CHAPTER 4: MANAGING AGRICHEMICALS

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PUBLICATION 8161

Pesticide Choice: Best Management Practice (BMP) for Protecting Surface Water Quality in Agriculture

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Pesticides are one type of pollutant found in California's surface waters at levels that may be harmful to the aquatic ecosystem. When toxicity occurs, pesticide loadings and surface water pesticide concentrations must be reduced to levels that are not harmful to aquatic life. Factors affecting the potential for a pesticide to move "offsite" from a treated area include field soil properties, climate, grower management practices, and the physical and chemical properties of the active ingredient. This publication provides information to assist pesticide users in evaluating their choice of pesticide products on the basis of the potential to impact surface water quality.

PESTICIDE PROPERTIES AFFECTING TRANSPORT IN WATER

The likelihood that a pesticide will move in irrigation or stormwater runoff from the site of application depends in large part on the properties of the active ingredient (a.i.), including the pesticide's field dissipation half-life, adsorption coefficient (K_{oc}), and aqueous solubility. Field dissipation half-life is the time required for half of a given quantity of a formulated pesticide to degrade or dissipate from the soil. In general, pesticides that remain in the field for many weeks after treatment (i.e., half-life >40 days) are more available to move in runoff because they last the longest in the environment.

The K_{oc} is the soil adsorption coefficient for the pesticide, which often depends on the pesticide's hydrophobicity. The larger the K_{oc} value, the more strongly the pesticide adsorbs to soil. K_{oc} determines how a pesticide moves in runoff. A pesticide with a low K_{oc} (i.e., weak adsorption) and high solubility will move in the dissolved form, while a pesticide with high K_{oc} (i.e., strong adsorption) will move primarily by associating itself with eroded soil or sediment particles.

Water solubility is the amount of pesticide that can be dissolved per liter of water. As solubility increases, K_{oc} usually decreases. However, there are exceptions to this general rule. For example, glyphosate (the active ingredient of Roundup) is highly water soluble, but adsorbs strongly to soil and does not move in water.

The K_{oc}, solubility, and half-life values for California-registered insecticides, miticides, fungicides, and herbicides are given in tables 1 through 4. The physicochemical data in these tables were extracted from USDA-ARS 2004 and PesticideWise 2004.

AQUATIC TOXICITY OF PESTICIDES

Pesticides differ in their degree of toxicity to aquatic life. In general, insecticides tend to have high toxicity to fish and invertebrates, while some herbicides have high toxicity to aquatic plants (i.e., phytotoxicity). The standard indicator species that the U.S. Environmental Protection Agency uses to assess water quality include zooplankton

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Table 1. Key pesticide properties influencing the potential for insecticides to move in runoff

Insecticide active ingredient (Common name)	Solubility (mg/L)*	K_{oc}†	Field dissipation half-life (days)‡	Aquatic toxicity§
abamectin	5	5,000	28	high
acephate	818,000	2	6	moderate
azinphosmethyl	28	940	10	very high
bifenthrin	0.0001	237,000	26	very high
carbaryl	110	288	14	moderate
carbofuran	350	46	50	high
chlorpyrifos	1.18	9930	43	extremely high
cyfluthrin	0.02	100,000	22	extremely high
cypermethrin	0.004	61,000	77	very high
diazinon	60	1,520	40	very high
diflubenzuron	0.08	8,700	10	very low
dimethoate	39,800	20	7	high
disulfoton	12	600	30	high
endosulfan	0.32	12,400	60	very high
esfenvalerate	0.0002	5,300	42	very high
fenpropathrin	0.014	5,000	14	high
fipronil	2	838	96	very high
imidacloprid	580	440	127	very low
lambda-cyhalothrin	0.005	180,000	30	very high
malathion	130	1,200	9	extremely high
methamidophos	1,000,000	5	6	high
methidathion	220	400	7	very high
methomyl	58,000	72	30	high
methyl parathion	55	6,300	10	very high
naled	2,000	180	1	very high
oxamyl	282,000	25	4	moderate
oxydemeton-me	1,000,000	10	10	moderate
permethrin	0.006	100,000	42	very high
phorate	22	1,000	37	very high
phosmet	20	668	14	very high
profenofos	28	2,000	9	moderate
spinosad	89	16,420	0.4	very low
tebufenozide	0.83	389	348	very low
thiodicarb	19.1	351	5	high
tralomethrin	0.001	100,000	27	very high

Sources: PAN 2004; PesticideWise 2004; USDA-ARS 2004.
Notes:
*Amount of pesticide able to be dissolved in water.
†Adsorption coefficient normalized over soil organic carbon content.
‡Time required for 50% of the chemical to disappear from the soil following treatment.
§Based on toxicity evaluation of water fleas *(Daphnia magna* or *Ceriodaphnia dubia)*, rainbow trout *(Oncorhynchus mykiss)*, or phytoplankton (typically *Selenastrum capricornatum*). See table 5.

Table 2. Key pesticide properties influencing the potential for miticides to move in runoff

Miticide active ingredient (Common name)	Solubility (mg/L)*	K_{oc}†	Field dissipation half-life (days)‡	Aquatic toxicity§
avermectin	5	5,000	28	high
bifenazate	4	4,600	5	moderate
clofentezine	0.0025	45,300	40	high
dicofol	0.8	6,064	57	high
fenbutatin oxide	0.0127	2,721	95	very high
formetanate hydrochloride	820,000	275	9	high
hexythiazox	0.5	6,200	30	moderate
propargite	0.6	41,000	84	high
pyridaben	0.012	110,000	86	very high

Sources: PAN 2004; PesticideWise 2004; USDA-ARS 2004.
Notes:
*Amount of pesticide able to be dissolved in water.
†Adsorption coefficient normalized over soil organic carbon content.
‡Time required for 50% of the chemical to disappear from the soil following treatment.
§Based on toxicity evaluation of water fleas *(Daphnia magna* or *Ceriodaphnia dubia)*, rainbow trout *(Oncorhynchus mykiss)*, or phytoplankton (typically *Selenastrum capricornatum*). See table 5.

(waterfleas, scud), fish, and phytoplankton (green algae) (US EPA 2002). Acute effect levels are typically based on LC_{50} (the dose of a pesticide that kills half the test organisms) or EC_{50} (the dose that causes some sublethal effect in half the test organisms). Aquatic toxicity rankings from extremely low to extremely high were used to determine an appropriate risk category (table 5). Data were extracted from the US EPA AQUIRE database (PAN 2004). When a range of values was given for a specific effect, the lowest concentration was generally selected for the toxicity ranking. The toxicity for the most sensitive indicator species was then used to rank the overall aquatic toxicity. The overall aquatic toxicity rankings for California registered insecticides, miticides, herbicides, and fungicides are listed in the last column in

Table 3. Key pesticide properties influencing the potential for fungicides to move in runoff

Fungicide active ingredient (Common name)	Solubility (mg/L)*	K_{oc}†	Field dissipation half-life (days)‡	Aquatic toxicity§
azoxystrobin	7	1,590	65	very high
captan	5	200	3	low
carboxin	195	260	6	moderate
chlorothalonil	0.6	5,000	30	high
copper sulfate	10,000	30	4	very high
cymoxanil	780	110	5	moderate
cyprodinil	13	1,000	50	moderate
dicloran	7	1,000	10	moderate
dodine	700	100,000	20	high
fenarimol	14	760	360	low
fenbuconazole	38	5,776	247	high
fosetyl-al	120,000	166	1	low
imazalil	1400	4,000	150	moderate
iprodione	14	700	14	moderate
mancozeb	6	6,000	70	high
maneb	6	2,000	70	high
myclobutanil	142	500	66	moderate
propiconazole	110	1,000	110	high
thiabendazole	50	2,500	403	high
thiophanate methyl	3.5	1,830	6	moderate
thiram	30	670	15	very high
triadimefon	72	300	26	moderate
triflumizole	12,500	40	14	high
vinclozolin	1,000	100	20	moderate
ziram	65	400	30	very high

Sources: PAN 2004; PesticideWise 2004; USDA-ARS 2004.
Notes:
*Amount of pesticide able to be dissolved in water.
†Adsorption coefficient normalized over soil organic carbon content.
‡Time required for 50% of the chemical to disappear from the soil following treatment.
§Based on toxicity evaluation of water fleas *(Daphnia magna* or *Ceriodaphnia dubia)*, rainbow trout *(Oncorhynchus mykiss)*, or phytoplankton (typically *Selenastrum capricornatum*). See table 5.

Table 4. Key pesticide properties influencing the potential for herbicides to move in runoff

Herbicide active ingredient (Common name)	Solubility (mg/L)*	K_{oc}†	Field dissipation half-life (days)‡	Aquatic toxicity§
alachlor	240	124	27	very high
atrazine	33	147	173	high
benefin	0.1	9,000	40	high
bensulide	6	1,000	120	high
bentazon sodium	2,300,000	35	27	moderate
bromacil	700	32	60	very high
bromoxynil butyrate	27	1,079	7	high
clethodim	5,400	10	3	low
clopyralid	9,000	36	30	low
cyanazine	155	218	14	very high
cycloate	95	272	27	moderate
2,4-d	890	48	10	moderate
2,4-db (salt)	46	440	5	high
dcpa	0.5	5,600	100	moderate
dicamba (salt)	360,000	2	16	moderate
dichlobenil	21	400	60	high
diclofop	0.8	16,000	20	high
difenzoquat methyl sulfate	817,000	55,000	100	moderate
diquat dibromide	718,000	1,000,000	1000	high
dithiopyr	1	800	400	high
diuron	42	480	90	very high
dsma	254,000	7,000	180	high
endothall	100,000	20	3	high
eptc	344	200	6	high
ethofumesate	50	340	30	moderate
fenoxaprop ethyl	0.9	9,490	12	high
fluazifop-p-butyl	2	5,700	15	high
glufosinate	1,370,000	100	7	moderate
glyphosate	12,000	24,000	47	moderate
halosulfuron	1,630	100	14	low
hexazinone	29,800	54	79	very high
imazapyr	15,000	100	90	very low
imazethapyr	200,000	10	90	low
isoxaben	1	1,400	100	high
linuron	75	400	60	high
mcpa	5	1,000	25	high
mecoprop	660,000	20	21	moderate
metham sodium	963,000	10	7	high
metolachlor	530	200	90	moderate
metribuzin	1,000	52	47	very high
msma	1,400,000	7,000	180	moderate
napropamide	74	400	70	moderate
nicosulfuron	12,000	30	21	extremely low
norflurazon	28	600	90	very high
oryzalin	2	600	20	high
oxadiazon	0.7	3,200	60	very high
oxyfluorfen	0.1	100,000	30	high
paraquat	620,000	1,000,000	1,000	moderate
pebulate	100	430	8	high
pendimethalin	0.3	5,000	90	very high
prodiamine	0.01	13,000	120	high
prometryn	33	400	60	very high
propyzamide	15	200	60	high
pyrithiobac sodium	730	70	60	very low
pyrazon	400	120	21	high
rimsulfuron	7,300	47	10	very low
sethoxydim	4,700	100	5	high
simazine	6	130	60	high
thiazopyr	2	400	85	moderate
triclopyr (ester)	23	780	46	high
trifluralin	0.3	7,200	60	very high

Sources: PAN 2004; PesticideWise 2004; USDA-ARS 2004.

Notes:

*Amount of pesticide able to be dissolved in water.

†Adsorption coefficient normalized over soil organic carbon content.

‡Time required for 50% of the chemical to disappear from the soil following treatment.

§Based on toxicity evaluation of water fleas *(Daphnia magna* or *Ceriodaphnia dubia)*, rainbow trout *(Oncorhynchus mykiss)*, or phytoplankton (typically *Selenastrum capricornatum*). See table 5.

Table 5. Basis for aquatic toxicity rankings for California-registered pesticides in tables 1 through 4

Aquatic Toxicity (µg/L, ppb)*	Risk ranking
<0.00014	extremely high
<0.14	very high
<14	high
<1400	moderate
<14000	low
<85000	very low
>85000	extremely low

Source: US EPA 2002.
Notes:
*Based on evaluation of water fleas *(Daphnia magna* or *Ceriodaphnia dubia)* toxicity (typically acute LC_{50}, 48-hr test); rainbow trout *(Oncorhynchus mykiss)* toxicity (typically acute LC_{50}, 96-hr test); or effect on population abundance of the phytoplankton *Selenastrum capricornatum* (typically EC_{50}).

tables 1 through 4. It is important to select a pesticide that has a low toxicity to aquatic life, especially when used near waterbodies.

PESTICIDE RUNOFF RISK

For each California-registered pesticide active ingredient examined in this publication, K_{oc}, solubility, and half-life values were used to fit two USDA-NRCS algorithms to determine the pesticide's tendency to move in dissolved form (i.e., solution runoff) or with soil (i.e., adsorption runoff). The potential to move off site, either in solution or with soil, was then categorized into "high" (great potential to move), "intermediate" (moderate potential to move), and "low" (limited potential to move) (tables 6–9). In general, when a pesticide has a relatively long half-life and a large K_{oc} and/or low solubility, the potential for adsorption runoff is high. If a pesticide has a relatively long half-life and a small K_{oc} and/or high solubility, the potential for solution runoff is high. The runoff potential was then considered together with the aquatic toxicity for a given pesticide to estimate its overall runoff risk. Overall runoff risk in this publication is a product of the runoff potential and the aquatic toxicity; this is listed in the last column in tables 6 through 9 for California-registered insecticides, miticides, fungicides, and herbicides. For example, if a pesticide has a high runoff potential but a low aquatic toxicity, the overall runoff risk is low. If a pesticide has a moderate or high runoff potential but very high aquatic toxicity, the overall runoff risk is high or very high. Pesticides labeled "very high" or "high" in tables 6 through 9 should be used with precautions and/or with proper mitigation practices.

Table 6. California-registered insecticides ranked by potential to move in solution or as adsorbed particles and overall pesticide runoff risk

Insecticide active ingredient (Common name)	Trade name=	Solution runoff potential*	Adsorption runoff potential†	Overall runoff risk‡
diazinon	Diazinon	high	high	very high
endosulfan	Thiodan	high	high	very high
phorate	Thimet	high	high	very high
chlorpyrifos	Lorsban, Dursban	high	intermediate	very high
abamectin	Agri-Mec, Zephyr	high	intermediate	high
fipronil	Regent	high	intermediate	high
tralomethrin	Scout X-Tra	high	intermediate	high
bifenthrin	Capture	low	high	high
cypermethrin	Ammo, Mustang	low	high	high
esfenvalerate	Asana	low	high	high
permethrin	Pounce	low	high	high
cyfluthrin	Baythroid	low	intermediate	high
lambda-cyhalothrin	Warrior, Karate	low	intermediate	high
azinphosmethyl	Guthion	intermediate	intermediate	moderate
methyl parathion	Parathion	intermediate	intermediate	moderate
profenofos	Curacron	intermediate	intermediate	moderate
carbaryl	Sevin	intermediate	low	moderate
disulfoton	Disyston	intermediate	low	moderate
malathion	Malathion	intermediate	low	moderate
methomyl	Lannate	intermediate	low	moderate
methidathion	Supracide	intermediate	low	moderate
phosmet	Imidan	intermediate	low	moderate
thiodicarb	Larvin	intermediate	low	moderate
carbofuran	Furadan	low	intermediate	moderate
fenpropathrin	Danitol	low	intermediate	moderate
diflubenzuron	Dimilin	high	intermediate	low
imidacloprid	Provado	high	intermediate	low
tebufenozide	Confirm	high	intermediate	low
spinosad	Success, Tracer	intermediate	intermediate	low
acephate	Orthene	low	low	low
dimethoate	Cygon	low	low	low
methamidophos	Monitor	low	low	low
naled	Dibrom	low	low	low
oxamyl	Vydate	low	low	low
oxydemeton- me	Metasystox-R	low	low	low

Notes:
*Likelihood that the active ingredient will transport from the area of treatment as dissolved chemical in runoff.
†Likelihood that the active ingredient will transport from the area of treatment as attachment to soil or sediment particles in runoff.
‡Overall likelihood to cause negative impact on surface water quality as a product of the runoff potential and the aquatic toxicity of the pesticide.

OTHER FACTORS AFFECTING PESTICIDE RUNOFF

The occurrence of pesticide runoff also depends heavily on many other factors, including soil properties, crop production practices, irrigation management, rain events, and pesticide application methods and timing. Soils high in clay and organic matter may adsorb pesticides better than

Table 7. California-registered miticides ranked by potential to move in solution or as adsorbed particles and overall pesticide runoff risk

Miticide active ingredient (Common name)	Trade name=	Solution runoff potential*	Adsorption runoff potential†	Overall runoff risk‡
fenbutatin oxide	Vendex	high	high	very high
pyridaben	Pyramite, Nexter	high	high	very high
clofentezine	Apollo	high	high	high
dicofol	Kelthane	high	high	high
formetanate hydrochloride	Carzol	high	high	high
propargite	Comite, Omite	high	high	high
avermectin	Avid, Agri-mek	high	intermediate	high
hexythiazox	Savey	high	intermediate	moderate
bifenazate	Acramite	intermediate	intermediate	moderate

Notes:

*Likelihood that the active ingredient will transport from the area of treatment as dissolved chemical in runoff.

†Likelihood that the active ingredient will transport from the area of treatment as attachment to soil or sediment particles in runoff.

‡Overall likelihood to cause negative impact on surface water quality as a product of the runoff potential and the aquatic toxicity of the pesticide.

Table 8. California-registered fungicides ranked by potential to move in solution or as adsorbed particles and overall pesticide runoff risk

Fungicide active ingredient (Common name)	Trade name=	Solution runoff potential*	Adsorption runoff potential†	Overall runoff risk‡
azoxystrobin	Quadris, Abound	high	high	very high
copper sulfate	copper sulfate	high	high	very high
fenbuconazole	Indar	high	high	high
maneb	Maneb	high	high	high
propiconazole	Break, Orbit, tilt	high	high	high
mancozeb	Dithane	high	high	high
thiabendazole	Mertect	high	high	high
chlorothalonil	Bravo, Echo	high	intermediate	high
thiram	Thiram	intermediate	low	high
ziram	Ziram	intermediate	low	high
cyprodinil	Vangard	high	high	moderate
imazalil	Fungaflor	high	high	moderate
myclobutanil	Rally, Laredo	high	intermediate	moderate
dicloran	Botran	intermediate	intermediate	moderate
thiophanate methyl	Topsin	intermediate	intermediate	moderate
carboxin	Vitavax	intermediate	low	moderate
cymoxanil	Curzate	intermediate	low	moderate
iprodione	Rovral	intermediate	low	moderate
triadimefon	Bayleton	intermediate	low	moderate
triflumizole	Procure	intermediate	low	moderate
vinclozolin	Ronilan	intermediate	low	moderate
fenarimol	Rubigan	high	intermediate	low
captan	Captan	intermediate	low	low
fosetyl-al	Aliette	low	low	low

Notes:

*Likelihood that the active ingredient will transport from the area of treatment as dissolved chemical in runoff.

†Likelihood that the active ingredient will transport from the area of treatment as attachment to soil or sediment particles in runoff.

‡Overall likelihood to cause negative impact on surface water quality as a product of the runoff potential and the aquatic toxicity of the pesticide.

Table 9. California-registered herbicides ranked by potential to move in solution or as adsorbed particles and overall pesticide runoff risk

Herbicide active ingredient (Common name)	Trade name=	Solution runoff potential*	Adsorption runoff potential†	Overall runoff risk‡
oxadiazon	Ronstar	high	high	very high
pendimethalin	Prowl	high	high	very high
trifluralin	Treflan	high	high	very high
diuron	Karmex, Direx	high	intermediate	very high
norflurazon	Solicam	high	intermediate	very high
prometryn	Caparol	high	intermediate	very high
benefin	Balan	high	high	high
bensulide	Prefar	high	high	high
dsma	DSMA	high	high	high
isoxaben	Gallery	high	high	high
prodiamine	Barricade	high	high	high
dichlobenil	Casoron	high	intermediate	high
diclofop	Hoelon	high	intermediate	high
dithiopyr	Dimension	high	intermediate	high
fenoxaprop ethyl	Acclaim, Whip	high	intermediate	high
fluazifop-p-butyl	Fusilade	high	intermediate	high
linuron	Lorox	high	intermediate	high
mcpa	MCPA	high	intermediate	high
oxyfluorfen	Goal	high	intermediate	high
atrazine	Aatrex	intermediate	intermediate	high
bromacil	Hyvar X	intermediate	intermediate	high
hexazinone	Velpar	intermediate	intermediate	high
alachlor	Lasso	intermediate	low	high
cyanazine	Bladex	intermediate	low	high
metribuzin	Sencor	intermediate	low	high
dcpa	Dacthal	high	high	moderate
difenzoquat methyl sulfate	Avenge	high	high	moderate
msma	MSMA	high	high	moderate
napropamide	Devrinol	high	intermediate	moderate
thiazopyr	Visor	high	intermediate	moderate
bromoxynil, butyrate	Buctril	intermediate	intermediate	moderate
metolachlor	Dual Magnum, Pennant	intermediate	intermediate	moderate
propyzamid	Kerb	intermediate	intermediate	moderate
simazine	Princep	intermediate	intermediate	moderate
triclopyr	Turflon, Garlon, Grandstand	intermediate	intermediate	moderate
2,4-db	Butyrac	intermediate	low	moderate
cycloate	Ro-neet	intermediate	low	moderate
eptc	Eptam	intermediate	low	moderate
ethofumesate	Nortron, Prograss	intermediate	low	moderate
oryzalin	Surflan	intermediate	low	moderate
pebulate	Tillam	intermediate	low	moderate
pyrazon	Pyramin	intermediate	low	moderate
sethoxydim	Poast	intermediate	low	moderate
diquat	Reward, Diquat	low	high	moderate
glyphosate	Roundup	low	high	moderate
paraquat	Gramoxone extra	low	high	moderate
dicamba	Clarity, Banvel	low	low	moderate
imazapyr	Arsenal, Chopper	intermediate	intermediate	low
pyrithiobac sodium	Staple	intermediate	intermediate	low
halosulfuron	Manage, Sandea, Sempra CA	intermediate	low	low
glufosinate	Finale, Rely	intermediate	low	low
rimsulfuron	Matrix	intermediate	low	low
imazethapyr	Pursuit	low	intermediate	low
2,4-d	2,4-D	low	low	low
bentazon sodium	Basagran	low	low	low
clethodim	Prism, Envoy	low	low	low
clopyralid	Stinger, Transline	low	low	low
endothall	Endothall	low	low	low
mecoprop	MCPP	low	low	low
metham sodium	Vapam	low	low	low
nicosulfuron	Accent	low	low	low

Notes:

*Likelihood that the active ingredient will transport from the area of treatment as dissolved chemical in runoff.

†Likelihood that the active ingredient will transport from the area of treatment as attachment to soil or sediment particles in runoff.

‡Overall likelihood to cause negative impact on surface water quality as a product of the runoff potential and the aquatic toxicity of the pesticide.

sandy soils; however, clay soils can be more prone to pesticide runoff, as they tend to have low water permeability and may allow water to pool on the soil surface. Correct pesticide application rates, accurate equipment calibration, proper application timing, careful handling of pesticides, minimizing drift, establishing buffer zones around waterways, and proper cleanup and disposal of pesticides minimize the potential for runoff problems associated with pesticide use.

To develop effective mitigation practices, pesticide applicators must understand whether a pesticide moves with runoff in solution or as attachment to solids. For instance, although some pesticides (such as pyrethroids) are not likely to move in the dissolved form in runoff water, they can move by attaching to eroded soil particles and can enter surface streams, where they may cause toxicity to sediment organisms. For these pesticides, it is useful to implement practices to reduce sediment transport in irrigation or storm water runoff from pesticide treated areas. One example of an effective management practice is the use of vegetative filter strips, such as grasses or sedges planted along ditches or streams, to help trap sediments. Other examples include tail-water ponds to help slow the flow of water and enable soil particles to settle out, or using polyacrylimide polymers (PAM) to aggregate soil particles, allowing them to precipitate from the water. However, these practices will not be equally effective if used for reducing the runoff of a pesticide moving primarily in solution. Because water movement is the driving force for any pesticide runoff, improving irrigation efficiency and reducing the amount of runoff is essential when applying pesticides that move in solution. Capturing runoff using a tail pond or retention pond allows more time for pesticides to degrade, resulting in reduced pesticide runoff for pesticides moving either in the solution or in the adsorbed phase.

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Pesticide Selection to Reduce Impacts on Water Quality

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Farm Water Quality Planning
A Water Quality and Technical Assistance Program for California Agriculture

This Reference Sheet is part of the **Farm Water Quality Planning (FWQP)** series, developed for a short course that provides training for growers of irrigated crops who are interested in implementing water quality protection practices. The short course teaches the basic concepts of watersheds, nonpoint source pollution (NPS), self-assessment techniques, and evaluation techniques. Management goals and practices are presented for a variety of cropping systems.

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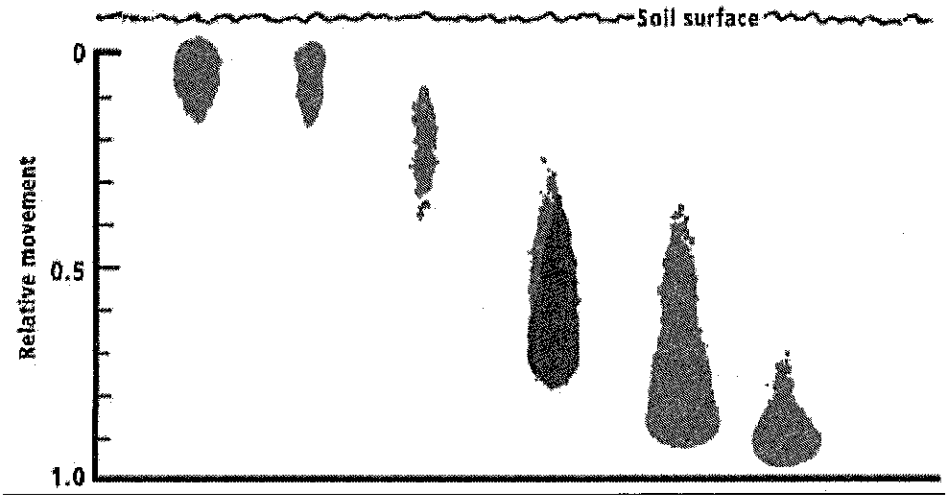
This publication's purpose is to help individual growers make their pesticide-use decisions with water quality in mind. There are several factors that influence a pesticide's potential to affect water quality, including soil properties (e.g., soil texture, organic matter content), pesticide properties (e.g., sorption to soil, half-life), climatic conditions (e.g., rainfall, temperature), and management practices or techniques (e.g., application method, irrigation). Table 1 summarizes how a number of these factors can affect water quality. Along with other site-specific factors, you should take the factors listed in Table 1 into consideration every time you choose a pesticide for application.

Despite all of these factors that can affect a pesticide's potential to impact water quality, though, it is the chemical properties of the pesticide that determine whether it is likely to impact surface water or ground water. In Tables 2, 3, and 4 we have ranked the potential of some common pesticides to impact surface water bodies and ground water according to three pesticide properties: K_{OC}, water solubility, and soil half-life.

K_{OC} is the soil/organic carbon partitioning coefficient. It is highly dependent both on the pesticide's fat solubility and on the organic carbon content of a soil. The larger the K_{OC}, the more strongly the pesticide will sorb to the soil and the less likely it is to migrate to ground water. Water solubility is reported in ppm (parts per million), which is equivalent to milligrams of chemical (in this case, pesticide) that can be dissolved in a liter of water (1 ppm ≈ 1 mg/L). The more soluble a pesticide is, the more likely it is to migrate to ground water or move offsite in surface runoff, although there are exceptions (e.g., glyphosate). A pesticide's soil half-life is the number of days it takes for half of the pesticide to degrade in the soil. The longer the half-life, the more persistent a pesticide is and thus the more probable it is that it will move into ground water or surface water.

Figure 1 gives examples of how K_{OC} and solubility affect the movement of pesticides in soils. Note that K_{OC} and solubility have a strong influence on pesticide leachability. The pesticides in Tables 2, 3, and 4 are reported as having a small, medium, or large potential to impact the surface or ground water. Precautionary actions should be taken above and beyond basic best management practices for pesticides that rank as medium or large potential.

It is important to note that, while the impact of pesticides on groundwater quality is mainly a human health concern (because of its effect on the potability of well water), the effect on surface water quality is often a concern for aquatic organisms or wildlife. This is especially important for pesticides that can run off from fields into streams and lakes, where the pesticides may harm aquatic invertebrates and fish or cause long-term harm to wildlife that feeds on those fish and invertebrates. Tables 2, 3, and 4, list the toxicity of some common pesticides to fish, birds, and other wildlife. By taking appropriate measures (e.g., modifying application methods, application



	CIPC	Diuron	Monuron	Fenac	Amiben	Dicamba
K_{OC}	?	480	150	20	15	2
Solubility (ppm)	?	42	230	5×10^5	9×10^5	4×10^5

Figure 1. Comparative leaching of several herbicides in soils. USDA photo by C.S. Helling; previously published in Brady 1984.

rates, timing, sediment/erosion control structures, tailwater recovery systems, vegetative buffers, etc.), you can reduce the potential impact to these species.

An additional concern is the potential effect of pesticides on the natural enemies of the target pests. If pesticide applications significantly reduce natural enemy populations, you may have to make more-frequent applications to suppress the resurgent pest populations. More applications, in turn, increase the potential to affect water quality. One of your goals is to protect water quality, so you should select a pesticide that has minimal effect on natural enemies, among other desirable characteristics. You can find more information on some common pesticides' toxicity toward certain natural enemies in the Natural Enemies Handbook (Flint and Dreistadt 1998) (UC ANR Publication 3386).

In summary, your choice of pesticides should be based on several factors. For example, when you are applying pesticides to a location where leaching is a major concern, you should choose a pesticide with a short half-life, high K_{OC}, low solubility, and low toxicity toward aquatic organisms, wildlife, beneficial insects, and other nontarget species. In contrast, when you are applying pesticides to a location where runoff is a major concern, pesticide properties (half-life, K_{OC}, solubility) become less important and management and pesticide toxicity become more important. You should still choose a pesticide with a small half-life, high K_{OC}, low solubility, and low toxicity to aquatic organisms, wildlife, beneficial insects, and other nontarget species, but you also need to pay close attention to field management practices. Erosion should be controlled, for instance, to keep pesticides that are associated with field sediment from making their way into streams and waterways. Pesticides should be incorporated during application if possible and any sediment generated from the field during rainfall or irrigation events should be retained, for instance, in a sediment pond or vegetated filter strip.

In selecting pesticides that are appropriate for a specific crop and pest issue, refer to the University of California IPM Pest Management Guidelines (http://www.ipm.ucdavis.edu), UC Cooperative Extension IPM Advisors, or a certified Pest Control Advisor (PCA). You can use Tables 1 through 4 along with other site-specific information to make an educated decision about which pesticide would be most appropriate in terms of water quality and fish or wildlife toxicity. If the pesticide you are interested in is not in Tables 2 through 4, consult the USDA–NRCS Windows Pesticide Screening Tool (http://www.wcc.nrcs.usda.gov/pestmgt/winpst.html) or the University of California's Pesticide Wise Web site (http://www.pw.ucr.edu), which contains a more comprehensive listing of pesticides and their properties.

Table 1. Water quality impact potential as influenced by water, pesticides, and soil properties (H = High and L = Low).

	Pesticide Properties					Soil Properties								Rainfall/ Irrigation Events		Management Practices	
	High water solubility	Low water solubility	Large K_{OC} (strongly sorbed to soil)	Small K_{OC} (weakly sorbed to soil)	Persistent	Coarse-textured soil	Fine-textured soil	High in organic matter	Low in organic matter	Many large connected soil pores	Few small discontinuous soil pores	Shallow water table	Deep water table	Small volumes not extending below root zone	Large volumes exceeding evapotranspiration	Broadcasting	Incorporating
Risk of groundwater impact	H	L	L	H	H	H	L	L	H	H	L	H	L	L	H*	L†	—‡
Risk of surface-water impact	L#	H	H	L#	H	L	H	H	L	L	H	—#	—#	L#	H	H	L

* can be L if pesticide solubility is low or K_{OC} is large and organic matter is high

† can be H if pesticide has high solubility, low K_{OC} and excessive rainfall/irrigation exists

‡ dependent on pesticide properties, soil properties, and rainfall/irrigation events

\# can be H if excessive runoff exists

Table 2. Water quality impact potential and toxicity information of some common herbicides.

Herbicide Common Name	Herbicide Trade Name	Soil Sorption Index (K_{OC})	Water Solubility (ppm)	Soil Half-Life (days)	Leaching Potential*	Solution Runoff Potential†	Adsorbed Runoff Potential‡	Toxicity to Fish#	Toxicity to Birds and Other Wildlife§	References
					Phenoxy and Benzoic Acids					
2,4-D dimethylamine	2,4-D amine	20	890	10	Medium	Medium	Small	Moderate to slight	High to Slight	1, 2
DCPA	Dacthal	5,000	0.5	100	Small	Medium	Large	Slight to practically nontoxic	Moderate to practically nontoxic	1, 2
Dicamba	Banvel	2	$4x10^5$	14	Large	Medium	Small	Practically nontoxic	Practically nontoxic	1, 2
					Triazines					
Atrazine	Aatrex	100	33	60	Large	Large	Medium	Slight	Practically nontoxic	1, 2
Cyanazine	Bladex	190	170	14	Medium	Medium	Small	Slight to moderate	Slight to moderate	1, 2
Hexazinone	Velpar	54	33,000	90	Large	Large	Medium	Slight	Slight to practically nontoxic	1, 2
Metribuzin	Sencor	60	1,220	40	Large	Large	Small	Slight	Moderate to slight	1, 2
Prometon	Pramitol	150	720	500	Large	Large	Medium	Practically nontoxic	Slight	1, 3
Prometryn	Promet	400	33	60	Medium	Large	Medium	Moderate	Practically nontoxic	1, 2
Simazine	Simazine	130	6.2	60	Large	Large	Medium	Slight to practically nontoxic	Practically nontoxic	1, 2
					Substituted Ureas					
Chlorsulfuron	Glean	40	7,000	160	Large	Large	Medium	Practically nontoxic	Practically nontoxic	1, 4
Diuron	Karmex	480	42	90	Medium	Large	Medium	Moderate	Slight	1, 3
Linuron	Lorox	400	75	60	Medium	Large	Medium	Slight	Slight	1, 2
Sulfometuron-methyl	Oust	78	70	20	Medium	Large	Small	Slight	Practically nontoxic	1, 2
Tebuthiuron	Spike	80	2,500	360	Large	Large	Medium	Slight to practically nontoxic	Practically nontoxic	1, 2
					Thiocarbamates					
Butylate	Sutan	400	44	13	Small	Large	Small	Moderate	Practically nontoxic	1, 2
Cycloate	Ro-Neet	430	95	30	Medium	Large	Small	Moderate	Practically nontoxic	1, 4

* The potential for the pesticide to be lost via leaching.

† The potential for the pesticide to be lost by being transported away in surface runoff in the solution phase.

‡ The potential for the pesticide to be lost by being transported away in surface runoff while adsorbed to soil particles.

The toxicity categories are defined in Table 5. Most toxicities are reported for fish, although some include aquatic invertebrates also.

§ The toxicity categories are defined in Table 5. Most toxicities are reported for birds, although some include rabbits and other wildlife also.

Table 2. Water quality impact potential and toxicity information of some common herbicides (con't).

Herbicide Common Name	Herbicide Trade Name	Soil Sorption Index (K_{OC})	Water Solubility (ppm)	Soil Half-Life (days)	Leaching Potential*	Solution Runoff Potential†	Adsorbed Runoff Potential‡	Toxicity to Fish#	Toxicity to Birds and Other Wildlife§	References
EPTC	Eradicane	200	344	6	Small	Medium	Small	Slight	Slight to practically nontoxic	1, 2
Molinate	Molinate	190	970	21	Medium	Medium	Small	High to slight	Practically nontoxic	1, 2
Pebulate	Tillam	430	100	14	Small	Medium	Small	Moderate	Practically nontoxic	1, 4
Triallate	Far-Go	2,400	4	82	Small	Large	Large	High	Practically nontoxic	1, 2
					Bipyridyliums					
Diquat dibromide	Diquat	$1x10^6$	$7.2x10^5$	1,000	Very small	Small	Large	Moderate to practically nontoxic	Slight to moderate	1, 2
Paraquat	Gramoxone	$1x10^6$	$6.2x10^5$	1,000	Very small	Small	Large	Moderate to slight	Moderate	1, 2
					Chloroacetamides					
Alachlor	Lasso	170	240	15	Medium	Medium	Small	Moderate	Practically nontoxic	1, 2
Metolachlor	Dual	200	530	90	High	High	Medium	Moderate	Slight to practically nontoxic	1, 2
					Dinitroanilines					
Oryzalin	Surflan	600	2.5	20	Small	Medium	Small	High	Slight to practically nontoxic	1, 2
Pendimethalin	Prowl	5,000	0.28	90	Small	Medium	Large	High	Slight	1, 2
Trifluralin	Treflan	8,000	0.3	60	Small	Medium	Large	Very high	Practically nontoxic	1, 2
					Nitriles					
Bromoxynil	Buctril	192	0.8	8	Small	Small	Medium	Very high to moderate	High to moderate	1, 2
Dichlobenil	Casoron	400	21.2	60	Medium	Large	Medium	Moderate to slight	Slight to practically nontoxic	1, 4

* The potential for the pesticide to be lost via leaching.
† The potential for the pesticide to be lost by being transported away in surface runoff in the solution phase.
‡ The potential for the pesticide to be lost by being transported away in surface runoff while adsorbed to soil particles.
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Table 2. Water quality impact potential and toxicity information of some common herbicides (con't).

Herbicide Common Name	Herbicide Trade Name	Soil Sorption Index (K_{OC})	Water Solubility (ppm)	Soil Half-Life (days)	Leaching Potential*	Solution Runoff Potential†	Adsorbed Runoff Potential‡	Toxicity to Fish#	Toxicity to Birds and Other Wildlife§	References
				Other Herbicides						
Acrolein	Magnacide-H	1	$2.1x10^5$	14	Large	Medium	Small	High to slight	Very high to high	1, 4
Bensulide	Prefar	1,000	5.6	120	Medium	Large	Large	Moderate to high	Slight	1, 2
Bentazon	Basagran	35	$2.3x10^6$	20	Large	Large	Small	Practically nontoxic	Slight	5, 1, 2
Bromacil	Hyvar	32	700	60	Large	Large	Medium	Slight to practically nontoxic	Practically nontoxic	1, 2
Clopyralid	Stinger	6	1,000	30	Large	Medium	Small	Practically nontoxic	Slight to practically nontoxic	1, 5
Diethayl-ethyl	Antor	1,400	105	21	Small	Medium	Medium	Moderate	N/A	1, 6
Ethofumesate	Norton	340	50	30	Medium	Large	Small	Slight to practically nontoxic	Practically nontoxic	1, 4
Glyphosate	Roundup	24,000	12,000	47	Very small	Large	Large	Practically non-Toxic	Slight	1, 2
Imazethapyr	Pursuit	10	$2x10^5$	90	Large	Large	Medium	Practically nontoxic	Practically nontoxic	1, 4
Isoxaben	Snapshot TG	1,400	1	100	Small	Large	Large	High to moderate	Practically nontoxic	1, 4
Napropamide	Devrinol	400	74	70	Medium	Large	Medium	Moderate to slight	Practically nontoxic	1, 2
Norflurazon	Evital	600	28	90	Medium	Large	Medium	Moderate	Slight to practically nontoxic	1, 4
Oxyfluorfen	Goal	$1x10^5$	0.1	35	Very small	Large	Medium	High	Practically nontoxic	1, 2
Propyzamide	Kerb	200	15	60	Large	Large	Medium	Slight to practically nontoxic	Practically nontoxic	1, 4
Pyrazon	Pyramin	120	400	21	Large	Large	Medium	Slight	Slight	1, 3
Rimsulfuron	Matrix	47	7,300	10	Medium	Medium	Small	Practically nontoxic	Slight to moderate	1, 3

* The potential for the pesticide to be lost via leaching.

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‡ The potential for the pesticide to be lost by being transported away in surface runoff while adsorbed to soil particles.

The toxicity categories are defined in Table 5. Most toxicities are reported for fish, although some include aquatic invertebrates also.

§ The toxicity categories are defined in Table 5. Most toxicities are reported for birds, although some include rabbits and other wildlife also.

Table 3. Water quality impact potential of common insecticides, nematicides, and other pesticides.

Pesticide Common Name	Pesticide Trade Name	Soil Sorption Index (K_{OC})	Water Solubility (ppm)	Soil Half-Life (days)	Leaching Potential	Solution Runoff Potential	Adsorbed Runoff Potential	Toxicity to Fish	Toxicity to Birds and Other Wildlife	References
				Pyrethroids and Botanicals						
Esfenvalerate	Asana	5,300	0.002	35	Small	Medium	Medium	Very high	Slight	1, 2
Fenvalerate	Pydrin	5,300	0.002	35	Small	Medium	Medium	High to moderate	Practically nontoxic	1, 4
Fluvalinate	Mavrik	$1x10^6$	0.005	30	Very small	Small	Medium	Very high	Slight	1, 2
Permethrin	Ambush	$1x10^5$	0.006	30	Very small	Small	Medium	Very high	Practically nontoxic	1, 2
Resmethrin	Crossfire	$1x10^5$	0.01	30	Very small	Small	Medium	Very high	Practically nontoxic	1, 2
				Carbamates						
Aldicarb	Temik	30	6,000	30	Large	Medium	Small	Moderate	Very high	1, 2
Carbaryl	Sevin	300	120	10	Small	Medium	Small	Moderate	Practically nontoxic	1, 2
Carbofuran	Furadan	22	351	50	Large	Large	Medium	High	High	1, 2
Formetanate	Carzol	$1x10^6$	$5x10^5$	100	Very small	Small	Large	Moderate to slight	High	1, 4
Methiocarb	Mesurol	300	24	30	Medium	Large	Small	Moderate to high	Very high to high	1, 4
Methomyl	Lannate	72	58,000	30	Large	Medium	Small	High to moderate	High	1, 2
Oxamyl	Vydate-L	$2.8x10^5$	25	4	Small	Medium	Small	Moderate to slight	Very high	1, 2
Thiodicarb	Larvin	350	19.1	7	Small	Large	Small	High to moderate	Practically nontoxic	1, 4
				Organophosphates						
Acephate	Orthene	2	818,000	3	Small	Medium	Small	Slight to practically nontoxic	Moderate to slight	1, 4
Azinphos-methyl	Guthion	1,000	29	10	Small	Medium	Medium	Very high to moderate	Slight to moderate	1, 2
Chlorpyrifos	Lorsban	6,070	0.4	30	Small	Small	Medium	Very high	Very high to moderate	1, 2
Chlorpyrifos-methyl	Dursban methyl	3,000	4	7	Small	Medium	Medium	Moderate to practically nontoxic	Slight	1, 4
Diazinon	D.Z.N.	1,000	60	40	Small	High	High	High to slight	Very high to high	1, 2
Dimethoate	Cygon	20	39,800	7	Medium	Medium	Small	Moderate	Very high to moderate	1, 2
Disulfoton	Di-Syston	600	25	30	Medium	Large	Small	High	Moderate	1, 2
Fenamiphos	Nemacur	100	400	50	Large	Large	Medium	High to moderate	Very high	1, 2

Table 3. Water quality impact potential of common insecticides, nematicides and other pesticides (con't).

Pesticide Common Name	Pesticide Trade Name	Soil Sorption Index (K_{OC})	Water Solubility (ppm)	Soil Half-Life (days)	Leaching Potential	Solution Runoff Potential	Adsorbed Runoff Potential	Toxicity to Fish	Toxicity to Birds and Other Wildlife	References
Fonofos	Dyfonate	870	16.9	40	Small	Large	Small	High	Extremely high	1, 2
Malathion	Cythion	1,800	130	1	Small	Small	Small	Very high to slight	Moderate	1, 2
Methyl parathion	Penncap-M	5,100	60	5	Small	Medium	Medium	Very high to high	Extreme	1, 2
Naled	Dibrom	180	2,000	1	Small	Medium	Small	High to moderate	High to moderate	1, 2
Parathion	Phoskil	5,000	24	14	Small	Medium	Medium	Very high to moderate	Very high to high	1, 4
Phorate	Thimet	1,000	22	60	Small	Large	Large	Very high	Very high to high	1, 2
Terbufos	Counter	500	5	5	Small	Medium	Small	High	Very high	1, 2
Trichlorfon	Dylox	10	$1.2x10^5$	10	Large	Medium	Small	Very high	High to moderate	1, 2
				Organochlorides (Chlorinated hydrocarbons)						
Dicofol	Kelthane	$1.8x10^5$	1	60	Very small	Small	Large	High	Slight	1, 2
Dienochlor	Pentac	1,000	25	300	Medium	Large	Large	Very high to high	Practically nontoxic	1, 2
Endosulfan	Thiodan	12,400	0.32	50	Very small	Medium	Large	Very high	High to moderate	1, 2
Lindane	Isotox	1,100	7	400	Medium	Large	Large	Very high to high	Moderate to practically nontoxic	1, 2
				Other						
Abamectin	Avid	5,000	5	28	Small	Medium	Medium	Very high	Practically nontoxic	1, 2
Bacillus thuringensis	Dipel	N/A	N/A	120	Very small (estimated)	N/A	N/A	Practically nontoxic	Practically nontoxic	2
Bifenthrin	Talstar	$2.4x10^5$	0.1	26	Very small	Small	Medium	Very high	Slight to practically nontoxic	1, 4
Cryolite	Kryocide	10,000	420	3,000	Small	Large	Large	Slight to practically nontoxic	Practically nontoxic	1, 4
Diflubenzuron	Dimilin	10,000	0.08	10	Small	Small	Medium	Practically nontoxic	Practically nontoxic	1, 2
Ethoprop	Mocap	70	750	25	Large	Medium	Small	Very high to slight	Very high to slight	1, 4
Imidacloprid	Admire	440	580	127	Large	Large	Medium	Slight to practically nontoxic	High to slight	1, 4
Metaldehyde	Metaldehyde	240	230	10	Small	Medium	Small	Moderate to practically nontoxic	Moderate to slight	1, 4
Oxydemeton-methyl	Metasystox-R	10	$1x10^6$	10	Large	Medium	Small	High to slight	High to slight	1, 4

Table 4. Water quality impact potential of common fungicides.

Fungicide Common Name	Fungicide Trade Name	Soil Sorption Index (K_{OC})	Water Solubility (ppm)	Soil Half-Life (days)	Leaching Potential	Solution Runoff Potential	Adsorbed Runoff Potential	Toxicity to Fish	Toxicity to Birds and Other Wildlife	Reference
					Dithiocarbamates					
Mancozeb	Dithane	2,000	6	70	Small	Large	Large	High to moderate	Slight	1, 2
Maneb	Maneb	2,000	6	70	Small	Large	Large	High	Practically nontoxic	1, 2
					Dicarboximides					
Iprodione	Rovral	700	13.9	14	Small	Large	Small	Moderate	Slight	1, 2
Vinclozolin	Ronilan	100	1,000	20	Medium	Medium	Small	Moderate to slight	Practically nontoxic	1, 2
					Organochlorides (Chlorinated hydrocarbons)					
Chlorothalonil	Bravo	1,380	0.6	30	Small	Medium	Medium	High	Practically nontoxic	1, 2
PCNB (Quintozene)	Terraclor	5,000	0.44	21	Small	Small	Medium	High	Practically nontoxic	1, 2
Dichloropropene	Telone II	32	2,250	10	Medium	Medium	Small	Moderate	Moderate to practically nontoxic	1, 4
					Other Fungicides					
Bacillus subtilis	Serenade	N/A	N/A	N/A	Very small (estimated)	Small	Small	Practically nontoxic	Practically nontoxic	3, 7
Benomyl	Benlate	1,900	2	67	Very small	Small	Small	Very high to high	Moderate to practically nontoxic	1, 2
Captan	Captan	200	5.1	3	Small	Medium	Small	Very high	Practically nontoxic	1, 2
Carboxin	Vitavax	260	195	7	Small	Medium	Small	High to slight	Slight to practically nontoxic	1, 4
Chloropicrin	Chlor-O-Pic	62	2,270	1	Small	Medium	Small	Very high to high	N/A	1, 4
Dicloran	Botran	1,000	7	10	Small	Medium	Medium	High to slight	Slight to practically nontoxic	1, 4
Fosetyl-Al technical	Aliette	20	$1.2x10^5$	1	Very small	Medium	Small	Practically nontoxic	Practically nontoxic	1, 4
Metalaxyl	Ridomil	70	8,400	50	Large	Large	Medium	Practically nontoxic	Practically nontoxic	1, 2
Triadimefon	Bayleton	300	71.5	26	Medium	Large	Small	Slight to practically nontoxic	Practically nontoxic	1, 2
Triflumizole	Procure	40	12,500	14	Medium	Medium	Small	High to moderate	Practically nontoxic	1, 4

Table 5. Definition of toxicity categories used in Tables 2, 3, and 4.

Toxicity Rating	Bird Acute Oral LD_{50} (mg/kg)	Fish water LC_{50}(mg/L)
Very high	<10	<0.1
High	10–50	0.1–1
Moderate	>50–500	>1–10
Slight	>500–2000	>10–100
Practically nontoxic	>2000	>100

SOURCE: Modified from Kamrin, 1997, Lewis Publishers (an imprint of CRC Press).

REFERENCES FOR TABLES 2 THROUGH 4

Note: These references are numbered, and they are referenced by number in Tables 2 through 4.

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Figure 1 in this publication was adapted from *The Nature and Properties of Soils* (Brady 1984), courtesy of C. S. Helling, USDA. The information in this publication was drawn from the above listed sources, the sources referenced in the tables, and discussions with qualified professionals. Contact your local NRCS office or visit http://www.nrcs.usda.gov for further information.

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You'll find detailed information on many aspects of resource conservation in these titles and in other publications, slide sets, CD-ROMs, and videos from UC ANR:

Developing a Nonpoint Source Pollution Evaluation Program, publication 8087
Nonpoint Sources of Pollution in Irrigated Agriculture, publication 8055
The Farm Water Quality Plan, publication 9002

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This publication has been anonymously peer reviewed for technical accuracy by University of California scientists and other qualified professionals. The review process was managed by the ANR Associate Editor for Natural Resources.

Best Management Farming Practices for Water Quality Protection
Agrichemical Handling Facility (309)

BMP: Protect creeks, streams and rivers from agrichemical inputs.

NRCS Practice Standard: Agrichemical Handling Facility (309)

A designated Agrichemical Handling Facility is needed when the handling of agrichemicals creates significant potential for pollution of surface water, groundwater, air or soil. The development of a permanent or temporary Facility helps ensure that chemicals are properly managed and associated equipment is properly operated. A Facility must have an adequate water supply for filling application equipment tanks, rinsing application equipment and chemical containers as needed for the operation. The pad, hoses, pipes, valves, seals, connectors, filters, tanks, and related plumbing material must be compatible with the chemicals being handled and capable of withstanding the intended use.

Agrichemical Handling Facility (NRCS Conservation Practice Code 309)

Definition: A facility with an impervious surface to provide an environmentally safe area for the handling of on-farm agrichemicals.

Purposes:

- To provide a safe environment on farm and ranch operations for the storage, mixing, loading and cleanup of agrichemicals, retain incidental spillage, and retain leakage
- To reduce pollution to surface water, groundwater, air, and/or soil.

Consider this:

For permanent facilities, the agrichemical handling facility may cause an increase in water use at the site from the mixing of agrichemicals and rinsing of agrichemical sprayers, containers and agrichemical-handling pad.

Consider providing a roof over permanent facilities.

Consider installing an apron at the facility entrance to minimize sediment transport onto the pad.

Consider providing a mixing platform for filling agrichemical sprayers.

For portable handling facilities consider using a top/bottom-loading valve with built-in check valve in the hose from the nurse tank to the spray tank. This will enable the operator to remain on the ground while filling the sprayer.

When the agrichemical handling facility is also used for agrichemical storage, provide sufficient space and designate a separate room or area.

Outlet drains are not permitted in the agrichemical collection, storage or handling areas.

For more information contact your local NRCS office or visit our website at http://efota.sc.egov.usda.gov/treemenuFS.asp

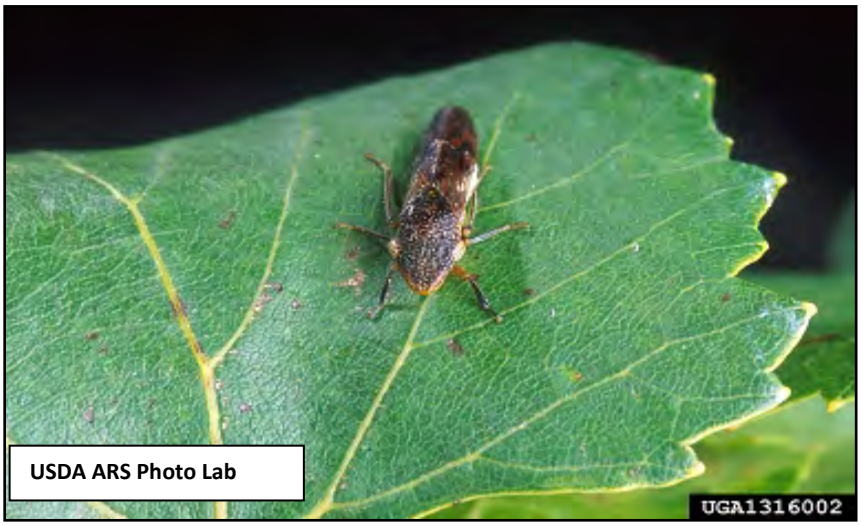
Best Management Farming Practices for Water Quality Protection

Integrated Pest Management (595) Fact Sheet

BMP: Reduce pesticide movement with water and eroding soil

NRCS Practice Standard: Integrated Pest Management 595

IPM is the management of agricultural pests, including weeds, insects, rodents and diseases, considering both the needs of the crop as well as the surrounding aquatic and terrestrial environment. IPM will be carried out by consulting and following UC IPM Pest Management Guidelines for crop-specific assessment techniques. http://www.ipm.ucdavis.edu/ Pesticides shall be applied at lowest effective labeled rate possible. http://www.wcc.nrcs.usda.gov/pestmgt/winpst.html



CONSIDER THIS:

Scout blocks regularly.

Maintain detailed records.

Use good sanitation practices.

Remove alternate hosts plants.

Control dust.

Use plant varieties and rootstock resistant to phylloxera and nematodes when planting and replanting.

Base pesticide application decisions on scouting data, pest thresholds and/or risk assessment models.

Select pesticides for lower risk of runoff or leaching based on site conditions, pesticide label warnings or transport models.

Apply at lowest effective labeled rate.

Integrated Pest Management (NRCS Conservation Practice Code 595)

Definition: A site-specific combination of pest prevention, pest avoidance, pest monitoring, and pest suppression strategies.

Purposes:

- Prevent or mitigate off-site pesticide risks to water quality from leaching, solution runoff and adsorbed runoff losses.
- Prevent or mitigate off-site pesticide risks to soil, water, air, plants, animals and humans from drift and volatilization.
- Prevent or mitigate on-site pesticide risks to pollinators and other beneficial species through direct contact.
- Prevent or mitigate cultural, mechanical and biological pest suppression risks to soil, water, air, plants, animals and humans.

For more information contact your local NRCS office or visit our website at http://efotg.sc.egov.usda.gov/treemenuFS.aspx

www.ipm.ucdavis.edu

Wine/Raisin Grape Year-Round IPM Program
Annual Checklist

Supplement to UC IPM Pest Management Guidelines: Grape

These practices are recommended for a monitoring-based IPM program that reduces water quality problems related to pesticide use. Track your progress through the year using this form.

Each time a pesticide application is considered, review the Pesticide Application Checklist at the bottom of this form for information on how to minimize water quality problems. This program covers the major pests of grape. Details on carrying out each practice, information on additional pests, and additional copies of this form are available from the UC IPM Pest Management Guidelines: Grape at http://www.ipm.ucdavis.edu/PMG.

This program applies only to wine and raisin grapes; it does not include information for table grapes. For **table grapes**, see the Table Grape Year-Round IPM Program.

✓ Done	**Delayed-dormant period activities** What should you be doing at this time?
	On a warm day, monitor vines and spurs for: • Mealybugs • Ants associated with mealybugs and European fruit lecanium scale • Orange overwintering spider mites • Cutworm Keep records on a monitoring form. Treat** if needed according to the PMG.
	In coastal areas, check orange tortrix pheromone traps that were put up during the dormant period. • Keep records on a monitoring form.
	Just before budbreak, put up omnivorous leafroller pheromone traps. • Check traps twice weekly until a biofix date is established; thereafter, check traps weekly. • Keep records on a monitoring form.
	If sharpshooters are a problem in your area, set out sticky traps just before budbreak for: • Glassy-winged sharpshooter In coastal regions near riparian and landscape areas: • Blue-green sharpshooter Change traps weekly. Keep records on a monitoring form.
	Keep records of other pests or pest damage you may see. • Rodents • Branch and twig borer • Click beetles • Bud beetles • *Eutypa*

✓ Done	**Budbreak period activities** What should you be doing at this time?
	On a warm day, monitor vines and spurs for: • Mealybugs • Ants associated with mealybugs and European fruit lecanium scale • Orange overwintering spider mites • Cutworm • Thrips Keep records on a monitoring form. Treat** if needed according to the PMG.
	Check pheromone traps for: • Omnivorous leafroller • Orange tortrix in coastal areas Keep records on a monitoring form.
	Monitor leaf wetness. Track powdery mildew ascospore release and mildew risk index. • Treat** if needed according to the PMG.
	Consider treating** for phomopsis cane and leaf spot if rain continues after budbreak.
	Remove vines that have spring symptoms of Pierce's disease.
	Check sticky traps for sharpshooters: • Glassy-winged sharpshooter In coastal regions near riparian and landscape areas: • Blue-green sharpshooter Change traps weekly. Keep records on a monitoring form.

✓ Done	**Rapid shoot growth period activities** What should you be doing at this time?
	Look for thrips if cold weather persists.
	Look for spider mites and their natural enemies weekly on first-emerging leaves. • Map areas of concern for bloom monitoring.
	Monitor leafhoppers weekly starting a month after budbreak or whenever first nymphs appear. • Keep records on a monitoring form.
	Continue checking pheromone traps for: • Omnivorous leafroller • Orange tortrix in coastal areas Keep records on a monitoring form.
	In southern San Joaquin Valley, put up vine mealybug pheromone traps around April 1 and check every two weeks. • If males are caught or honeydew, sooty mold, or ants are found, look for female infestations on surrounding vines. • Keep records on a monitoring form. • Treat** if needed according to PMG.
	Monitor caterpillars if they have been a problem in the past: • Western grapeleaf skeletonizer • Grape leaffolder • Orange tortrix in coastal vineyards • Omnivorous leafroller Map areas of concern for bloom monitoring.
	If European fruit lecanium scale has been a problem in the past, monitor female development on old wood.
	Manage ants if mealybugs and scale are a problem.
	Monitor sharpshooters: • Glassy-winged sharpshooter In coastal regions near riparian and landscape areas check for: • Blue-green sharpshooter Change sticky traps weekly. Keep records on a monitoring form.
	Monitor for flagging. If you see a flag, distinguish between *Botrytis* shoot blight and branch and twig borer.
	Monitor leaf wetness. Track powdery mildew ascospore release and mildew risk index. • Treat** if needed according to PMG.
	Survey weeds to plan a weed management strategy. • If herbicides** are used, use the late-spring weed survey form to record your observations and make pre- and postemergent herbicide selection decisions.
	Keep records of other pests or pest damage you may see: • Eutypa dieback • Phomopsis

✓ Done	**Bloom to veraison period activities** What should you be doing at this time?
	Monitor leafhopper and spider mites weekly. • Keep records on a monitoring form. • Treat** if needed according to PMGs.
	Monitor for *Botrytis* and powdery mildew by inspecting leaves and shoots.
	If European fruit lecanium scale has been a problem in the past, monitor for egg hatch to time treatment**.
	Check pheromone traps for: • Omnivorous leafroller • Orange tortrix (in central coast areas) Keep records on a monitoring form.
	In areas other than southern San Joaquin Valley, put up vine mealybug pheromone traps. In all areas, check traps every two weeks. • If males are caught or honeydew, sooty mold, or ants are found, look for female infestations on surrounding vines. • Keep records on a monitoring form. • Treat** if needed according to PMG.
	Monitor *Pseudococcus* mealybugs by looking for honeydew, sooty mold, and ant activity. • Keep records on a monitoring form. • If you see crawlers, treat** if needed according to PMG.
	To reduce possible summer rot, *Botrytis*, and leafhoppers, remove basal leaves or basal lateral shoots beginning around berry set. • Time leaf pull before first-generation grape leafhoppers become adults. Treat** for *Botrytis* prior to rain, if leaves are not removed.
	Monitor caterpillars if they have been a problem in the past: • Omnivorous leafroller • Orange tortrix • Grape leaffolder • Western grapeleaf skeletonizer Keep records on a monitoring form.
	Monitor sharpshooters: • Glassy-winged sharpshooter In coastal regions near riparian and landscape areas check for: • Blue-green sharpshooter Change sticky traps weekly. Keep records on a monitoring form.
	Keep a record of other pests or pest damage you may see; • Grasshopper • Whitefly

✓ Done	**Veraison period activities** What should you be doing at this time?
	Monitor leafhoppers and spider mites weekly. • Keep records on a monitoring form. Treat** if needed according to PMGs.
	Check pheromone traps for: • Omnivorous leafroller • Orange tortrix in coastal areas Keep records on a monitoring form.
	Check vine mealybug pheromone traps. • If males are found, or if honeydew, sooty mold, or ant activity is found, look for female infestations on surrounding vines. • Educate field crew to flag cluster infestations for treatment. Treat** if needed according to PMG.
	Monitor grape and obscure mealybugs. • Keep records on a monitoring form. • If you see crawlers, treat** if needed according to PMG.
	Monitor sharpshooters: • Glassy-winged sharpshooter Check traps weekly. Keep records on a monitoring form.
	Look for vine symptoms of Pierce's disease.
	If rain occurs shortly after veraison, monitor for *Botrytis*.
	Monitor caterpillars if they have been a problem in the past: • Omnivorous leafroller • Orange tortrix • Grape leaffolder • Western grapeleaf skeletonizer Keep records on a monitoring form.
	Look on roots of weakened vines for galls or phylloxera.
	If necessary manage birds with netting or scare devices as fruit ripens.
	Keep a record of other pests or pest damage you may see. • Whitefly • European fruit lecanium • Grasshoppers

✓ Done	**Harvest period activities** What should you be doing at this time?
	Be aware that high populations of adult leafhoppers may interfere with hand harvesting.
	Monitor for grape, obscure, and vine mealybugs. • Look for cluster infestations and mark on map. • Educate harvest crew to flag cluster infestations of vine mealybug for treatment. • Treat** vine mealybug if needed according to PMG.
	If you have vine mealybug, steam sanitize equipment before moving to an uninfested area of the vineyard.
	For Pierce's disease: • Flag vines with symptoms for removal.
	If necessary, continue managing birds with netting or scare devices.
	Treat** for *Botrytis* prior to any anticipated rain.
	Sample soil and roots for nematodes; look at roots for galls and phylloxera.
	Monitor glassy-winged sharpshooter: • Check traps weekly and keep records on a monitoring form.

✓ Done	**Postharvest period activities** What should you be doing at this time?
	If necessary, treat** for vine mealybug immediately after harvest according to the PMG.
	To reduce risk of transferring vine mealybug, do not place winery pomace in the vineyard; compost pomace or cover piles securely with clear plastic.
	Look for symptoms of Pierce's disease on vines and flag for removal.
	Look for European fruit lecanium on leaves.
	If you desire a cover crop, seed after harvest.

✓ Done	**Dormant period activities** What should you be doing at this time?
	Apply lime sulfur** for powdery mildew in areas other than Madera, Fresno, and Tulare counties.
	In coastal areas, set out orange tortrix pheromone traps by December. • Check traps twice weekly until a biofix date is established; thereafter, check traps weekly. • Keep records on a monitoring form.
	If present, treat** for Phomopsis cane and leaf spot before rainfall.
	Sample for nematodes in January or February.
	Carry out dormant-season sanitation activities: • Prune late in dormancy after rains to reduce wound infections. • Destroy prunings of older infested wood to reduce pest sources. • Remove dried grape clusters on vines and disc weeds and clusters where orange tortrix or omnivorous leafroller is a problem. • In vineyards with a history of branch and twig borers, examine old pruning scars and dead parts of vines for brown frass and wood dust. • If you have vine mealybug, steam sanitize equipment before moving to uninfested area of the vineyard.
	Survey weeds to plan a weed management strategy. • If herbicides** are used, use the late-winter survey form to record your observations and make pre- and postemergent herbicide selection decisions.

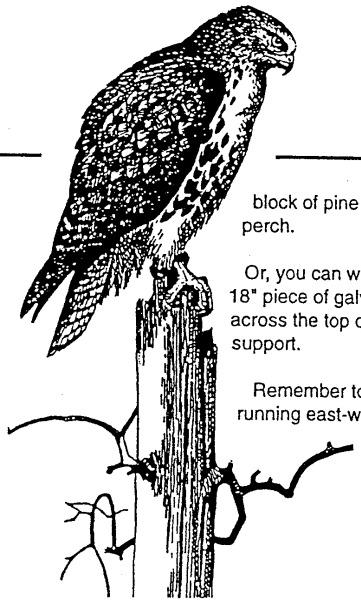
✓ Done	**Pesticide application checklist
	When planning for possible pesticide applications in an IPM program, review and complete this checklist to consider practices that minimize environmental and efficacy problems. ✓ Choose a pesticide from the UC IPM Pest Management Guidelines for the target pest considering: ▪ Impact on natural enemies. ▪ Potential for water quality problems using the UC IPM WaterTox database. (For more information, see http://www.ipm.ucdavis.edu/TOX/simplewatertox.html.) ▪ Impact on aquatic invertebrates. (For more information, see *Pesticide Choice,* UC ANR Publication 8161, http://anrcatalog.ucdavis.edu/pdf/8161.pdf.) ▪ Chemical mode of action if pesticide resistance is an issue. ✓ Select an alternative chemical or nonchemical treatment when risk is high. ▪ Choose sprayers and application procedures that keep pesticides on target. ▪ Identify and take special care to protect sensitive areas (for example, waterways or riparian areas) surrounding your application site. ▪ Review and follow label for pesticide handling, storage, and disposal guidelines. ▪ Check and follow restricted entry intervals (REI) and preharvest intervals (PHI). ▪ After an application is made, record application date, product used, rate, and location of application. Follow up to confirm that treatment was effective. ✓ Consider water management practices that reduce pesticide movement off-site. (For more information, see UC ANR Publication 8214, *Reducing Runoff from Irrigated Lands: Causes and Management of Runoff from Surface Irrigation in Orchards,* http://anrcatalog.ucdavis.edu/pdf/8214.pdf.) ▪ Install an irrigation recirculation or storage and reuse system. ▪ Use drip rather than sprinkler or flood irrigation. ▪ Limit irrigation to amount required using soil moisture monitoring and evapotranspiration (ET). ▪ Consider vegetative filter strips or ditches. (For more information, see *Vegetative Filter Strips*, UC ANR Publication 8195, http://anrcatalog.ucdavis.edu/pdf/8195.pdf.) ▪ Redesign inlets into tailwater ditches to reduce erosion. ✓ Consider management practices that reduce air quality problems. ▪ When possible, choose pesticides that are not in emulsifiable concentrate (EC) form which release volatile organic compounds (VOCs). VOCs react with sunlight to form ozone, a major air pollutant.

ARTIFICAL PERCHES FOR RAPTORS

ans and Instructions

United States Department of Agriculture

Natural Resources Conservation Service
Davis, CA 95616



ENCOURAGE RAPTORS IN YOUR AREA FOR MORE EFFICIENT RODENT CONTROL

Raptors are birds of prey that are greatly beneficial in controlling of rodents. A small, one-time investment in artificial perches can help increase the presence of these birds in your area, reducing the need for other methods of pest control.

PERCH SITES

Raptors hunt in open areas such as mowed alfalfa fields, golf courses, vineyards, along roadsides, ditch banks, rural school grounds and meadows. Any of these areas are good potential perch sites.

By providing strategically-located vantage points to these sharp-sighted birds through artificial perches you can help improve the hunting efficiency of raptors, reducing rodent pests. These perches can be especially valuable in the winter and early spring, before the primary rodent breeding [illegible]on when many crops are either absent or provide little

While we are not familiar with any studies of the impact of artificial perches on rodent populations, it would clearly be beneficial to your raptor population if artificial perches make it easier for them to spot prey or help them use less energy to hunt.

IMPORTANT POINTS TO CONSIDER

All perches should be placed with the horizontal axis pointing east-west to avoid instability due to wind direction and changing visibility due to sun and moonlight.

Artificial perches are readily accepted by many resident raptors, including American kestrels, barn owls, great horned owls, burrowing owls, short-eared owls, red-tailed and red-shouldered hawks and black-shouldered kites.

Perches can be erected any time of year. The acceptance and use of the perches by raptors indicate that perches may prove useful as a management tool for raptors.

B[illegible]DING A PERCH

[illegible]icial perches are easy to build. The ideal material is 3/4" galvanized steel pipe, 18' long. Set the pipe about 3 feet deep in the ground with an 18" x 2" x 2" rounded edge block of pine or redwood as the perch.

Or, you can weld a 1 1/2N to 2" x 18" piece of galvanized steel pipe across the top of the vertical support.

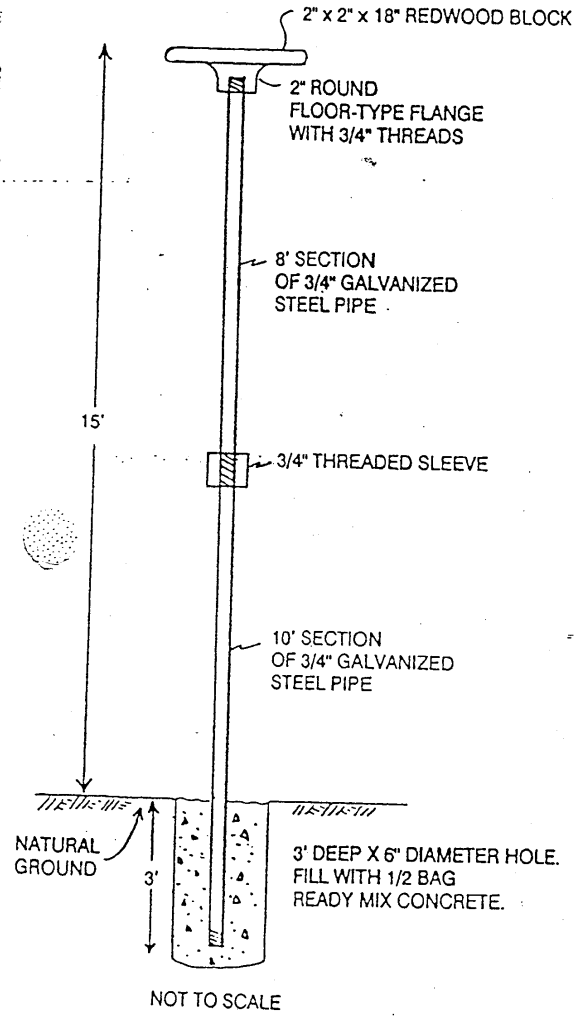
Remember to place the perch running east-west, longways.

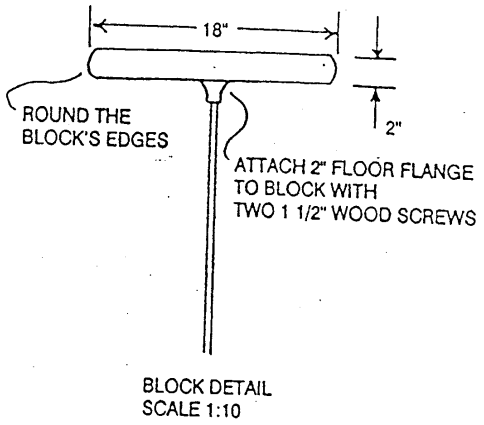
Job sheet compiled by Patrick J. Burke, (Natural Resources Conservation Service, Escondido) from a research paper, "Raptor Use of Artificial Perches," by Timothy R. Hall, Walter E. Howard and Rex E. Marsh, Wildlife and Fisheries Biology, University of California at Davis, 1980 and 1981.

Revised January 1996 Job Sheet CA-502

ARTIFICAL PERCHES FOR RAPTORS

Plans





MATERIALS

A. TWO 10' SECTIONS GALVANIZED STEEL POPE, 3.4" DIAMETER
B. ONE 2"X2"X18" REDWOOD BLOCK
C. TWO 1 1/2" WOOD SCREWS
D. ONE CUBIC FOOT READY MIX CONCRETE
E. ONE 2"X3/4" FLOOR FLANGE
F. ONE 3/4" THREADED SLEEVE
G. ONE CAN "DUNE TAN" RUST PREVENTIVE SPRAY PAINT

NOTES

1. PAINT ALL ABOUVE-GROUND STEEL WITH "DUNE TAN" RUST PREVENTIVE PAINT.
2. MIX CONCRETE AS RECOM MENDED BY MANUFACTURER.
3. ORIENT THE PERCH EAST TO WEST TO MINIMIZE GLARE..

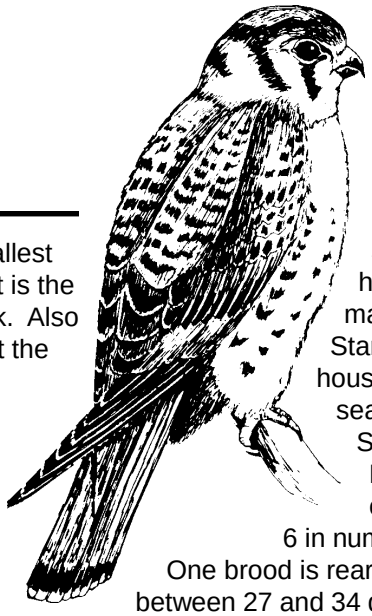
REFERENCE

THE WILDLIFE SOCIETY
V E 9, NUMBER 4, WINTER 1981
PA 296-298

KESTREL HOUSE
Plans and Instructions

United States Department of Agriculture

Natural Resources Conservation Service
Davis, CA 95616



The American Kestrel (Falco sparverius) is our smallest falcon and the most brightly colored of our hawks. It is the only small hawk with a facial mask and rusty red back. Also known as the Sparrow Hawk or Kitty Hawk, it is about the size of a robin or mourning dove.

The Kestrel is often seen hovering (hunting) over a field or meadow and frequents poles and wires along roadsides. Its principal diet is insects, grasshoppers, and mice.

NESTING SITES

Historically, Kestrels have been cavity nesters but will also use secluded buildings and crevices. Removal of dead trees and old buildings and increased competition with Starlings have reduced nesting sites. Fortunately, Kestrels take well to houses you can build.

PICKING A HOUSE SITE

Good locations for Kestrel houses are open fields and meadows or along fence rows. Houses can be mounted on utility poles, buildings, lone trees, or your own post. The house should face south or east. Pick a location where a tall tree or pole and wire is within 100 to 200 yards, as Kestrels like high perches near the house. The house should be 10 to 100 feet from the ground and the entrance should not be hindered by twigs or branches as the Kestrel prefers an uninhibited exit from the house. The best time to erect a Kestrel house is November through January.

When picking your house location, keep in mind that the house needs to be cleaned and checked periodically. Therefore, do not erect it where it is impossible to reach later-with a ladder or from your vehicle. An alternative to ladders is to put up your own post (an eight loot-long 4 x 4 attached to a twelve-foot-long 2 x 4) with six-inch bolts to enable you to swing the house down. It is often difficult to find a tree or pole facing the right direction which isn't miles from your car! With your own post, you can dig a hole wherever you find an ideal spot. The only tools you'll need later are a wrench and a screwdriver for opening the box). The height of the box can be 10 to 15 feet from the ground (see diagram on this page).

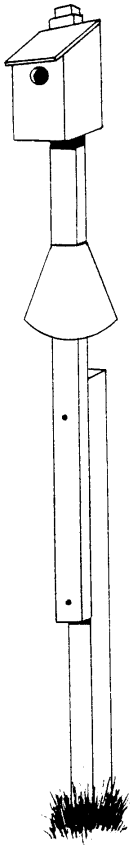
MONITORING THE HOUSE

It is very important to check the house weekly in the spring to keep Starlings and other undesirables out of the house. Kestrels take no nesting materials into the house, so 2 to 3 inches of wood shavings or coarse sawdust should be put into the house. Straw or dry leaves are acceptable. Screech owls also will use a Kestrel house and are desirable tenants. They also bring no nesting material, so any nesting material found in the house will almost certainly be Starling material and should be removed. Starlings are persistent, so check the house at least weekly during the nesting season. (Starling eggs are pale blue, Screech Owl eggs are white, and Kestrel eggs are white/cinnamon colored with spots of brown and 4 to 6 in number.) Incubation is about 28 days. One brood is reared during the season. Birds fledge between 27 and 34 days.

CAUTION—Don't overdo the checking as this will inhibit the Kestrels.

BUILDING A HOUSE

Kestrel houses are easy and fun to build. Ideal materials are rough redwood and cedar because they are long lasting. Wood which is subject to warping can be stained or painted a natural color; avoid very dark colors that will absorb excessive heat.



Revised May 1998 Job Sheet CA-499

KESTREL HOUSE
Plans

Guide

1. Entrance hole is 3" in diameter and 9-10" above floor.

2. An inside perch should be placed 3" from bottom of entrance hole. Use half of entrance cut-out and attach with screw.

3. Use a screwdriver or auger to make indentations in side the front and under the entrance hole to enable the young to climb to exit.

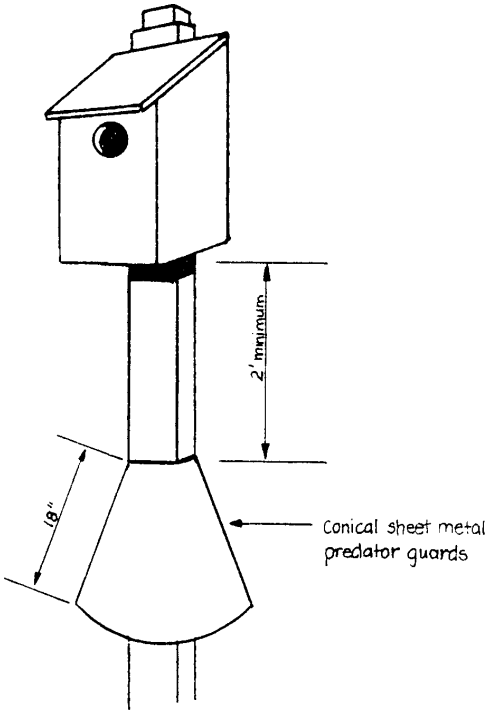
4. Trim off 1/2" of corners of bottom panel for water drainage.

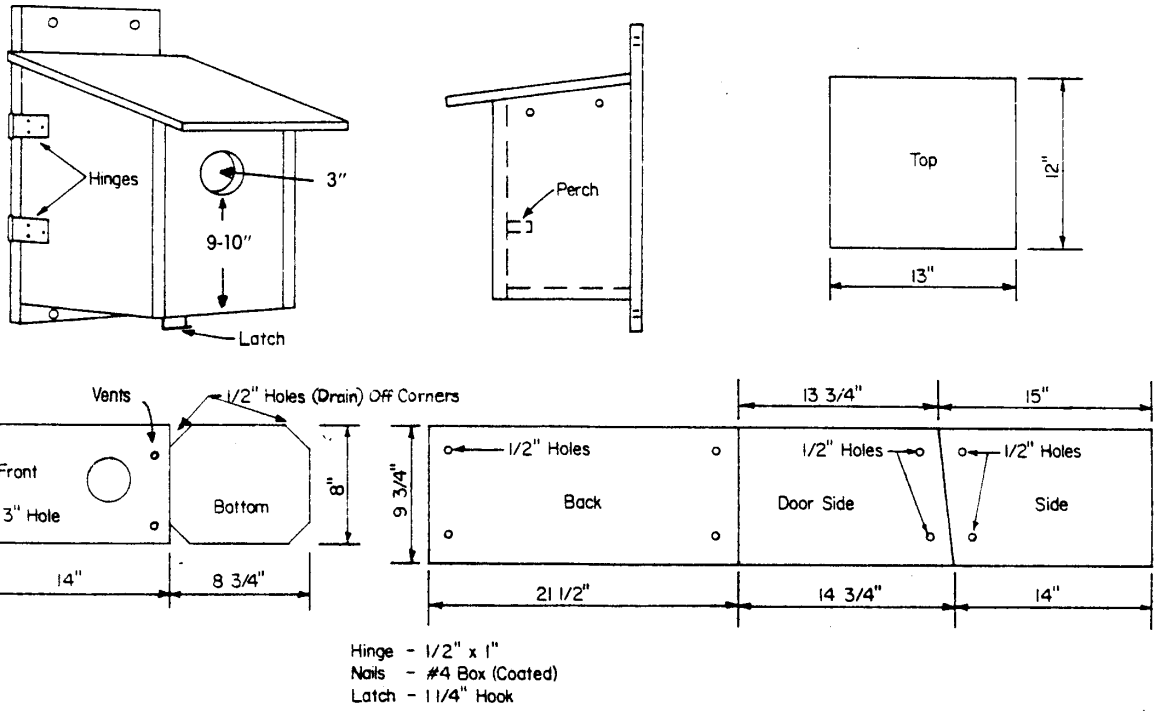
5. Two 1/2" holes should be drilled at top of both sides for ventilation.

6. CONSTRUCTION TIPS: For easier construction, the roof should be put on last. First step is the side being nailed to back; then front to side; then floor; hinged side is next before the roof. The roof and top of front could be beveled 5 degrees for a tighter fit.

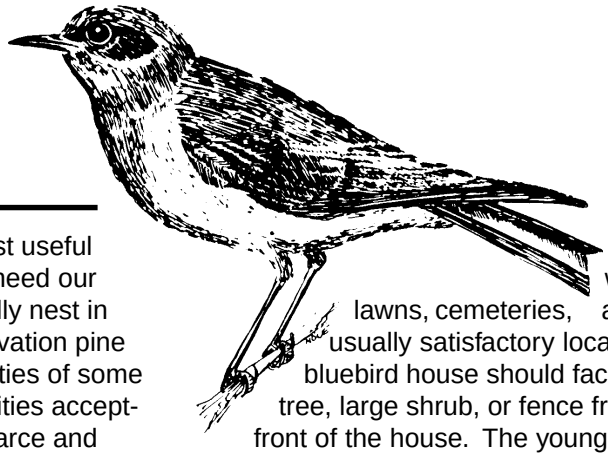
7. A six foot board, 1" x 10" can be used with no waste. For the roof, a 1" x 12" board 13" long should be used.

8. Hinged side is shorter by 1/4" to allow side to swing





BLUEBIRD HOUSE
Plans and Instructions



United States Department of Agriculture

Natural Resources Conservation Service
Davis, CA 95616

Bluebirds are one of our best loved and most useful birds. They are rapidly disappearing and need our help now before it is too late. Bluebirds normally nest in more open areas of oak woodland or lower elevation pine forests in California. They will nest only in cavities of some sort, either natural or constructed. Natural cavities acceptable to bluebirds have become increasingly scarce and those that do exist are usually occupied by house sparrows or starlings. Bluebirds are unable to compete with them for nesting sites.

Bluebirds lay 4 to 6 eggs which are plain light bluish white in color.

The food of the bluebird consists of about 80 percent insects and other small invertebrates, and 20 percent plants. Common animal foods are beetles and their larvae, caterpillars, grasshoppers, and spiders. Common fruits are blackberries, raspberries, elderberries, mistletoe berries, and fruits of palm. They may be attracted to stationary feeders by currants, raisins, and other choice fruits. Toyon is a native plant they feed on.

Suitable nesting boxes when properly located are usually eagerly accepted by any bluebirds in the area. The bluebird house illustrated on the other side of this sheet has been carefully designed to meet bluebird requirements, to last for years, and to provide for easy mounting and easy access for observation and cleaning. It cannot be entered by starlings and, if properly located, sparrow interference will be minimized. Use 1-inch thick boards, when available, use redwood or cedar lumber. Use screws for wood.

NOTE: Hinged side is 1/4'' shorter than other side to allow side to swing open.

PAINTING

It is not necessary to paint the bluebird house. If the house is painted, use white or light color. Dark colors should not be used since they may cause the house to overheat on hot days with disastrous effects on the eggs or young birds. Do not paint the inside.

LOCATION

Selecting a suitable location for the bluebird house is of utmost importance. Unfortunately, bluebirds rarely nest in cities, large towns, or close-in suburban areas. Thus, success should only be expected where competition from English sparrows and European starlings is low.

Bluebird houses should he erected in reasonably open areas since the birds will not nest in the woods and rarely in the deep shade. Best of all is an open area with scattered trees and a considerable distance from buildings. Pastures, fields, open waste lands, large lawns, cemeteries, and golf courses are usually satisfactory locations. Ideally, the bluebird house should face an open area with a tree, large shrub, or fence from 25 to 100 feet in front of the house. The young birds then have a good chance of reaching this on their first flight and thus have a better chance of surviving the first critical hours out of the nest. The house should face south or southeast.

Do not place bluebird houses in or near any area where widespread use is made of insecticides or herbicides. Many of these substances will destroy the birds' food supply or even kill the birds themselves.

When locating more than one house, space houses 100 yards apart and have a screen of shrubs or trees between the houses if possible.

MOUNTING

By using the small holes shown in the top and bottom extensions of the back board, the house may be nailed or screwed to the top or side of a wooden post, or it may be bolted or wired to the top or side of a metal post. A smooth metal post such as a galvanized pipe is preferred to a wooden post since it offers better protection against predators such as cats, raccoons, and snakes. A 3/4-inch galvanized pipe threaded at one end can be neatly and firmly attached to the bottom of the house by means or a pipe flange which may be obtained at any hardware store. A bluebird house on a wooden post may be protected from predators by means of a sheet metal collar or conical guard 18 or more inches wide attached just below the house. Where predators are not a problem, bluebird houses may be mounted conveniently on posts of existing fences or on the trunks of isolated trees (never among the branches). If posts of pasture fences are used, the houses should be on the side away from the animals or placed high enough so the animals will not use them as back scratchers.

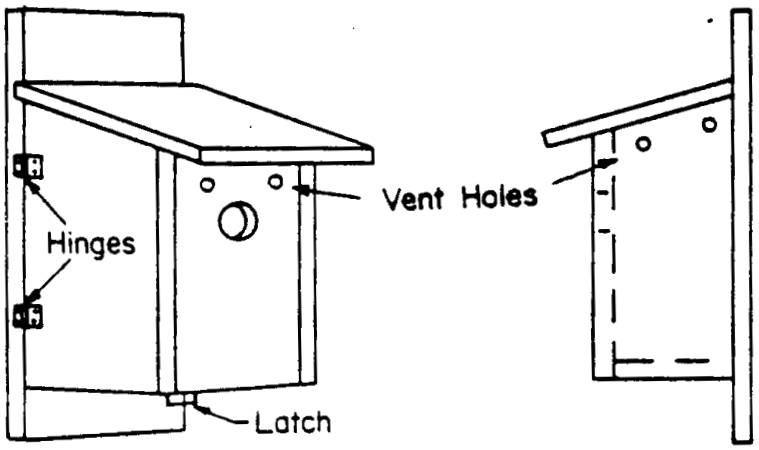
Bluebird houses should be mounted at a height of from 5 to 7 feet, measured from the ground to the floor of the house. They should be set out by February 15.

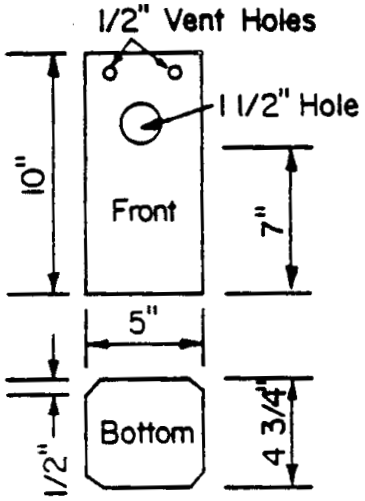
MAINTENANCE

Bluebird nests should be removed from the houses as soon as the young have left since this will increase the chances of second broods being raised in the same houses. The houses should be inspected, cleaned, and repaired, if necessary, in February each year. Make sure the drain holes in the floors are open. If house sparrows take over a house, remove the nest as often as necessary.

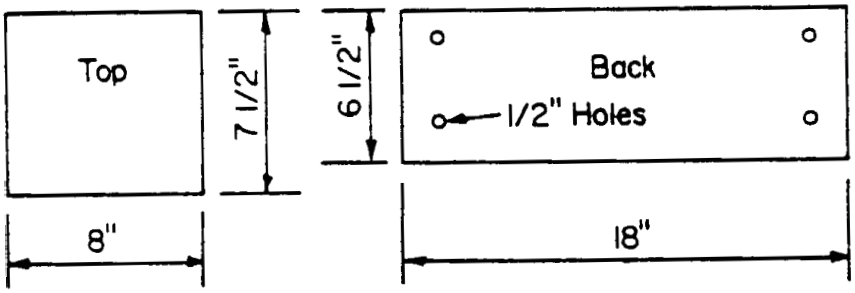
Revised January 1996 **Job Sheet CA-500**

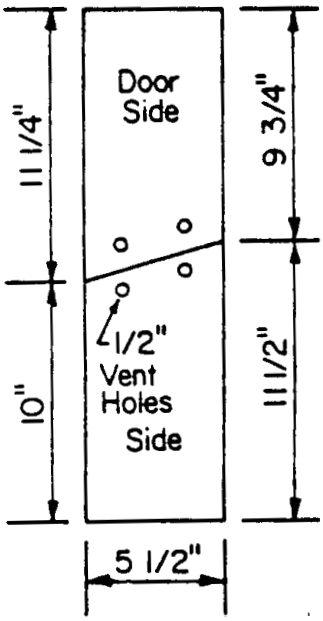
BLUEBIRD HOUSE
Plans





Hinge - 1/2" x 1"
Nails - #4 Box (Coated)
Latch - 1 1/4" Hook





BARN OWL NEST BOX

Plans and Instructions

United States
Department of
Agriculture

Natural
Resources
Conservation
Service
Davis, CA 95616

The barn owl (Tyto alba) is one of the most benefi cial owls in the world. Farmers who know the merits of the barn owl strive to keep this “cat with wings” around their crops. One of the common resident owls, the barn owl has, a white heart-shaped face and is distinguished by whitish or pale cinnamon under-parts (that look ghostly at night) and buffy or rusty upper plumage. Average barn owls weigh about 1 pound, and are approximately 15 inches long with a wingspan of about 40 inches.

Barn owls frequently are seen near roads, vacant fields, and wooded areas at night. Their call is a long, raspy scream. They hunt from perched or flying positions. Velvety feathers with soft fringes allow them to silently approach their prey, which they can find in total darkness. A barn owl’s diet consists mainly of rodents, such as gophers, ground squirrels, and meadow mice.

The female lays 1 to 11 white eggs between November and July. Incubation is about 30 days. One to two broods are reared during the season with the young leaving the nest after about 8 weeks.

NESTING SITES

Barn owls do not build nests but lay eggs in holes in rotted trees, rocky cliffs, or bluffs. Alternatively, they may use structures with an appropriate cavity, including barns, silos, and abandoned buildings. You can encourage barn owls by building a nesting box and by establishing perching sites.

PICKING A NEST SITE

Good locations for barn owl nest boxes are wooded areas or in open fields and meadows with a few trees. Oak and sycamore are ideal tree species. The box can face any direction and should be hung 3 feet below a stout tree limb suspended by cables or mounted on poles 15 to 30 feet above the ground. The entrance should be unobstructed and the box positioned so it does not attract human attention. Place about 6 boxes per square mile. Boxes mounted high in barns or abandoned buildings also are readily occupied by owls. If the nest box is placed on a post, the post should be wrapped with an 18-inch metal, conical predator guard.

IMPORTANT FACTS TO CONSIDER

Honey bees frequently take over barn owl nest boxes, making them useless for nesting. About one fourth of the nest boxes in coastal southern California are used by honey bees.

About 85 percent of barn owl nesting attempts produce fledging young. Reasons for mortality include human disturbance, limb breakage, and attacks by raccoons, opossums, skunks, and bobcats.

Summer is the best time to erect a barn owl nest box. Boxes should not be disturbed during the nesting season or owls may desert them.

Barn owl nest boxes can be especially useful on farms and ranches where rodent control is desired.

BUILDING A NEST BOX

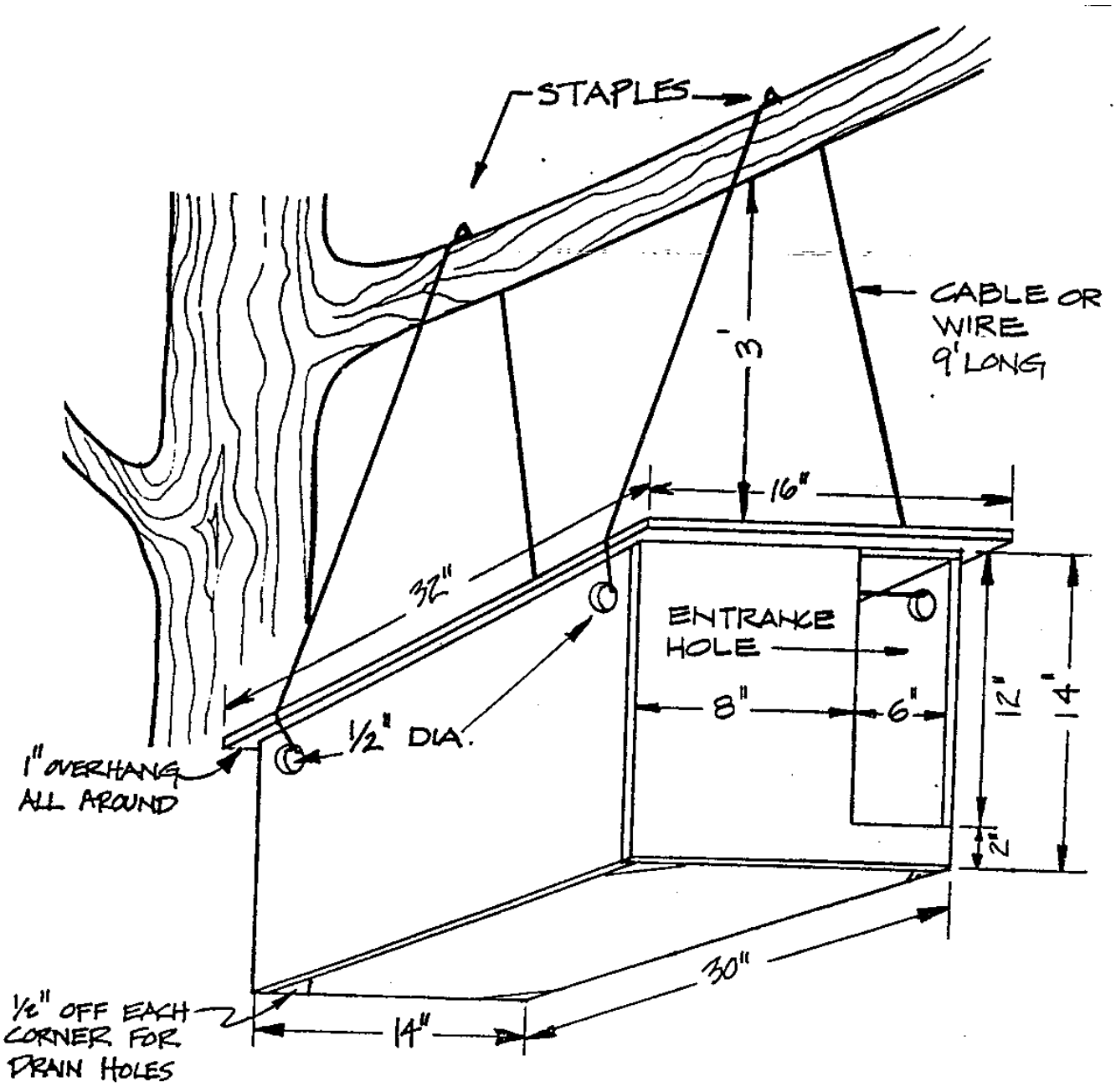
Barn owl nest boxes are easy to build. Ideal material is 3/8-inch or 1/2-inch plywood. Nest boxes should be painted using a camouflage pattern or drab green, black, and brown to minimize human disturbance. Painting also helps prevent warping. Place a 2-inch layer of sawdust or wood chips in the bottom of the box and replace each year.

GUIDE

1. Make the entrance hole 6 inches wide by 12 inches high.
2. Hang or mount the box 15 to 30 feet above the ground and, if in a tree, 3 feet below a sturdy branch.
3. Use scrap exterior grade 3/8-inch or 1/2-inch ply wood.
4. Use #4 or #5 galvanized hot dipped box nails.
5. Use a marine grade plastic resin or exterior wood glue for assembly.
6. Make the roof 16 inches by 26 inches to give a 1-inch overhang all around.
7. Use wire staples to keep the cable from moving on the branch.
8. Use at least a 9-foot long piece of wire to hang boxes.

BARN OWL NEST BOX

Plans



FACT SHEET

URCD FS-06

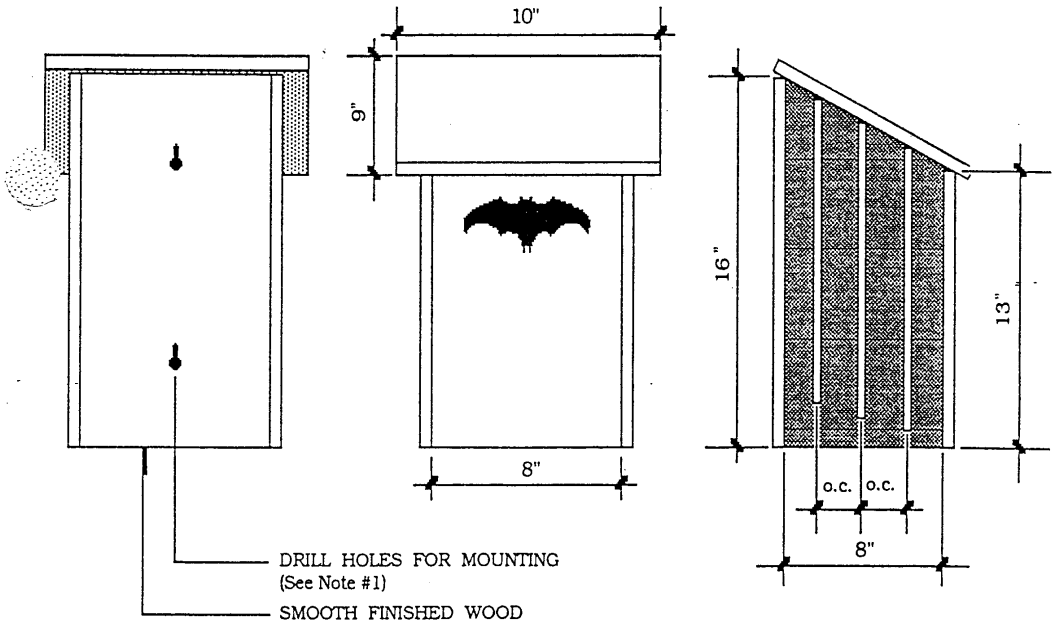
Conservation District
December 1991

BAT HOUSES

Fear of things we do not understand is a well documented aspect of human behavior and is a problem faced by today's bats. Unfortunately, lack of knowledge, late night horror movies, myths and/or superstitions about this amazing flying mammal leave us to believe that bats are harmful.

Bats are wonderful creatures who fly during the night looking for insects to eat. Seventy percent of the bat species eat insects. Few bats are carnivorous - hunting small vertebrates, such as fish, frogs, mice and birds. There are only 3 species of the much persecuted vampire bat which are found only in Latin America. All bats in the United States and Canada are insectivores and are major predators of night-flying insects, included mosquitoes and numerous crop pests. The bat's eyes and echolocation technique enable them to see well in dim light as they search for food, primarily at dusk. Under a controlled study, scientists found that bats are capable of catching up to 600 mosquitoes per hour. Large colonies consume countless billions of insects each season.

The mouse-eared bat (genus Myotis) is the most widely distributed species in North America. Color of these local bats can range from brown or russet to gray. All are small with wingspans ranging from 222 mm to 315 mm. Mouse-eared bats occupy a wide variety of summer roosts, including caves, buildings, and tree hollows. Summer roosts are abandoned in August or September for a winter roost. Some colonies travel up to 200 miles or more to reach the nearest suitable cave for their six to eight month hibernation.



BACK VIEW **FRONT VIEW** **SIDE VIEW**

CONSTRUCTION NOTES FOR SMALLER BAT HOUSE:

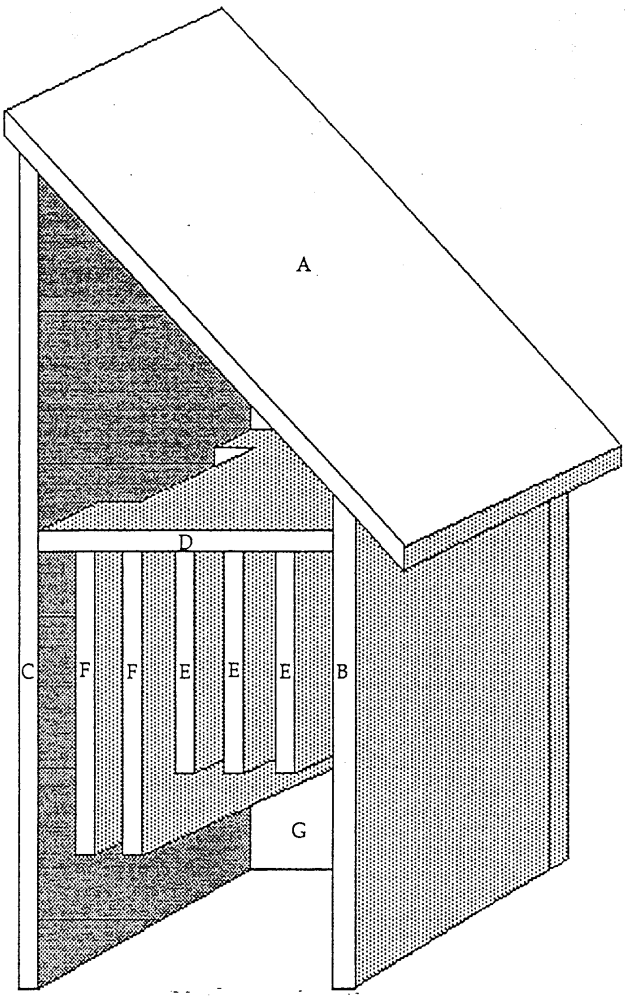
1. Use 2" finishing nails when constructing the house. Mount the Bat House on 3" nails.
2. Western cedar or redwood will withstand out door exposure better than pine or plywood; although they are all suitable.
3. Use 1/2" rough sawed wood for the interior walls. Secure the interior walls o.c. (equal distances on center). These walls are to be cut 13 inches in length and the same width of the back exterior wall.

Bats are the only mammals that truly fly. Their large trough skinned wings are well suited for flying. A bat is relatively helpless when it's on the ground because of its weak legs whose knees bend backward. Their back feet have tiny sharp claws allowing them to hang upside down f[illegible]walls, cave ceilings, old buildings, or in the [illegible] of a tree.

But aren't bats rabid? Rabies come in different forms. Bats usually contract a form of rabies which only effectes rodents and is not considered dangerous to humans, although bats are susceptible to rabies just as any other animal. The highest percent of rabies in humans is contracted through dogs and cats. Our best defense against rabies is having our dogs and cats vaccinated. Any bat that could be caught may be sick, but not necessarily with rabies. Sick bats, as any other sick animal, should be approached with caution and should never be picked up without wearing leather gloves.

Bats need dark places to rest during the day. They could be attracted to your property by providing a bat house (see diagram to build your own bat house). Build your bat house and locate it in a high place, 10 to 15 feet off the ground, facing east or southeast to catch the morning sun. The entrance should be free of obstructions such as branches. When building your bat house, keep in mind that the bat hangs b[illegible] tiny claws on its back feet; thus, rough w[illegible] on the interior of the house would offer better foot hold than smooth wood. Once in place, it may take as long as a year before bats take up residency.

We are providing you with two bat house designs. The larger house, designed by the Bat Conservation International, can occupy a hundred or more bats. The smaller design could house as many as 20 bats.



DIMENSIONS:

A. ROOF 16 1/2" x 11 1/4"
B. FRONT 18 3/4" x 9 1/4"
C. BACK 27" x 9 1/4"
D. CEILING 9 3/4" x 9 1/4"
E. PARTITIONS 9 1/4" wide x 8" high
F. PARTITIONS 9 1/4" wide x 14" high
G. SIDES 11 1/4" wide x 27" at back, 18 3/4" at front

CONSTRUCTION NOTES FOR LARGE BAT HOUSE:

1. Use 2" finishing nails when constructing the house.
2. Western cedar or redwood will withstand outdoor exposure better than pine or plywood; although they are all suitable.
3. Use 1/2" rough sawed wood for the interior walls. Spacing between partitions front to back: 3/4", 3/4", 3/4", 1", 1 1/2", 1 1/4".
4. Mount the bat house on 3" nails.

R[illegible]ENCES

T[illegible] Merlin D. 1990. *America's Neighborhood Bats.* University of Texas Press, Austin.

This fact sheet was created by Diane Hefner, Ulatis Resource Conservation District Technician (916) 678-1655.

- Biological Control is the use of a specially chosen living organism (a predator, a parasite, or a disease) to control a particular pest.
- It is a type of pest management that can be thought of as using "living pesticides".
- Often Biological Control is part of an integrated pest management approach which includes the use of chemical, mechanical, and biological means to combat pest organisms.

The Sonoma County Agricultural Commissioner's Office has released biocontrols on the following pests:

- Yellow Star Thistle
- Purple Star Thistle
- Bull Thistle
- Musk Thistle
- Gorse
- Ash White Fly
- Scotch Broom
- Blue Gum Lerp Psyllid
- Red Gum Lerp Psyllid

Examples of Biological Controls released in Sonoma County

Biocontrol / **Pest**

Gorse Spider Mite *Tetranychus lintearius*

Gorse
Ulex eropaeus

Biocontrol / **Pest**

Hairy Weevil *Eustenopus villosus*

Yellow Starthistle
Centaurea solstitialis

Bangasternus orientalis

Urophora sirunaseva

Biocontrol / **Pest**

parasitoid wasp
Psyllaephagus bliteus

Red Gum Lerp Psyllid
Glycaspis brimblecombei

Biocontrol / **Pest**

Knapweed Weevil
Larinus minutus

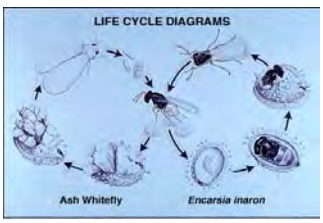
Purple Starthistle
Centaurea calcitrapas

Bangasternus orientalis

Biocontrol / **Pest**

Encarsia inaron
Adult laying eggs inside ash whitefly

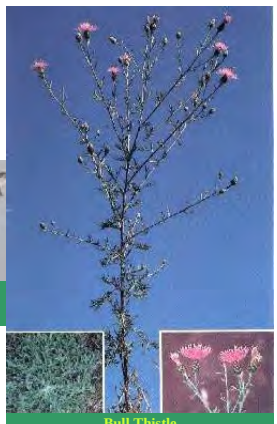
Ash Whitefly



Parasitized Whitefly egg masses

Biocontrol / **Pest**

Bull Thistle Gall Fly
Urophora stylata



Bull Thistle

Pros:

- Attacks specific pests without disturbing other "non-target" organisms
- Can provide long-lasting or permanent suppression of pest populations
- Can be more economical than chemical pest control
- Reduces impacts on the environment

Cons:

- Requires a greater understanding of the biology of the pest and intensive management and planning
- May not completely eradicate the pest

Beneficial Bugs for Winegrape Growers

Using and encouraging beneficial insencts and mites to control vineyard pests

By Paul Franson

BENEFICIAL	ATTRACTIVE PLANTS	HABITAT TYPE
Predatory mites	Flowering plants in vine rows and adjacent areas throughout year for nectar and pollen. Herbaceous or woody perennials ideal	Overwinter in debris under trees and in crevices in trees. Prefers perennial undisturbed habitats
Parasitic wasps	Nectar plants for adults Annuals: Umbel family plants, Bolting brassicas Perennials: Golden-rod, yarrow, salvia	Diverse nesting requirements: burrows, soil crevic-es, cavities, non-disturbed areas within 50 meters of crop
Lacewings	Nectar in annual bor-ders of early grasses, sunflower, legumes, or brassicas. Umbel family plants	Twiggy mulch pro-vides overwintering habitat
Syrphid flies and parasitoids	Flowering plants like helianthus, tithonia, Umbels with nectar and pollen	Riparian areas are natural refuges

St. Helena, Calif.—All grapegrowers know that there are good bugs and bad bugs, and most would like to encourage the good ones, even introduce them to their fields.

At the recent Organic Grapegrowing Conference sponsored by the Napa Valley Grapegrowers, two experts talked about introducing these beneficial insects and planting crops to encourage them. Kim Gallagher-Horton of Biobest Sustainable Crop Management raises beneficial insects (six legs) and predatory mites (arachnids with eight legs) for pest control.

She recommends the “Natural Enemies Handbook” from the University of California, Davis, as a guide to these beneficial creatures, but highlighted a few that kill major vine pests such as spider mites, mealybugs and leafhoppers.

Controlling mites

Gallagher-Horton said that predatory mites are some of the most effective predators to release in vineyards for spider mite control. The Western predatory mite, Galendromus occidentalis is native to

western North America and found in deciduous orchards and vineyards. The Cali predatory mite Neoseiulus californicus is found throughout California and other locations.

The Cali mite is sensitive to temperatures above 105°F, while the Western version is good to 120°.

Commonly used pesticides kill most of these predatory mites, but the Sterling insectary strain of these predatory mites has been bred to be resistant to many pesticides

G. occidentalis is most effective against web-spinning mites in trees including the Pacific, two-spotted Willamette spider mites and can be an effective predator of European red and citrus red spider mites.

N. californicus is effective against the web-spinning mites and persea mites in vineyards and greenhouses. These predators do not feed on foliage or become pests. If spider mites are not available, they will starve or migrate.

G. occidentalis and N. californicus are produced commercially by growing them on bean plants. When a cut bean plant is placed into the crotch of a vine canopy, the predators will walk off the wilting foliage into the tree or onto the vine. Once they find spider mites, they settle down and reproduce. They can move from vine to vine by walking and by wind currents. These predators can also be purchased in bottles. The bottle is filled with a carrier media (corn grit) and can be sprinkled on to the vines.

When 5% to 15% of sampled leaves are infected with spider mites, it is time to release predatory mites. A release rate of between 2,000 to 5,000 predatory mites per acre is usually enough to initially inoculate a vineyard. Careful follow up sampling can determine if another release is necessary.

Three criteria must be addressed when releasing predatory mites. Release them early in the season to take advantage of their ability to increase rapidly. They must be released when some spider mites are present so that they do not starve and leave your vines. Though less an issue for organic growers, some chemicals can affect the predatory mites. Spider mites often migrate into crops during late March to May.

Heaviest applications are needed around dusty roads and in weak blocks.

Another predator of spider mites is the six-spotted thrip. “It loves spider mites,” said Gallagher-Horton. “Put it in places with high infestation.”

Dealing with mealybugs

Both grape and vine mealybugs are major pests. “You want to eradicate them,” Gallagher-Horton stated. They’re also hard to kill with chemicals because they have waxy coatings that resist absorption.

Two predators kill mealybugs. The aptly named mealybug destroyer beetle (Cryptolaemus montrouzieri) is a cousin of the ladybug, which is also really a beetle.

The destroyer beetle lays its eggs in wooly mealybug masses. The adults and larvae of the mealybug destroyers feed on all stages of the mealybugs. If no mealybugs are around, Cryptolaemus feeds on

aphids and scale. The recommended release rate is 500 per acre or one adult per square foot. The beetle is most active in sunlight and when the mealybug population is high. It's important to control ants when using predators, however, as they will attack predators. Ant bait stations are recommended.

Gallagher-Horton warns that it can take many weeks to control the mealybug population.

Another predator on mealybugs is the anagyrus or vine mealybug parasitoid wasp (Anagyrus pseudococci.) It stings the mealybug and lays an egg in it. This stops the mealybug from feeding, and the wasp larva will consume the mealybug and emerge as an adult.

A recommended release rate is 500 female wasps per acre per month from April until August. They're effective from the second instar through adult mealybugs. These predators can be used with the mealybug destroyer.

Leafhoppers

Gallagher-Horton noted that there are no specific predators available for leafhoppers. Among the general predators are green lacewings (Chrysopidea.) Their larvae are vicious carnivores, she noted. But the adults love flowers with pollen.

She also said that the minute pirate bug (Orius) eats anything. Biobest supplies these beneficial and predatory insects and mites.

Planting right

The right plants will also attract and sustain beneficial creatures. Ann Baker specializes in designing landscapes that do just that.

She recommends planting a diverse ecosystem to reduce the pest concentrations that would exist in a vineyard monoculture. This includes developing plant communities for different areas, soils and light gradients as well as increasing diversity through mutualism and plant synergies.

Baker urged linking habitat areas so they aren't isolated. She suggests adding insectary plantings in vine rows, avenues, riparian and other natural areas, field edges, utility areas, swales and ditches, road edges, power lines and reservoir banks, ideally at 50-meter intervals.

And also increase habitat for diverse bird species; some birds like bluebirds and swallows, are voracious feeders on insects, while raptors consume rodents and other mammalian pests.

She recommends planting local seed mixes, and also culinary herbs, buckwheat, native strawberry and yerba buena. Poppies, sunflowers and umbel family plants (parsley, carrots, Queen Anne's lace), coyote bush, ceanothus, willow and native oaks are also especially recommended.

Read more at: http://www.winesandvines.com/template.cfm?section=news&content=103788

866.453.9701 | 415.453.9700 | Fax: 415.453.2517

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info@winesandvines.com

Grape

BOTRYTIS BUNCH ROT

PATHOGEN: *BOTRYTIS CINEREA*

(Reviewed 6/06, updated 10/08)

In this Guideline:

SYMPTOMS AND SIGNS

Early-season shoot blight may occur following frequent spring rains. Flowers can become infected during bloom; generally the fungus then becomes dormant until late in the season when sugar concentration increases in the infected berry. The fungus then resumes growth and spreads throughout the berry. Infected berries split and leak, thus allowing the pathogen to grow and sporulate on berry surfaces and spread to adjoining berries by mid-season. Spores from infected fruit can directly infect intact, ripe berries as harvest approaches.

COMMENTS ON THE DISEASE

The fungus overwinters as sclerotia in berry mummies on the ground or left hanging on the vine and in canes. Germination and spore production occur in spring. Infections require free water for a definite period of time depending on temperature. Infections may occur during bloom should rains occur; preclose rachis infections often occur on Chardonnay. Late-season infections are most severe when relative humidity exceeds 92%, free moisture is present on the fruit surface, and temperatures are in the 58° to 82°F range. Berries that have been damaged by insects, birds, machinery, etc. may become infected at any time after the fruit

begins to ripen because the juice in the berry can provide the necessary water and nutrients for fungal growth.

MANAGEMENT

Successful management of Botrytis bunch rot can be achieved through the use of several strategies. The efficacy of a fungicide depends on getting good coverage, and coverage is affected by the canopy and stage of growth. By employing cultural control methods, properly applying fungicides, and using resistant varieties, the disease can be managed.

Cultural Control

Excellent control has been achieved using canopy management and leaf removal in particular. Removal of basal leaves or basal lateral shoots at or immediately after berry set has resulted in significantly reduced incidence and severity of disease. In warmer growing areas, be careful not to remove excessive numbers of leaves, which can lead to sunburned fruit. This condition is made worse when leaves are removed later in the season. If leaves are removed at cluster set, the berries acclimate readily to the sunlight and develop a thick cuticle that helps prevent sunburn as well as Botrytis infection.

On cordon-trained vines, only remove leaves from the side of the vine that receives morning sun. Do not remove lateral shoots. If leaves are not removed and weather is dry in spring, one fungicide application should be made sometime between bloom and pea-size berries. Otherwise, apply sprays before rainfall especially at bloom or after veraison.

Northern and coastal production areas. Remove leaves or lateral shoots around clusters beginning at late bloom and continue to berry set.

Central Valley. Remove leaves (from bloom to berry set) or hedge (mid-season) to open canopy.

Organically Acceptable Methods

Canopy management and other cultural control methods along with sprays of Organic JMS Stylet Oil and Serenade are organically acceptable methods.

Monitoring and Treatment Decisions

Look for flagging shoot tips or entire shoots during rapid shoot growth. If you see flagging, attempt to break or cut the shoot in the region between the flaccid area and the adjacent area with normal turgor. Brown discoloration on the cut surface is evidence of *Botrytis.*

If the entire shoot is involved, look for a hole at the base, which could indicate feeding by branch and twig borer.

If basal leaves are not removed, apply fungicides before rain in northern and coastal production areas to prevent flower infections. Research data shows a trend toward better control if fungicides are applied at bloom, preclose, and veraison. If leaf removal is practiced, then sprays can be limited to one application if wet weather occurs during bloom (or none if no rain occurs). Thorough coverage is essential for all fungicide treatments.

A fungicide application may also be warranted if a major rain is expected late in the season when grapes are nearly mature. Otherwise, management of Botrytis bunch rot following bloom generally relies on proper cultural practices as outlined in SUMMER BUNCH ROT.

At harvest, check table grape for Botrytis symptoms to assess this year's management program and to plan for next year.

Summary of Important Links

Common name (trade name)	Amount/Acre**	R.E.I.+ (hours)	P.H.I.+ (days)

The following materials are listed in order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies and honey bees. When choosing a pesticide, also consider information relating to environmental impact. Not all registered pesticides are listed. Always read label of product being used.

Note: *Treatments can be made in conjunction with plant growth regulators and other applications.*

A.	CYPRODINIL (Vangard) WG	10 oz	12	7

MODE OF ACTION GROUP NAME (NUMBER[1]):

Anilinopyrimidine (9)
COMMENTS: Do not apply more than 20 oz/acre/season. Rate is 5–10 oz if tank-mixed with another fungicide.

B. FENHEXAMID (Elevate) 50WDG 1 lb 12 0
MODE OF ACTION GROUP NAME (NUMBER[1]): Hydroxyanilide (17)
COMMENTS: Do not apply more than 3 lb a.i. product/acre/season.

C. IPRODIONE (Rovral) 4F 1.5–2 lb 48 7
MODE OF ACTION GROUP NAME (NUMBER[1]): Dicarboximide (2)
COMMENTS: Do not apply more than 4 times/season. Addition of a narrow range oil (superior, supreme) at 1% increases the effectiveness of this material.

D. PYRACLOSTROBIN/BOSCALID (Pristine) 8–10.5 oz 24 14
MODE OF ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11) and Carboxamide (7)
COMMENTS: Do not apply on Concord, Worden, Fredonia, Niagara, and related varieties. Do not make more than 2 sequential applications before rotating to a fungicide with a different mode of action.

E. NARROW RANGE OIL# (Organic JMS Stylet) 1% 4 0
MODE OF ACTION GROUP NAME (NUMBER[1]): A contact fungicide with smothering and barrier effects.
COMMENTS: Foliage burn may occur if oil is applied within 2 weeks of sulfur or captan sprays. Oil will temporarily remove the 'bloom' on the berries; to avoid this, do not spray within 2 weeks of harvest.

F. BACILLUS SUBTILIS# (Serenade Max) 1–3 lb 4 0
MODE OF ACTION: A biological fungicide.

G. CAPTAN 50WP 2 lb 4 days
MODE OF ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M4)
COMMENTS: Do not apply in combination with, immediately before, or closely following oil sprays.

H. DICHLORAN (Botran) 75WSB/75W Label rates 12 0
MODE OF ACTION GROUP NAME (NUMBER[1]): Aromatic hydrocarbon (14)
COMMENTS: May be applied at onset of bloom. Do not apply in combination with sulfur products in sensitive varieties. Up to 5.33 lb may be applied per season.

I. MANCOZEB (Dithane M-45, Penncozeb 75DF) 1.5–2.5 lb 24 see comments
MODE OF ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M3)
COMMENTS: Do not apply after bloom. Do not apply more than 6 lb a.i./acre/season.

** Apply with enough water to provide complete coverage.

+ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

Acceptable for use on organically grown produce.

[1] Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to

different modes of actions. Fungicides with a different Group number are suitable to alternate in a resistance management program. For more information, see http://www.frac.info/.

IMPORTANT LINKS

Photos of flagging symptoms

Photos of fruit damage at harvest

Precautions

PUBLICATION

UC IPM Pest Management Guidelines: Grape
UC ANR Publication 3448
Diseases
W. D. Gubler, Plant Pathology, UC Davis
R. J. Smith, UC Cooperative Extension, Sonoma County
L. G. Varela, UC IPM Program, Sonoma County
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A. H. Purcell, Environmental Science, Policy and Management, UC Berkeley
Acknowledgment for contributions to Diseases:
G. M. Leavitt, UC Cooperative Extension, Madera County

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Grape

BOTRYTIS BUNCH ROT

PATHOGEN: *BOTRYTIS CINEREA*

(Reviewed 6/06, updated 10/08)

In this Guideline:

SYMPTOMS AND SIGNS

Early-season shoot blight may occur following frequent spring rains. Flowers can become infected during bloom; generally the fungus then becomes dormant until late in the season when sugar concentration increases in the infected berry. The fungus then resumes growth and spreads throughout the berry. Infected berries split and leak, thus allowing the pathogen to grow and sporulate on berry surfaces and spread to adjoining berries by mid-season. Spores from infected fruit can directly infect intact, ripe berries as harvest approaches.

COMMENTS ON THE DISEASE

The fungus overwinters as sclerotia in berry mummies on the ground or left hanging on the vine and in canes. Germination and spore production occur in spring. Infections require free water for a definite period of time depending on temperature. Infections may occur during bloom should rains occur; preclose rachis infections often occur on Chardonnay. Late-season infections are most severe when relative humidity exceeds 92%, free moisture is present on the fruit surface, and temperatures are in the 58° to 82°F range. Berries that have been damaged by insects, birds, machinery, etc. may become infected at any time after the fruit

begins to ripen because the juice in the berry can provide the necessary water and nutrients for fungal growth.

MANAGEMENT

Successful management of Botrytis bunch rot can be achieved through the use of several strategies. The efficacy of a fungicide depends on getting good coverage, and coverage is affected by the canopy and stage of growth. By employing cultural control methods, properly applying fungicides, and using resistant varieties, the disease can be managed.

Cultural Control

Excellent control has been achieved using canopy management and leaf removal in particular. Removal of basal leaves or basal lateral shoots at or immediately after berry set has resulted in significantly reduced incidence and severity of disease. In warmer growing areas, be careful not to remove excessive numbers of leaves, which can lead to sunburned fruit. This condition is made worse when leaves are removed later in the season. If leaves are removed at cluster set, the berries acclimate readily to the sunlight and develop a thick cuticle that helps prevent sunburn as well as Botrytis infection.

On cordon-trained vines, only remove leaves from the side of the vine that receives morning sun. Do not remove lateral shoots. If leaves are not removed and weather is dry in spring, one fungicide application should be made sometime between bloom and pea-size berries. Otherwise, apply sprays before rainfall especially at bloom or after veraison.

Northern and coastal production areas. Remove leaves or lateral shoots around clusters beginning at late bloom and continue to berry set.

Central Valley. Remove leaves (from bloom to berry set) or hedge (mid-season) to open canopy.

Organically Acceptable Methods

Canopy management and other cultural control methods along with sprays of Organic JMS Stylet Oil and Serenade are organically acceptable methods.

Monitoring and Treatment Decisions

Look for flagging shoot tips or entire shoots during rapid shoot growth. If you see flagging, attempt to break or cut the shoot in the region between the flaccid area and the adjacent area with normal turgor. Brown discoloration on the cut surface is evidence of *Botrytis.*

If the entire shoot is involved, look for a hole at the base, which could indicate feeding by branch and twig borer.

If basal leaves are not removed, apply fungicides before rain in northern and coastal production areas to prevent flower infections. Research data shows a trend toward better control if fungicides are applied at bloom, preclose, and veraison. If leaf removal is practiced, then sprays can be limited to one application if wet weather occurs during bloom (or none if no rain occurs). Thorough coverage is essential for all fungicide treatments.

A fungicide application may also be warranted if a major rain is expected late in the season when grapes are nearly mature. Otherwise, management of Botrytis bunch rot following bloom generally relies on proper cultural practices as outlined in SUMMER BUNCH ROT.

At harvest, check table grape for Botrytis symptoms to assess this year's management program and to plan for next year.

Summary of Important Links

Common name (trade name)	Amount/Acre**	R.E.I.+ (hours)	P.H.I.+ (days)

The following materials are listed in order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies and honey bees. When choosing a pesticide, also consider information relating to environmental impact. Not all registered pesticides are listed. Always read label of product being used.

Note: *Treatments can be made in conjunction with plant growth regulators and other applications.*

A.	CYPRODINIL (Vangard) WG	10 oz	12	7

MODE OF ACTION GROUP NAME (NUMBER[1]):

Anilinopyrimidine (9)
COMMENTS: Do not apply more than 20 oz/acre/season. Rate is 5–10 oz if tank-mixed with another fungicide.

B. FENHEXAMID (Elevate) 50WDG 1 lb 12 0
MODE OF ACTION GROUP NAME (NUMBER[1]): Hydroxyanilide (17)
COMMENTS: Do not apply more than 3 lb a.i. product/acre/season.

C. IPRODIONE (Rovral) 4F 1.5–2 lb 48 7
MODE OF ACTION GROUP NAME (NUMBER[1]): Dicarboximide (2)
COMMENTS: Do not apply more than 4 times/season. Addition of a narrow range oil (superior, supreme) at 1% increases the effectiveness of this material.

D. PYRACLOSTROBIN/BOSCALID (Pristine) 8–10.5 oz 24 14
MODE OF ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11) and Carboxamide (7)
COMMENTS: Do not apply on Concord, Worden, Fredonia, Niagara, and related varieties. Do not make more than 2 sequential applications before rotating to a fungicide with a different mode of action.

E. NARROW RANGE OIL# (Organic JMS Stylet) 1% 4 0
MODE OF ACTION GROUP NAME (NUMBER[1]): A contact fungicide with smothering and barrier effects.
COMMENTS: Foliage burn may occur if oil is applied within 2 weeks of sulfur or captan sprays. Oil will temporarily remove the 'bloom' on the berries; to avoid this, do not spray within 2 weeks of harvest.

F. BACILLUS SUBTILIS# (Serenade Max) 1–3 lb 4 0
MODE OF ACTION: A biological fungicide.

G. CAPTAN 50WP 2 lb 4 days
MODE OF ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M4)
COMMENTS: Do not apply in combination with, immediately before, or closely following oil sprays.

H. DICHLORAN (Botran) 75WSB/75W Label rates 12 0
MODE OF ACTION GROUP NAME (NUMBER[1]): Aromatic hydrocarbon (14)
COMMENTS: May be applied at onset of bloom. Do not apply in combination with sulfur products in sensitive varieties. Up to 5.33 lb may be applied per season.

I. MANCOZEB (Dithane M-45, Penncozeb 75DF) 1.5–2.5 lb 24 see comments
MODE OF ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M3)
COMMENTS: Do not apply after bloom. Do not apply more than 6 lb a.i./acre/season.

** Apply with enough water to provide complete coverage.

+ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

Acceptable for use on organically grown produce.

[1] Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to

different modes of actions. Fungicides with a different Group number are suitable to alternate in a resistance management program. For more information, see http://www.frac.info/.

IMPORTANT LINKS

Photos of flagging symptoms

Photos of fruit damage at harvest

Precautions

PUBLICATION

UC IPM Pest Management Guidelines: Grape
UC ANR Publication 3448
Diseases
W. D. Gubler, Plant Pathology, UC Davis
R. J. Smith, UC Cooperative Extension, Sonoma County
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A. H. Purcell, Environmental Science, Policy and Management, UC Berkeley
Acknowledgment for contributions to Diseases:
G. M. Leavitt, UC Cooperative Extension, Madera County

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Grape

BOTRYTIS BUNCH ROT

PATHOGEN: *BOTRYTIS CINEREA*

(Reviewed 6/06, updated 10/08)

In this Guideline:

SYMPTOMS AND SIGNS

Early-season shoot blight may occur following frequent spring rains. Flowers can become infected during bloom; generally the fungus then becomes dormant until late in the season when sugar concentration increases in the infected berry. The fungus then resumes growth and spreads throughout the berry. Infected berries split and leak, thus allowing the pathogen to grow and sporulate on berry surfaces and spread to adjoining berries by mid-season. Spores from infected fruit can directly infect intact, ripe berries as harvest approaches.

COMMENTS ON THE DISEASE

The fungus overwinters as sclerotia in berry mummies on the ground or left hanging on the vine and in canes. Germination and spore production occur in spring. Infections require free water for a definite period of time depending on temperature. Infections may occur during bloom should rains occur; preclose rachis infections often occur on Chardonnay. Late-season infections are most severe when relative humidity exceeds 92%, free moisture is present on the fruit surface, and temperatures are in the 58° to 82°F range. Berries that have been damaged by insects, birds, machinery, etc. may become infected at any time after the fruit

begins to ripen because the juice in the berry can provide the necessary water and nutrients for fungal growth.

MANAGEMENT

Successful management of Botrytis bunch rot can be achieved through the use of several strategies. The efficacy of a fungicide depends on getting good coverage, and coverage is affected by the canopy and stage of growth. By employing cultural control methods, properly applying fungicides, and using resistant varieties, the disease can be managed.

Cultural Control

Excellent control has been achieved using canopy management and leaf removal in particular. Removal of basal leaves or basal lateral shoots at or immediately after berry set has resulted in significantly reduced incidence and severity of disease. In warmer growing areas, be careful not to remove excessive numbers of leaves, which can lead to sunburned fruit. This condition is made worse when leaves are removed later in the season. If leaves are removed at cluster set, the berries acclimate readily to the sunlight and develop a thick cuticle that helps prevent sunburn as well as Botrytis infection.

On cordon-trained vines, only remove leaves from the side of the vine that receives morning sun. Do not remove lateral shoots. If leaves are not removed and weather is dry in spring, one fungicide application should be made sometime between bloom and pea-size berries. Otherwise, apply sprays before rainfall especially at bloom or after veraison.

Northern and coastal production areas. Remove leaves or lateral shoots around clusters beginning at late bloom and continue to berry set.

Central Valley. Remove leaves (from bloom to berry set) or hedge (mid-season) to open canopy.

Organically Acceptable Methods

Canopy management and other cultural control methods along with sprays of Organic JMS Stylet Oil and Serenade are organically acceptable methods.

Monitoring and Treatment Decisions

Look for flagging shoot tips or entire shoots during rapid shoot growth. If you see flagging, attempt to break or cut the shoot in the region between the flaccid area and the adjacent area with normal turgor. Brown discoloration on the cut surface is evidence of *Botrytis.*

If the entire shoot is involved, look for a hole at the base, which could indicate feeding by branch and twig borer.

If basal leaves are not removed, apply fungicides before rain in northern and coastal production areas to prevent flower infections. Research data shows a trend toward better control if fungicides are applied at bloom, preclose, and veraison. If leaf removal is practiced, then sprays can be limited to one application if wet weather occurs during bloom (or none if no rain occurs). Thorough coverage is essential for all fungicide treatments.

A fungicide application may also be warranted if a major rain is expected late in the season when grapes are nearly mature. Otherwise, management of Botrytis bunch rot following bloom generally relies on proper cultural practices as outlined in SUMMER BUNCH ROT.

At harvest, check table grape for Botrytis symptoms to assess this year's management program and to plan for next year.

Summary of Important Links

Common name (trade name)	Amount/Acre**	R.E.I.+ (hours)	P.H.I.+ (days)

The following materials are listed in order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies and honey bees. When choosing a pesticide, also consider information relating to environmental impact. Not all registered pesticides are listed. Always read label of product being used.

Note: *Treatments can be made in conjunction with plant growth regulators and other applications.*

A.	CYPRODINIL (Vangard) WG	10 oz	12	7

MODE OF ACTION GROUP NAME (NUMBER[1]):

Anilinopyrimidine (9)
COMMENTS: Do not apply more than 20 oz/acre/season. Rate is 5–10 oz if tank-mixed with another fungicide.

B. FENHEXAMID (Elevate) 50WDG 1 lb 12 0
MODE OF ACTION GROUP NAME (NUMBER[1]): Hydroxyanilide (17)
COMMENTS: Do not apply more than 3 lb a.i. product/acre/season.

C. IPRODIONE (Rovral) 4F 1.5–2 lb 48 7
MODE OF ACTION GROUP NAME (NUMBER[1]): Dicarboximide (2)
COMMENTS: Do not apply more than 4 times/season. Addition of a narrow range oil (superior, supreme) at 1% increases the effectiveness of this material.

D. PYRACLOSTROBIN/BOSCALID (Pristine) 8–10.5 oz 24 14
MODE OF ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11) and Carboxamide (7)
COMMENTS: Do not apply on Concord, Worden, Fredonia, Niagara, and related varieties. Do not make more than 2 sequential applications before rotating to a fungicide with a different mode of action.

E. NARROW RANGE OIL# (Organic JMS Stylet) 1% 4 0
MODE OF ACTION GROUP NAME (NUMBER[1]): A contact fungicide with smothering and barrier effects.
COMMENTS: Foliage burn may occur if oil is applied within 2 weeks of sulfur or captan sprays. Oil will temporarily remove the 'bloom' on the berries; to avoid this, do not spray within 2 weeks of harvest.

F. BACILLUS SUBTILIS# (Serenade Max) 1–3 lb 4 0
MODE OF ACTION: A biological fungicide.

G. CAPTAN 50WP 2 lb 4 days
MODE OF ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M4)
COMMENTS: Do not apply in combination with, immediately before, or closely following oil sprays.

H. DICHLORAN (Botran) 75WSB/75W Label rates 12 0
MODE OF ACTION GROUP NAME (NUMBER[1]): Aromatic hydrocarbon (14)
COMMENTS: May be applied at onset of bloom. Do not apply in combination with sulfur products in sensitive varieties. Up to 5.33 lb may be applied per season.

I. MANCOZEB (Dithane M-45, Penncozeb 75DF) 1.5–2.5 lb 24 see comments
MODE OF ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M3)
COMMENTS: Do not apply after bloom. Do not apply more than 6 lb a.i./acre/season.

** Apply with enough water to provide complete coverage.

+ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

Acceptable for use on organically grown produce.

[1] Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to

different modes of actions. Fungicides with a different Group number are suitable to alternate in a resistance management program. For more information, see http://www.frac.info/.

IMPORTANT LINKS

Photos of flagging symptoms

Photos of fruit damage at harvest

Precautions

PUBLICATION

UC IPM Pest Management Guidelines: Grape
UC ANR Publication 3448
Diseases
W. D. Gubler, Plant Pathology, UC Davis
R. J. Smith, UC Cooperative Extension, Sonoma County
L. G. Varela, UC IPM Program, Sonoma County
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J. J. Stapleton, UC IPM Program, Kearney Agricultural Research Center, Parlier
A. H. Purcell, Environmental Science, Policy and Management, UC Berkeley
Acknowledgment for contributions to Diseases:
G. M. Leavitt, UC Cooperative Extension, Madera County

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Grape

BOTRYTIS BUNCH ROT

PATHOGEN: *BOTRYTIS CINEREA*

(Reviewed 6/06, updated 10/08)

In this Guideline:

SYMPTOMS AND SIGNS

Early-season shoot blight may occur following frequent spring rains. Flowers can become infected during bloom; generally the fungus then becomes dormant until late in the season when sugar concentration increases in the infected berry. The fungus then resumes growth and spreads throughout the berry. Infected berries split and leak, thus allowing the pathogen to grow and sporulate on berry surfaces and spread to adjoining berries by mid-season. Spores from infected fruit can directly infect intact, ripe berries as harvest approaches.

COMMENTS ON THE DISEASE

The fungus overwinters as sclerotia in berry mummies on the ground or left hanging on the vine and in canes. Germination and spore production occur in spring. Infections require free water for a definite period of time depending on temperature. Infections may occur during bloom should rains occur; preclose rachis infections often occur on Chardonnay. Late-season infections are most severe when relative humidity exceeds 92%, free moisture is present on the fruit surface, and temperatures are in the 58° to 82°F range. Berries that have been damaged by insects, birds, machinery, etc. may become infected at any time after the fruit

begins to ripen because the juice in the berry can provide the necessary water and nutrients for fungal growth.

MANAGEMENT

Successful management of Botrytis bunch rot can be achieved through the use of several strategies. The efficacy of a fungicide depends on getting good coverage, and coverage is affected by the canopy and stage of growth. By employing cultural control methods, properly applying fungicides, and using resistant varieties, the disease can be managed.

Cultural Control

Excellent control has been achieved using canopy management and leaf removal in particular. Removal of basal leaves or basal lateral shoots at or immediately after berry set has resulted in significantly reduced incidence and severity of disease. In warmer growing areas, be careful not to remove excessive numbers of leaves, which can lead to sunburned fruit. This condition is made worse when leaves are removed later in the season. If leaves are removed at cluster set, the berries acclimate readily to the sunlight and develop a thick cuticle that helps prevent sunburn as well as Botrytis infection.

On cordon-trained vines, only remove leaves from the side of the vine that receives morning sun. Do not remove lateral shoots. If leaves are not removed and weather is dry in spring, one fungicide application should be made sometime between bloom and pea-size berries. Otherwise, apply sprays before rainfall especially at bloom or after veraison.

Northern and coastal production areas. Remove leaves or lateral shoots around clusters beginning at late bloom and continue to berry set.

Central Valley. Remove leaves (from bloom to berry set) or hedge (mid-season) to open canopy.

Organically Acceptable Methods

Canopy management and other cultural control methods along with sprays of Organic JMS Stylet Oil and Serenade are organically acceptable methods.

Monitoring and Treatment Decisions

Look for flagging shoot tips or entire shoots during rapid shoot growth. If you see flagging, attempt to break or cut the shoot in the region between the flaccid area and the adjacent area with normal turgor. Brown discoloration on the cut surface is evidence of *Botrytis.*

If the entire shoot is involved, look for a hole at the base, which could indicate feeding by branch and twig borer.

If basal leaves are not removed, apply fungicides before rain in northern and coastal production areas to prevent flower infections. Research data shows a trend toward better control if fungicides are applied at bloom, preclose, and veraison. If leaf removal is practiced, then sprays can be limited to one application if wet weather occurs during bloom (or none if no rain occurs). Thorough coverage is essential for all fungicide treatments.

A fungicide application may also be warranted if a major rain is expected late in the season when grapes are nearly mature. Otherwise, management of Botrytis bunch rot following bloom generally relies on proper cultural practices as outlined in SUMMER BUNCH ROT.

At harvest, check table grape for Botrytis symptoms to assess this year's management program and to plan for next year.

Summary of Important Links

Common name (trade name)	Amount/Acre**	R.E.I.+ (hours)	P.H.I.+ (days)

The following materials are listed in order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies and honey bees. When choosing a pesticide, also consider information relating to environmental impact. Not all registered pesticides are listed. Always read label of product being used.

Note: *Treatments can be made in conjunction with plant growth regulators and other applications.*

A.	CYPRODINIL (Vangard) WG	10 oz	12	7

MODE OF ACTION GROUP NAME (NUMBER[1]):

Anilinopyrimidine (9)
COMMENTS: Do not apply more than 20 oz/acre/season. Rate is 5–10 oz if tank-mixed with another fungicide.

B. FENHEXAMID (Elevate) 50WDG 1 lb 12 0
MODE OF ACTION GROUP NAME (NUMBER[1]): Hydroxyanilide (17)
COMMENTS: Do not apply more than 3 lb a.i. product/acre/season.

C. IPRODIONE (Rovral) 4F 1.5–2 lb 48 7
MODE OF ACTION GROUP NAME (NUMBER[1]): Dicarboximide (2)
COMMENTS: Do not apply more than 4 times/season. Addition of a narrow range oil (superior, supreme) at 1% increases the effectiveness of this material.

D. PYRACLOSTROBIN/BOSCALID (Pristine) 8–10.5 oz 24 14
MODE OF ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11) and Carboxamide (7)
COMMENTS: Do not apply on Concord, Worden, Fredonia, Niagara, and related varieties. Do not make more than 2 sequential applications before rotating to a fungicide with a different mode of action.

E. NARROW RANGE OIL# (Organic JMS Stylet) 1% 4 0
MODE OF ACTION GROUP NAME (NUMBER[1]): A contact fungicide with smothering and barrier effects.
COMMENTS: Foliage burn may occur if oil is applied within 2 weeks of sulfur or captan sprays. Oil will temporarily remove the 'bloom' on the berries; to avoid this, do not spray within 2 weeks of harvest.

F. BACILLUS SUBTILIS# (Serenade Max) 1–3 lb 4 0
MODE OF ACTION: A biological fungicide.

G. CAPTAN 50WP 2 lb 4 days
MODE OF ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M4)
COMMENTS: Do not apply in combination with, immediately before, or closely following oil sprays.

H. DICHLORAN (Botran) 75WSB/75W Label rates 12 0
MODE OF ACTION GROUP NAME (NUMBER[1]): Aromatic hydrocarbon (14)
COMMENTS: May be applied at onset of bloom. Do not apply in combination with sulfur products in sensitive varieties. Up to 5.33 lb may be applied per season.

I. MANCOZEB (Dithane M-45, Penncozeb 75DF) 1.5–2.5 lb 24 see comments
MODE OF ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M3)
COMMENTS: Do not apply after bloom. Do not apply more than 6 lb a.i./acre/season.

** Apply with enough water to provide complete coverage.

+ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

Acceptable for use on organically grown produce.

[1] Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to

different modes of actions. Fungicides with a different Group number are suitable to alternate in a resistance management program. For more information, see http://www.frac.info/.

IMPORTANT LINKS

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Acknowledgment for contributions to Diseases:
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Grape

BOTRYTIS BUNCH ROT

PATHOGEN: *BOTRYTIS CINEREA*

(Reviewed 6/06, updated 10/08)

In this Guideline:

SYMPTOMS AND SIGNS

Early-season shoot blight may occur following frequent spring rains. Flowers can become infected during bloom; generally the fungus then becomes dormant until late in the season when sugar concentration increases in the infected berry. The fungus then resumes growth and spreads throughout the berry. Infected berries split and leak, thus allowing the pathogen to grow and sporulate on berry surfaces and spread to adjoining berries by mid-season. Spores from infected fruit can directly infect intact, ripe berries as harvest approaches.

COMMENTS ON THE DISEASE

The fungus overwinters as sclerotia in berry mummies on the ground or left hanging on the vine and in canes. Germination and spore production occur in spring. Infections require free water for a definite period of time depending on temperature. Infections may occur during bloom should rains occur; preclose rachis infections often occur on Chardonnay. Late-season infections are most severe when relative humidity exceeds 92%, free moisture is present on the fruit surface, and temperatures are in the 58° to 82°F range. Berries that have been damaged by insects, birds, machinery, etc. may become infected at any time after the fruit

begins to ripen because the juice in the berry can provide the necessary water and nutrients for fungal growth.

MANAGEMENT

Successful management of Botrytis bunch rot can be achieved through the use of several strategies. The efficacy of a fungicide depends on getting good coverage, and coverage is affected by the canopy and stage of growth. By employing cultural control methods, properly applying fungicides, and using resistant varieties, the disease can be managed.

Cultural Control

Excellent control has been achieved using canopy management and leaf removal in particular. Removal of basal leaves or basal lateral shoots at or immediately after berry set has resulted in significantly reduced incidence and severity of disease. In warmer growing areas, be careful not to remove excessive numbers of leaves, which can lead to sunburned fruit. This condition is made worse when leaves are removed later in the season. If leaves are removed at cluster set, the berries acclimate readily to the sunlight and develop a thick cuticle that helps prevent sunburn as well as Botrytis infection.

On cordon-trained vines, only remove leaves from the side of the vine that receives morning sun. Do not remove lateral shoots. If leaves are not removed and weather is dry in spring, one fungicide application should be made sometime between bloom and pea-size berries. Otherwise, apply sprays before rainfall especially at bloom or after veraison.

Northern and coastal production areas. Remove leaves or lateral shoots around clusters beginning at late bloom and continue to berry set.

Central Valley. Remove leaves (from bloom to berry set) or hedge (mid-season) to open canopy.

Organically Acceptable Methods

Canopy management and other cultural control methods along with sprays of Organic JMS Stylet Oil and Serenade are organically acceptable methods.

Monitoring and Treatment Decisions

Look for flagging shoot tips or entire shoots during rapid shoot growth. If you see flagging, attempt to break or cut the shoot in the region between the flaccid area and the adjacent area with normal turgor. Brown discoloration on the cut surface is evidence of *Botrytis.*

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A fungicide application may also be warranted if a major rain is expected late in the season when grapes are nearly mature. Otherwise, management of Botrytis bunch rot following bloom generally relies on proper cultural practices as outlined in SUMMER BUNCH ROT.

At harvest, check table grape for Botrytis symptoms to assess this year's management program and to plan for next year.

Summary of Important Links

Common name (trade name)	Amount/Acre**	R.E.I.+ (hours)	P.H.I.+ (days)

The following materials are listed in order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies and honey bees. When choosing a pesticide, also consider information relating to environmental impact. Not all registered pesticides are listed. Always read label of product being used.

Note: *Treatments can be made in conjunction with plant growth regulators and other applications.*

A.	CYPRODINIL (Vangard) WG	10 oz	12	7

MODE OF ACTION GROUP NAME (NUMBER[1]):

Anilinopyrimidine (9)
COMMENTS: Do not apply more than 20 oz/acre/season. Rate is 5–10 oz if tank-mixed with another fungicide.

B. FENHEXAMID (Elevate) 50WDG 1 lb 12 0
MODE OF ACTION GROUP NAME (NUMBER[1]): Hydroxyanilide (17)
COMMENTS: Do not apply more than 3 lb a.i. product/acre/season.

C. IPRODIONE (Rovral) 4F 1.5–2 lb 48 7
MODE OF ACTION GROUP NAME (NUMBER[1]): Dicarboximide (2)
COMMENTS: Do not apply more than 4 times/season. Addition of a narrow range oil (superior, supreme) at 1% increases the effectiveness of this material.

D. PYRACLOSTROBIN/BOSCALID (Pristine) 8–10.5 oz 24 14
MODE OF ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11) and Carboxamide (7)
COMMENTS: Do not apply on Concord, Worden, Fredonia, Niagara, and related varieties. Do not make more than 2 sequential applications before rotating to a fungicide with a different mode of action.

E. NARROW RANGE OIL# (Organic JMS Stylet) 1% 4 0
MODE OF ACTION GROUP NAME (NUMBER[1]): A contact fungicide with smothering and barrier effects.
COMMENTS: Foliage burn may occur if oil is applied within 2 weeks of sulfur or captan sprays. Oil will temporarily remove the 'bloom' on the berries; to avoid this, do not spray within 2 weeks of harvest.

F. BACILLUS SUBTILIS# (Serenade Max) 1–3 lb 4 0
MODE OF ACTION: A biological fungicide.

G. CAPTAN 50WP 2 lb 4 days
MODE OF ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M4)
COMMENTS: Do not apply in combination with, immediately before, or closely following oil sprays.

H. DICHLORAN (Botran) 75WSB/75W Label rates 12 0
MODE OF ACTION GROUP NAME (NUMBER[1]): Aromatic hydrocarbon (14)
COMMENTS: May be applied at onset of bloom. Do not apply in combination with sulfur products in sensitive varieties. Up to 5.33 lb may be applied per season.

I. MANCOZEB (Dithane M-45, Penncozeb 75DF) 1.5–2.5 lb 24 see comments
MODE OF ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M3)
COMMENTS: Do not apply after bloom. Do not apply more than 6 lb a.i./acre/season.

** Apply with enough water to provide complete coverage.

+ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

Acceptable for use on organically grown produce.

[1] Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to

different modes of actions. Fungicides with a different Group number are suitable to alternate in a resistance management program. For more information, see http://www.frac.info/.

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Photos of fruit damage at harvest

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UC ANR Publication 3448
Diseases
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Acknowledgment for contributions to Diseases:
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Grape

BOTRYTIS BUNCH ROT

PATHOGEN: *BOTRYTIS CINEREA*

(Reviewed 6/06, updated 10/08)

In this Guideline:

SYMPTOMS AND SIGNS

Early-season shoot blight may occur following frequent spring rains. Flowers can become infected during bloom; generally the fungus then becomes dormant until late in the season when sugar concentration increases in the infected berry. The fungus then resumes growth and spreads throughout the berry. Infected berries split and leak, thus allowing the pathogen to grow and sporulate on berry surfaces and spread to adjoining berries by mid-season. Spores from infected fruit can directly infect intact, ripe berries as harvest approaches.

COMMENTS ON THE DISEASE

The fungus overwinters as sclerotia in berry mummies on the ground or left hanging on the vine and in canes. Germination and spore production occur in spring. Infections require free water for a definite period of time depending on temperature. Infections may occur during bloom should rains occur; preclose rachis infections often occur on Chardonnay. Late-season infections are most severe when relative humidity exceeds 92%, free moisture is present on the fruit surface, and temperatures are in the 58° to 82°F range. Berries that have been damaged by insects, birds, machinery, etc. may become infected at any time after the fruit

begins to ripen because the juice in the berry can provide the necessary water and nutrients for fungal growth.

MANAGEMENT

Successful management of Botrytis bunch rot can be achieved through the use of several strategies. The efficacy of a fungicide depends on getting good coverage, and coverage is affected by the canopy and stage of growth. By employing cultural control methods, properly applying fungicides, and using resistant varieties, the disease can be managed.

Cultural Control

Excellent control has been achieved using canopy management and leaf removal in particular. Removal of basal leaves or basal lateral shoots at or immediately after berry set has resulted in significantly reduced incidence and severity of disease. In warmer growing areas, be careful not to remove excessive numbers of leaves, which can lead to sunburned fruit. This condition is made worse when leaves are removed later in the season. If leaves are removed at cluster set, the berries acclimate readily to the sunlight and develop a thick cuticle that helps prevent sunburn as well as Botrytis infection.

On cordon-trained vines, only remove leaves from the side of the vine that receives morning sun. Do not remove lateral shoots. If leaves are not removed and weather is dry in spring, one fungicide application should be made sometime between bloom and pea-size berries. Otherwise, apply sprays before rainfall especially at bloom or after veraison.

Northern and coastal production areas. Remove leaves or lateral shoots around clusters beginning at late bloom and continue to berry set.

Central Valley. Remove leaves (from bloom to berry set) or hedge (mid-season) to open canopy.

Organically Acceptable Methods

Canopy management and other cultural control methods along with sprays of Organic JMS Stylet Oil and Serenade are organically acceptable methods.

Monitoring and Treatment Decisions

Look for flagging shoot tips or entire shoots during rapid shoot growth. If you see flagging, attempt to break or cut the shoot in the region between the flaccid area and the adjacent area with normal turgor. Brown discoloration on the cut surface is evidence of *Botrytis.*

If the entire shoot is involved, look for a hole at the base, which could indicate feeding by branch and twig borer.

If basal leaves are not removed, apply fungicides before rain in northern and coastal production areas to prevent flower infections. Research data shows a trend toward better control if fungicides are applied at bloom, preclose, and veraison. If leaf removal is practiced, then sprays can be limited to one application if wet weather occurs during bloom (or none if no rain occurs). Thorough coverage is essential for all fungicide treatments.

A fungicide application may also be warranted if a major rain is expected late in the season when grapes are nearly mature. Otherwise, management of Botrytis bunch rot following bloom generally relies on proper cultural practices as outlined in SUMMER BUNCH ROT.

At harvest, check table grape for Botrytis symptoms to assess this year's management program and to plan for next year.

Summary of Important Links

Common name	**Amount / Acre****	**R.E.I.+**	**P.H.I.+**
(trade name)		**(hours)**	**(days)**

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Note: *Treatments can be made in conjunction with plant growth regulators and other applications.*

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COMMENTS: Do not apply more than 4 times/season. Addition of a narrow range oil (superior, supreme) at 1% increases the effectiveness of this material.

D. PYRACLOSTROBIN/BOSCALID (Pristine) 8–10.5 oz 24 14
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University of California
Division of Agriculture and Natural Resources
http://anrcatalog.ucdavis.edu

CALIFORNIA MASTER GARDENER TIP SHEET PUBLICATION 8367 / SEPTEMBER 2009

Composting Is Good for Your Garden and the Environment

PAMELA M. GEISEL, Academic Coordinator, UC Statewide Master Gardener Program; and
DONNA C. SEAVER, Program Representative, UC Statewide Master Gardener Program

WHY COMPOST?

Composting is good for several reasons:

- It saves water by helping the soil hold moisture and reduce water runoff.
- It benefits the environment by recycling organic resources while conserving landfill space.
- It reduces the need for commercial soil conditioners and fertilizers.

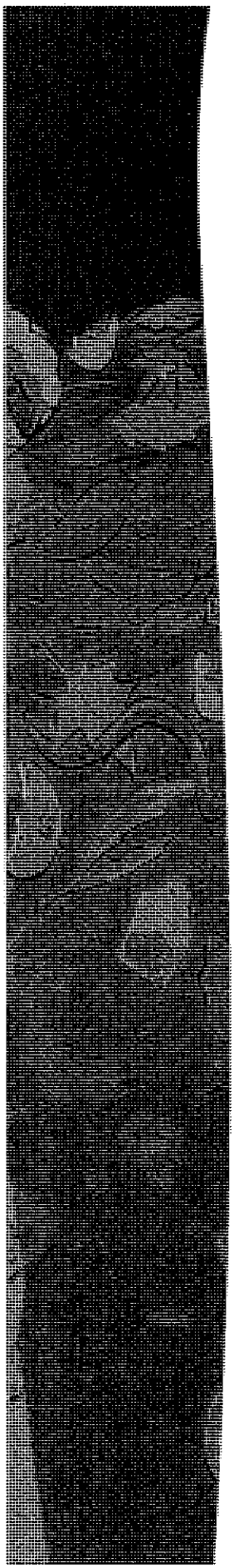
Compost provides many benefits. It

- adds nutrients and beneficial microbes, holds water, and improves plant growth
- provides a supplemental amount of slow-release nutrients
- increases soil organic matter
- encourages healthy root structure
- lightens clay soils and helps sandy soils hold water
- attracts and feeds earthworms and other beneficial soil microorganisms
- helps balance pH (acidity/alkalinity)
- helps control soil erosion
- helps protect plants from drought and freezes
- decreases use of petrochemical fertilizers
- moderates soil temperature and reduces weeds when used as a mulch

WAYS TO USE COMPOST

Different composts have different properties, and vary in tbeir suitability for various uses. Compost can be used as mulch, topdressing, soil amendment, or as an organic fertilizer.

- Mix it into flower bed and vegetable garden planting areas to improve soil properties. Before planting, mix a 3- to 4-inch layer of compost into newly reclaimed or poor soils. Mix a ½- to 3-inch layer of compost into annual garden beds at least once a year. Do not plant trees in small holes filled with compost, as this could cause root restriction. (For equivalents between U.S. and metric systems of measurement, a conversion table is provided at the end of this publication.)



- Spread a 1- to 4-inch layer of coarse compost around flowers, shrubs, trees, and vegetables as a mulch. Composts with larger particle size are generally better for mulches.
- Apply and maintain a 3-inch layer of coarse compost around trees and shrubs, keeping it at least a foot away from tree trunks.
- Top-dress your lawn by evenly spreading a ⅛- to ½-inch layer of compost over established grass (high end only for cool-season species such as tall fescue that are not mowed as short as warm-season grasses).
- Use compost in potting mixes for indoor and outdoor plants. Sprinkle a thin layer of compost around houseplants. Make a potting soil by mixing one part compost with one part sand, one part ground bark, and one part peat moss.
- If you don't have a garden—use compost with house plants, give it to a friend, or donate it to a community garden.

How to Compost

Several methods of composting can be used. Talk with your local Master Gardener to learn

- which method will work best for the time, energy, and materials you have to devote to the process
- which method will give you the amount of compost you need and in the time you need it
- the details for successfully using the method that best suits you and your gardening needs

Composting Basics

1. Chop materials ½ to 1½ inches for rapid composting.
2. Mix equal volumes of carbon-rich dry brown and nitrogen-rich green plant materials.
3. Keep compost only as moist as a wrung-out sponge.
4. Turn every few days to fluff the pile so air can penetrate.
5. A hot pile composts quickly, a cool pile takes much longer.
6. Finished compost should smell earthy, never rancid.

DO Compost

Browns	Greens
most sawdust	tea bags
chopped woody prunings	citrus rinds
pine needles	coffee grounds
fallen/dried leaves	coffee filters
dried grass	shrub and grass clippings
straw	fruit waste
shredded paper	vegetable waste
shredded cardboard	wilted flowers
shredded newspaper	young weeds
old potting mix	

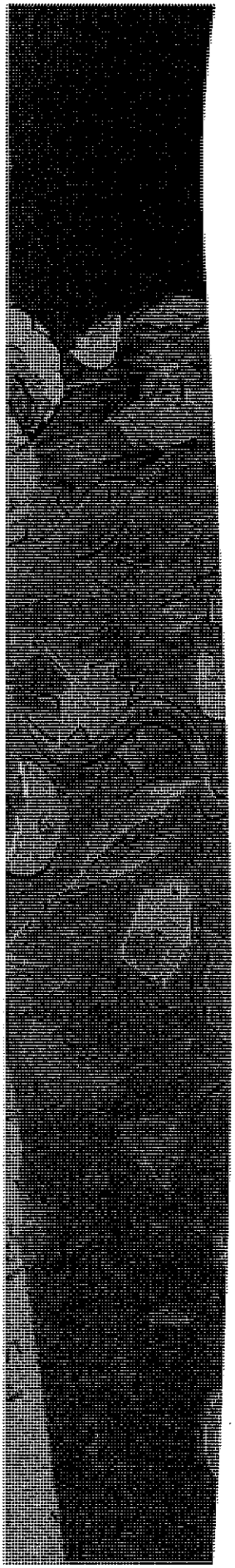
Do NOT Compost

dirt/soil
ashes from a stove, fireplace, or barbecue
animal products (meat, bones, fish, grease/fat)
dairy products
sawdust from plywood/treated wood
diseased plants
seed-bearing weeds (e.g., Bermuda grass, ivy, oxalis bulbs, burr clover)
manure or human waste

Note that adding manure to compost piles from any animal should be avoided because there is a potential risk of disease-producing bacterial contamination that may be harmful to humans. Commercial composting operations effectively control pathogens. Backyard piles may not, however, because they are smaller and may not maintain sufficient heat.

Compost is generated when organic matter is consumed and decomposed by microorganisms under favorable environmental conditions. Key management factors for the compost process include maintaining a good nutrient balance, correct moisture content and temperatures, and adequate aeration. Composting is a managed process for accelerating the decomposition of organic matter while improving its characteristics.

The majority of compost formation should occur when temperatures range from 100° to 150°F (38° to 66°C). At these temperatures the rate of organic matter decomposition is maximized and indicator species of pathogens are reduced to non-detectable levels. The Environmental Protection Agency (EPA) has found that decomposing organic



matter in aerated static piles exposed to 131°F (55°C) for 3 days is enough to eliminate parasites, fecal bacteria, and plant pathogens as well as inactivate most weed seeds. However, piles need to be turned 5 times and maintained at 131°F (55°C) for 3 consecutive days between turnings. Turning the pile regularly to allow cooler surface zones to mix with hot center areas is recommended to maintain 131°F (55°C).

Please contact your local Master Gardener for more information or go online to http://camastergardeners.ucdavis.edu.

We gratefully acknowledge support for this project from the *Elvenia J. Slosson Research Endowment for Ornamental Horticulture.* Content used in this publication was excerpted from *Compost in a Hurry* (ANR Publication 8037) by Pamela M. Geisel and Carolyn L. Unruh; *California Master Gardener Handbook* (ANR Publication 3382), edited by Dennis Pittenger; *Basic Composting* and *Composting 101*, UC Cooperative Extension, Placer and Nevada Counties; and *Compost Use for Landscape and Environmental Enhancement* by UC editors Janet Hartin and David Crohn, published by California Integrated Waste Management Board.

Poster design and illustrations: Will Suckow Illustration.

Resources Accessible Online

Web Sites

California Master Gardeners
http://camastergardeners.ucdavis.edu/

UCCE Placer/Nevada Counties Composting Education Project
http://ceplacer.ucdavis.edu/Master_Gardener252/

Publications/Brochures

California Master Gardener Handbook

ANR Publication 3382
http://anrcatalog.ucdavis.edu/InOrder/Shop/ItemDetails.asp?ItemNo=3382

Compost in a Hurry

ANR Publication 8037
http://anrcatalog.ucdavis.edu/InOrder/Shop/ItemDetails.asp?ItemNo=8037

Compost Use for Landscape and Environmental Enhancement
http://www.ciwmb.ca.gov/Publications/Organics/44207002.pdf

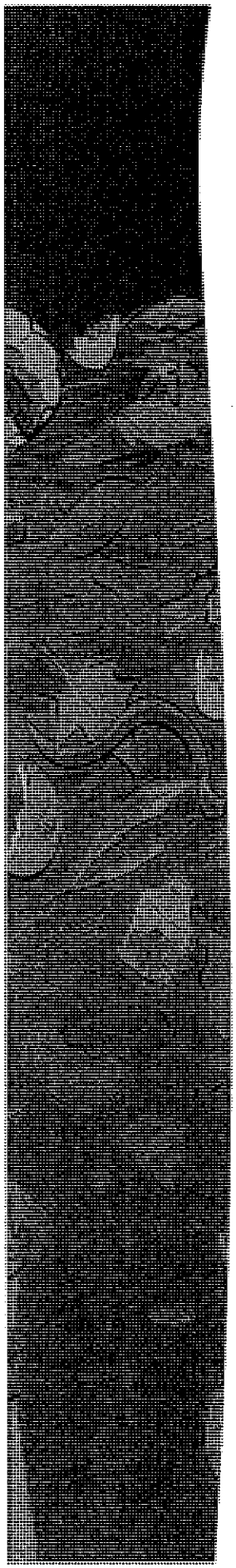
Key Points of Control and Management for Microbial Food Safety: Edible Landscape Plants and Home Garden Produce
ANR Publication 8101
http://anrcatalog.ucdavis.edu/InOrder/Shop/ItemDetails.asp?ItemNo=8101

Water Conservation Tips for the Home Lawn and Garden

ANR Publication 8036
http://anrcatalog.ucdavis.edu/InOrder/Shop/ItemDetails.asp?ItemNo=8036

Metric Conversions

English	Conversion factor for English to metric	Conversion factor for metric to English	Metric
inch (in)	2.54	0.394	centimeter (cm)
foot (ft)	0.3048	3.28	meter (m)



For Further Information

To order or obtain ANR publications and other products, visit the ANR Communicatiou Services online catalog at http://anrcatalog.ucdavis.edu or phone 1-800-994-8849. You can also place orders by mail or FAX, or request a printed catalog of our products from

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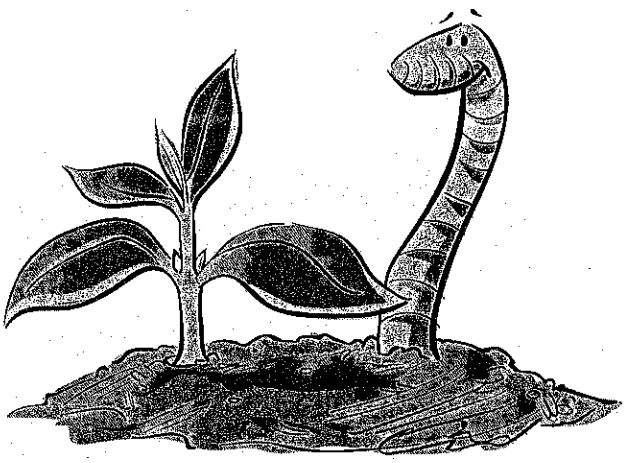
Ask a UC Master Gardener

Composting is Good for Your Garden and the Environment

Using compost helps



- grow healthier plants
- reduce landfill
- save water
- improve soil properties
- decrease need for chemical fertilizers

Please contact your local Master Gardener for more information (http://camastergardeners.ucdavis.edu).

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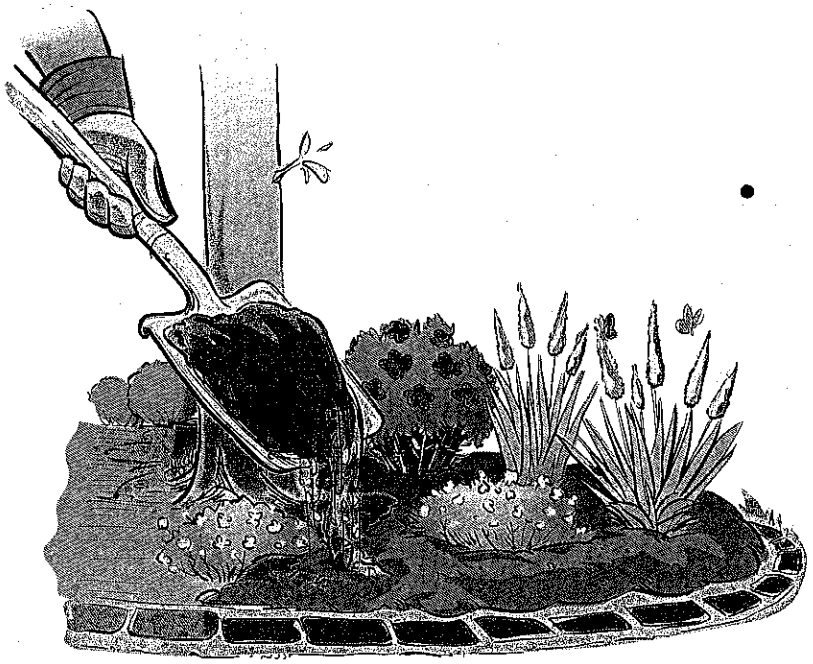
Composting is Good for Your Garden and the Environment

Ways to Use Compost

Compost can be used as mulch, topdressing, soil amendment, or organic fertilizer.



- Mix it into planting areas to improve soil properties.

- If you don't have a garden—use it with house plants, give it to a friend, or donate it to a community garden.

Composting is Good for Your Garden and the Environment

How to Compost

There are several methods of composting.
Ask your local Master Gardener for specifics.

Composting Basics

1. Chop materials ½ to 1½ inches.
2. Mix equal volumes of carbon-rich dry brown and nitrogen-rich green plant materials.
3. Keep compost only as moist as a wrung out sponge.
4. Turn often.

Best Management Farming Practices for Water Quality Protection
Nutrient Management (590)

BMP: Protect creeks, streams and rivers from nutrient inputs.

NRCS Practice Standard: Nutrient Management (590)

A nutrient management plan addresses the nutrient needs of the crop and the water quality concerns of the watershed. To promote health and conserve input use, application method, timing, rate should be specified according to plant and site needs. The plan should also describe how nutreints will be kept on site and use by plants, and not influence water quality.

Nutrient Management (NRCS Conservation Practice Code 590)

Definition: Managing the amount, application rate, source, placement, application method, and timing of plant nutrients and soil amendments.

Purposes:

- To budget, supply, and conserve nutrients for plant production.
- To minimize agricultural nonpoint source pollution of surface and groundwater resources.
- To properly utilize manure or organic by-products as a plant nutrient source.
- To protect air quality by reducing odors, nitrogen emissions (ammonia, oxides of nitrogen), and the formation of atmospheric particulates.
- To maintain or improve the physical, chemical, and biological condition of soil.

Consider this:

Use no-till/strip-till with cover crops to sequester nutrients, increase soil organic matter, increase aggregate stability, reduce compaction, improve infiltration, and enhance soil biological activity to improve nutrient use efficiency.

Develop site-specific yield maps to diagnose low- and high- yield areas, or zones, and make the necessary management changes.

Use soil tests, plant tissue analyses, and field observations to check for secondary plant nutrient deficiencies or toxicity that may impact plant growth or nutrient availability.

Use conservation practices that slow runoff, reduce erosion, and increase infiltration, e.g., filter strip, contour farming, or contour buffer strips.

Use application methods and timing strategies that reduce the risk of nutrient transport by ground and surface waters.

Use high-efficiency irrigation technologies (e.g., reduced-pressure drop nozzles for center pivots) to reduce the potential for nutrient losses.

For more information contact your local NRCS office or visit our website at http://efotg.sc.egov.usda.gov/treemenuFS.asp