea MRL	Japan MRL	Australia MRL
Kryocide/cryolite	-	-	-	
Lorsban Advanced/ chlorpyrifos	1	0.3	1	1
Sevin/carbaryl	10	0.5	7	7
Actara/thiamethoxam	0.4	1	1	1


Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Citrus Red Mite
Oils, miticides
San Joaquin Valley
Pest Management
Navels & Mandarins
Citrus thrips + katydids
Thrips: Delegate, Agri-Mek
Katydids: Lorsban, pyrethroid, Micromite, kryocide
California red scale
Esteem, Movento, Lorsban, Sevin
Citricola scale
Lorsban, Applaud, Assail, Actara, Admire, Platinum
Carbaryl is a tool for invasive pests like GWSS and ACP and export issues like FRB
Fuller rose beetle
Actara, Sevin, Kryocide
Asian citrus psyllid
Early spring treatment
Late fall Foliar


Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Citrus Red Mite
Oils, miticides
San Joaquin Valley
Pest Management
Navels & Mandarins
Citrus thrips + katydids
Thrips: Delegate
Katydids: Lorsban, pyrethroid, Micromite, kryocide
California red scale
Esteem, Movento, + Lorsban, Sevin, Applaud, Oil
Citricola scale
Lorsban, Assail, Actara
Drought conditions exacerbated California red scale and Sevin was used as one of several treatments to get populations under control (it kills all life stages on all plant parts)
Fuller rose beetle
Actara, Kryocide

Reasons for carbaryl (Sevin) use in California citrus

1. Carbaryl is broad spectrum and controls multiple pests simultaneously– reducing the number of applications, which in turns minimizes costs, compaction, fruit damage, VOCs, risks for workers
2. Relatively short REI (12 hours or 3 days for ≥5lbs/acre) and PHI (5 days)
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5. Utilized in the California red scale eradication program in portions of S. Calif
6. Provides a chemistry that could potentially help with resistance management – a rotational chemical for California red scale

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Carbaryl (Sevin) Formulations Available

- **Carbaryl 4L**
- Carbaryl Cutworm Bait
- **Drexel Carbaryl 4L**
- Drexel Carbaryl 5% Bait
- First Choice Carbaryl Cutworm Bait
- **Sevin 5 Bait**
- Sevin Brand 4F Carbaryl Insecticide
- **Sevin Brand XLR Plus Carbaryl Insecticide**
- Sevin SL Carbaryl Insecticide
- The Andersons Professional Turf Products 8% Granular Insecticide With Carbaryl