Burrowing Vertebrate Pest Fumigation

A Study Manual for Private Applicators

California Environmental Protection Agency
dpr Department of Pesticide Regulation

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Introduction

This study manual is intended to prepare certified private applicators for the *California Department of Pesticide Regulation's (DPR's)* additional Burrowing Vertebrate Pest Fumigation (BVPF or BVF) Certification examination. The additional BVF certification is required of any *private applicator* who intends to use, or supervise the use of, any fumigant classified as a restricted material and labeled for the control of burrowing vertebrate pests in California on property owned, leased, or rented by him/her or his/her employer for the purpose of producing an agricultural commodity.

In this context, "agricultural commodity" has a specific legal definition from the *United States Environmental Protection Agency (U.S. EPA)*. In this instance the term means:

Any plant, fungus, or algae, or part thereof, or any animal or animal product, produced by a person (including, but not limited to, farmers, ranchers, vineyardists, plant propagators, Christmas tree growers, aquaculturists, floriculturists, orchardists, foresters, or other comparable persons) primarily for sale, consumption, propagation, or other use by man or animals.

In California, possession of a Private Applicator Certificate (PAC) alone is not sufficient to allow an individual to conduct soil and non-soil fumigations. DPR only allows PAC holders to conduct a subset of non-soil fumigation activities using restricted materials: non-soil fumigation for the control of burrowing vertebrate pests. DPR requires PACs to pass a written examination on burrowing vertebrate pest fumigation before they can conduct these fumigations. This study manual will ensure that you possess the required knowledge, skills, and information to safely conduct these limited non-soil fumigation activities.

If you need to use or supervise the use of a fumigant to conduct a soil fumigation, or a non-soil fumigation in another setting (such as a commodity fumigation), you must instead obtain a Qualified Applicator Certificate or License (QAC or QAL) from DPR with the appropriate category.

If you meet the definition of a private applicator and you wish to use restricted materials labeled as a fumigant to control burrowing vertebrate pests, you must first successfully pass the Private Applicator Certificate examination, and then pass the additional Burrowing Vertebrate Pest Fumigation Certificate examination administered by the *County Agricultural Commissioner's* (CAC) office. You must have your PAC before obtaining the additional Burrowing Vertebrate Pest Fumigation Certificate.

This study manual will address the basics of using non-soil fumigants to control burrowing vertebrate pests, including but not limited to the following topics: use, handling, pesticide products, application and planning, safety, personal protective equipment (PPE), methods, application equipment, application settings, and pests. DPR does not endorse or recommend the use of any pesticide product or pesticidal device mentioned in this study manual, but instead provides them as examples.

Each chapter of this study manual ends with review questions. After reading each chapter, test your understanding of the information presented in the chapter by answering the review questions. Correct answers are given on page 51. These review questions are in the same multiple-choice selection format as the questions on the BVF certification exam, however, these questions are not necessarily examination questions.

Important terms to know throughout this study manual are italicized in the text and defined in the glossary.

Chapter 1: Fumigants

Background

In California, the term "soil fumigation" is reserved for applications where soil is being treated with a fumigant (e.g., soil in agricultural fields, golf courses, tree hole fumigations, etc.). Non-soil fumigations are all other uses of fumigants, such as fumigations of other spaces or items (such as commodities or items in a structure, vehicle, or under a tarp). Non-soil fumigation also includes fumigations of rodent and other pest burrows to control pests, even though these burrows are in soil.

Fumigations are high-risk applications that require specialized training and expensive equipment to comply with pesticide labeling and other regulatory requirements.

What are Fumigants?

Before we discuss fumigants, we need to define the broader term - *pesticide*. A pesticide is any substance, or mixture of substances, which is intended to prevent, destroy, or reduce pest populations or pest damage. Not all pesticides kill the target pest, some may repel it or prevent it from reproducing.

For the scope of this study manual, Title 3, *California Code of Regulations* (3 CCR) section 6400 designates the following pesticides as restricted materials:

- Any pesticide labeled as a *Restricted Use Pesticide* (RUP),
- Any pesticide used under a Section 18 Emergency Exemption, and
- Certain other pesticides listed in the section.

Fumigants are pesticides which are highly *toxic* to humans and other animals. Burrowing vertebrate pest fumigants are gaseous pesticides used as a means of pest control for burrowing pests, such as rodents. A *vertebrate* is an animal with an internal backbone.

Fumigants are a type of pesticide with unique chemical and physical characteristics. They generally either turn into *gases* after application or are applied in gaseous forms. Fumigants are usually not easily visible and can be odorless.

Fumigants are highly toxic to humans and other animals. For this reason, it is important to know how a fumigant works and how some fumigants transform from a solid into a gaseous state, making it a fumigant.

Fumigants in a gaseous form can penetrate small openings and must be contained to an enclosed area to maximize effectiveness. If the gas can escape from the intended area, it will decrease the effectiveness of the fumigant.

There are many factors that affect the efficiency of a fumigant including, but not limited to, boiling point, *molecular weight*, *solubility*, and flammability. External factors include weather, *temperature*, *humidity,* and soil conditions. Always consult the label to help determine the best conditions for use of a pesticide labeled as a fumigant.

A chemical, including some fumigants, becomes a gas when it reaches its *boiling point*. A boiling point is the temperature at which a chemical or fumigant becomes a gas. For example, the boiling point of water is 212°F (100°C). The boiling point is also related to the chemical's *vapor pressure*. In general, the higher the boiling point, the lower the vapor pressure, and the slower a fumigant will change to a gas.

Some fumigants have a low boiling point so they are gases at room temperature. These fumigants are usually stored as liquids under high pressure. Other fumigants have a high boiling point and are liquids or solids at room temperature. Aluminum and magnesium phosphide, which release phosphine gas when exposed to moisture, may be packaged as solid tablets, pellets, ropes, plates, or strips.

There are many factors that contribute to a chemical's conversion into a gaseous state, such as pH, humidity in the air, moisture content, and temperature. It is important to consult the label to determine the appropriate conditions and timing when using any pesticide labeled as a fumigant.

Burrowing Vertebrate Pest Fumigants

The fumigants used to control burrowing vertebrate pests are aluminum and magnesium phosphide, which generate a toxic gas called phosphine to control the pest. These two metal phosphides, as they are sometimes called, will both be covered in this study manual, although applicators tend to prefer using aluminum phosphide over magnesium phosphide for a variety of reasons.

Aluminum and Magnesium Phosphide

For burrowing vertebrate pest control, aluminum phosphide products are formulated as solid tablets or pellets, and magnesium phosphide is formulated as plates. These *formulations* are activated by moisture and are stored in tightly sealed containers. The tablets and pellets are packaged in resealable aluminum flasks (Figure 1-1) and the plates are packaged within gas-tight pouches in metal drums.

In this study manual we will discuss aluminum phosphide products labeled for the control of burrowing pests outdoors in:

- agricultural areas,
- orchards,
- pastures and rangelands, and
- other non-crop areas on a farm.

NOTE: When used for outdoor burrowing rodent fumigation, aluminum and magnesium phosphide labels prohibit fumigation of burrows within 100 feet of any building where humans and/or domestic animals reside or might reside.

Figure 1-1. Sealed aluminum flask containing aluminum phosphide tablets.

When exposed to moisture in the air, aluminum and magnesium phosphide react to release phosphine gas. Phosphine (also called hydrogen phosphide) is a toxic gas and is about 20% heavier than air. Aluminum phosphide tablets are larger than pellets and release more phosphine. However, the smaller pellet form of aluminum phosphide reacts faster than the larger tablet. Aluminum and magnesium phosphides typically react faster as temperature increases; the total time needed to reach the desired phosphine *concentration* can vary, depending on temperature and other factors, such as humidity and soil moisture levels. This reaction starts slowly and gradually accelerates resulting in a gradual increase of phosphine gas. The reaction tapers off as little to no metal phosphide is left to react with moisture. The initial slow reaction is important to allow sufficient time for the applicator to open the package, place the fumigant in the burrow, and cover the opening(s) of the burrow. Magnesium phosphide releases more phosphine, and at a more rapid rate, than aluminum phosphide.

The chemical equation for the reaction between aluminum phosphide and water to create phosphine gas is shown below:

$$AlP + 3H_2O \rightarrow Al(OH)_3 + PH_3$$

The chemical equation for the reaction between magnesium phosphide and water to create phosphine gas is shown below:

$$Mg_3P_2 + 6H_2O \rightarrow 3Mg(OH)_2 + PH_3$$

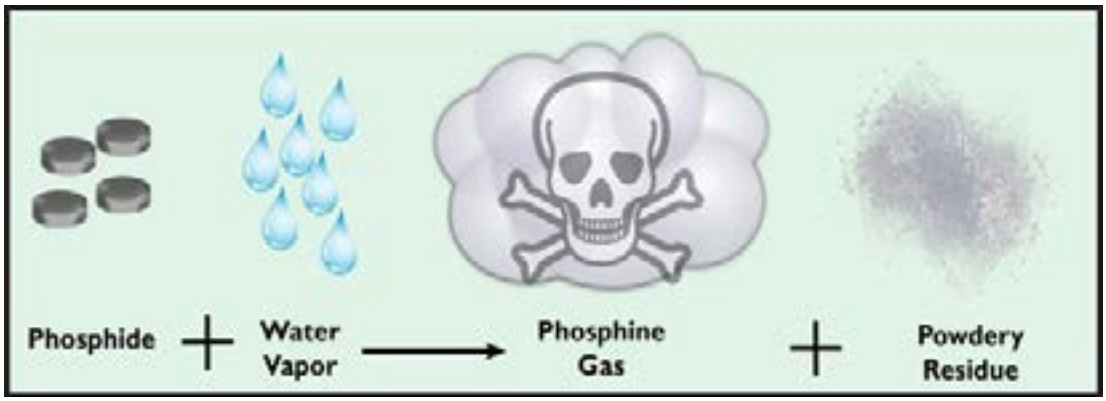


Figure 1-2. Phosphine gas production from phosphide solids. This illustration shows the reaction of phosphide solids (applies to both aluminum and magnesium phosphides) with atmospheric moisture to create phosphine gas. (Illustration © UW Madison Pesticide Applicator Training Program based illustration by Ruth O'Neill, MSU in the Montana non-soil fumigation manual).

Both aluminum phosphide and magnesium phosphide produce *residue* when they react with moisture in the air. For aluminum phosphide, this partially reacted dust is called "*green dust*" because it remains slightly greenish in color, while the spent residual dust is grayish white. Do not assume that a fumigation is complete just because you see residue, as gas may still be releasing even if residue is present.

Phosphine will be produced more quickly under warm, humid conditions compared to cool, dry conditions. Since the production of phosphine requires moisture, higher humidity means more water is available to increase phosphine gas generation. If the air is too dry, the fumigant may stay in its solid form. Keep in mind that magnesium phosphide products are much more reactive than aluminum phosphide products and may be better suited for fumigations conducted in cooler and drier conditions.

Flammability

Flammability is a measure of the capacity to catch fire. Phosphine is extremely flammable and may spontaneously ignite at high concentrations. When using highly flammable fumigants you need to carefully follow procedures on the label intended to prevent fires. Aluminum phosphide tablets and pellets contain ammonium carbamate which converts to ammonia and carbon dioxide, inert gases which serve to reduce fire hazards. Magnesium phosphide plates do not contain ammonium carbonate.

Chemical Reactivity

Some fumigants react with other chemicals where they are released. The label will advise you of these potential reactivities. Pure phosphine gas is practically insoluble in water or fats and oils and is stable at normal fumigation temperatures. Phosphine gas reacts with copper to cause serious *corrosion*. Copper can be commonly found in electrical wiring, motors, batteries, computers, and plumbing. Phosphine gas will also react with certain metallic salts and, therefore, sensitive items such as photographic film, some inorganic pigments, etc. should not be exposed.

Odor

Sensory irritants or warning chemicals are sometimes added to otherwise odorless fumigants to give them a detectable odor. This odor is intended to give an indication that the fumigant gas is present in the air and allows you to take the proper safety measures. Pure phosphine gas is odorless but, in some instances, some users may notice a garlic odor caused by a contaminant. Remember that the garlic like odor of phosphine is not always detectable by everyone and the absence of a garlic odor does not indicate safe levels of phosphine gas. In other words, do not rely on odor as an adequate indicator of phosphine's presence since it is not a reliable indicator of hazardous concentrations. You will want to use the correct monitoring device for accurately measuring phosphine gas levels.

How People are Exposed

Due to the nature of phosphine producing fumigants, fumigant *handlers*, other workers, and bystanders can potentially be exposed to phosphine gas. It is your job as the applicator to ensure that the *risk* of human *exposure* to the fumigant is very low. The four *routes of exposure* (skin, eye, oral (mouth), and respiratory) were covered in detail in Chapter 6 of the Pesticide Safety: A Study Manual for Private Applicators, Third Edition. With fumigants, respiratory exposure is the most common and hazardous route for both handlers and bystanders.

The *inhalation* risks to handlers of aluminum and magnesium phosphide are greatest when opening the fumigant container, during application, and during deactivation and disposal of the solid fumigant.

Other risks to handlers and bystanders may arise from either not reading the label or not following its safety directions and precautions. Mistakes that could cause people to be exposed to fumigant gases include:

- Neglecting to post the treatment areas, causing people to not be aware of the dangers,
- Failing to monitor fumigant levels (or not using the proper gas detection equipment),
- Not using the appropriate *Personal Protective Equipment (PPE)*,
- Using poorly fitted respirators, and
- Not maintaining PPE, including not changing respirator cartridges/canisters daily.

Potential Symptoms of Exposure

Although phosphine exposure *symptoms* can be severe, the symptoms are recognizable and may be reversible if exposure is ended quickly. Knowing the signs and symptoms associated with exposure will assist you in protecting yourself. Be aware of the signs and symptoms that indicate exposure to phosphine gas.

- Slight or mild poisoning symptoms include fatigue, ringing in the ears, nausea, uneasiness, severe lung irritation, chest tightness or burning chest pain, and cough.
- Medium to heavy poisoning symptoms include fatigue, nausea, vomiting, stomachache, diarrhea, disturbance of equilibrium, strong pains in the chest, back pains, a feeling of coldness, and difficulty breathing.
- Severe poisoning symptoms occur rapidly and include difficulty breathing, change in skin color, agitation, unconsciousness, and death. Death may be immediate, or it can follow several days of chemical pneumonia, paralysis of the central respiratory system, and/or fluid buildup of the brain.

Adverse health effects generally occur within the first few hours following inhalation of phosphine. Cardiovascular complications may cause death within 12 to 24 hours following exposure. Deaths that occur 24 hours after exposure are usually a result of liver or kidney failure, but signs of liver damage may be delayed 48 to 72 hours following exposure. Pulmonary edema (fluid in the lungs) may be delayed for 72 hours following exposure.

First Aid for Fumigant Poisoning

Administering first aid is the initial response to a pesticide exposure and is vital in helping a victim. However, first aid is not, and should not be, considered a substitute for professional medical help. Be able to recognize when someone needs medical attention, know where to get it, and be prepared to get it. Seek medical attention whenever someone:

- Exhibits any illness while, or soon after, working with pesticides or in a treated area,
- Has swallowed a pesticide,
- Has gotten a pesticide in their eyes, or
- Exhibits symptoms of poisoning or injury following dermal or inhalation exposure to a pesticide.

There are situations where you and others should seek medical attention even in the absence of symptoms. For example, a person who has entered a fumigated space without the required respiratory protection should be immediately taken to a medical facility for evaluation and monitoring, even if they do not show symptoms of poisoning. The onset of poisoning symptoms from some fumigants can be delayed for many hours.

You should call for or seek medical help immediately. However, you may need to provide some first aid until medical care can be given. Be sure to protect yourself (i.e., wear required PPE) before trying to help someone else in an area under active fumigation. Get yourself and the other person to fresh air as soon as possible. The First Aid section of the fumigant label will give you first aid instructions specific to the fumigant involved.

Additional information on first aid for inhalation exposures to pesticides can be found in Chapter 12 of the Pesticide Safety: A Study Manual for Private Applicators, Third Edition.

California regulations require an employer to make certain that any employee that has a pesticide illness, or has been exposed to a pesticide that might lead to an illness or injury, is immediately taken for medical care. You should never send an injured or ill employee to seek medical care alone. When transporting a victim of fumigant exposure, roll down the vehicle's windows to prevent the vehicle occupants from being exposed to fumes that may be released from the victim's body or clothing. Be ready to provide medical personnel with the *U.S. EPA registration number*, full *trade name*, *active ingredient*, and *Safety Data Sheet (SDS)* of the fumigant used. Providing the product label may be helpful but be sure that the label and/or SDS is not contaminated to ensure no *hazard* is presented to medical staff.

Where to Get Help

In California, your employer must post in a prominent place at the worksite, or work vehicle if there is no designated worksite, the name, address, and telephone number of a facility able to provide medical care. The label required Fumigation Management Plan (FMP) must include a section with the contact information of local medical facilities. The FMP will be discussed in detail in Chapter 3. Also, the First Aid section of the pesticide label includes the telephone numbers of the manufacturer and of the Poison Control Center. The Poison Control Center (1-800-222-1222) is available 24 hours and is a good source of information on the treatment of pesticide poisonings. The Poison Control Center has the most complete and current information on poisons and has specialized personnel trained to address and assist medical personnel with poisoning cases. Calling the Poison Control Center's 800 number will automatically direct a caller to the closest Poison Control Center in the area.

Chapter 1 Review Questions

Correct answers are given on page 51.

1. The temperature at which a liquid becomes a gas is _____.
    a. boiling point
    b. evaporation
    c. pressure peak

2. What does phosphine gas react with to cause corrosion?
    a. Calcium
    b. Cobalt
    c. Copper

3. Aluminum and magnesium phosphide react to release phosphine gas when exposed to _____.
    a. pressure
    b. moisture in the air
    c. soil temperature

4. Why are sensory irritants or warning chemicals sometimes added to fumigants?
    a. to increase efficacy of the fumigant
    b. to discourage non-target pests entering burrows
    c. to give them a detectable odor

Chapter 2: California Pesticide Use Requirements

State and federal requirements dictate how you may use restricted materials on property you or your employer own or operate. Pesticide applicators must understand pesticide labeling and the pesticide laws and *regulations* before applying any type of pesticide, including fumigants. Pesticide applicators must always follow federal and state laws and regulations as well as local use requirements. Always follow the strictest requirements when preparing to conduct a non-soil fumigation for the control of a burrowing vertebrate pest.

Many California pesticide regulations go above and beyond the pesticide label. Many of these requirements were covered in the Pesticide Safety: A Study Manual for Private Applicators, Third Edition.

Aluminum phosphide and magnesium phosphide are federal Restricted Use Pesticides and also classified as restricted materials. This chapter will cover the restricted materials permitting process and DPR's pesticide use reporting.

Restricted Materials and Permitting

As discussed earlier, the most common fumigant used on burrowing vertebrate pests is aluminum phosphide, though there are also a limited number of magnesium phosphide products labeled for this use. Aluminum phosphide and magnesium phosphide are classified as *restricted materials* in Title 3, California Code of Regulations section 6400 and require a *restricted materials permit* to possess or use the fumigant. These permits are obtained from the local County Agricultural Commissioner's office.

Agricultural use permits are issued to the *property operator* to allow them to purchase, use, and store these products. The permit application requires the property operator to identify all known "sensitive sites." These are areas that could be adversely impacted by the use of the pesticide(s) specified on the permit application.

"Sensitive sites" collectively refer to areas such as hospitals, schools, playgrounds, residential areas, labor camps, parks, lakes, waterways, wildlife management areas, livestock, or crops. Prior to applying for a permit, the grower must consider, and if feasible, adopt any reasonable, effective, and practical mitigation measure, or use any feasible alternative, which would substantially lessen any significant adverse impact on the environment. The permit will include the name of the *certified applicator* responsible for the application or supervising the application of the product and their certification.

The CACs may establish local use requirements called *permit conditions*. These are stricter requirements than found on the pesticide's labeling or in California law and regulation. Permit conditions issued by the CAC must be followed. If violated, an individual may be cited, fined, or referred to the district attorney for prosecution of a crime. If using a non-soil fumigant in more than one county, a restricted materials permit must be obtained from each county in which the application will be conducted. In addition, the permittee must submit a Notice of Intent to Apply Restricted Materials (NOI) to the local CAC at least 24 hours prior to fumigating. In some instances, this notification may be longer than 24 hours. Check with the local CAC for specific details on NOI requirements.

Pesticide Recordkeeping and Use Reporting

Property operators must maintain records of the pesticides applied and submit a Pesticide Use Report (PUR) to the local CAC. The Pesticide Use Reports for burrowing vertebrate fumigations in a field, vineyard, or orchard which are applied to, or for the production of an agricultural commodity, are submitted on the Pesticide Use Report Form for each application conducted. Applications other than those specified above are reported as a monthly summary of applications on the Production Agriculture Monthly Pesticide Use Report Form. For more information on recordkeeping and use reporting, contact your local CAC's office.

Chapter 2 Review Questions

Correct answers are given on page 51.

1. Property operators must maintain records of the pesticides applied and submit a Pesticide Use Report to _____.
    a. the Department of Pesticide Regulation
    b. the United States Environmental Protection Agency
    c. the local county agricultural commissioner

2. On a restricted material permit application, areas that could be adversely impacted by the use of a pesticide are specified and called _____.
    a. protected and threatened species sites
    b. restricted sites
    c. sensitive sites

Chapter 3: Fumigant Labeling and Handling Requirements

Fumigation Safety

This study manual covers important aspects of pesticides used to fumigate burrowing vertebrate pest burrows. However, this study manual is not a substitute for reading and understanding the label of the specific fumigant product you will be using. Thoroughly read the label prior to purchase and application. Be aware that pesticide manufacturers may update or change the contents of (or information/ instructions on) a pesticide label to address hazards to handlers, nearby workers, other bystanders, and the environment. Reading the label will inform you of any application restrictions to avoid potential human exposure incidents, protect endangered or non-target species, and to avoid harmful environmental effects from the use of the pesticide. Always carefully read and understand the label of the pesticide product you are using and the restricted material permit conditions issued by the CAC for the application.

Fumigants are some of the most toxic pesticides and require great skill and care when used. Even though the fumigant used for burrowing vertebrate pests is placed underground, the *sites* you treat are often located near where people live and work. Many sites are located near livestock and other animals.

When used for outdoor burrowing vertebrate fumigation, applications of aluminum and magnesium phosphide are prohibited within 100 feet of any building where humans and/or domestic animals do, or might, reside. Labels that allow burrowing rodent control will contain a statement such as the following:

> "For burrowing vertebrate applications: The use of this product is strictly prohibited within 100 feet of any building where humans and/or domestic animals do or may reside on single and multi-family residential properties, and nursing homes, schools (except athletic fields), daycare facilities, and hospitals."

Your ability to safely apply fumigants, or supervise their safe application, is critical. You must protect the public and the environment from exposure. Several important ways to protect others from fumigant exposure include:

- Reading and following the label directions,
- Preparing and planning well before application,
- Obtaining a restricted material permit and submitting a Notice of Intent,
- Maintaining an adequate distance from occupied structures,
- Posting warning signs,
- Using proper methods, rate, and equipment,
- Monitoring fumigant exposure, and
- Safely transporting, storing, and disposing of fumigants and their containers.

In addition, review your restricted material permit conditions to determine any local restrictions in the county where you plan to apply the fumigant.

Fumigant Labels

The pesticide *label* is one of the most important tools to ensure the safe and effective use of pesticides. Pesticide registrants are required by law to put certain information on the label. Always read, understand, and follow all the information on the pesticide label.

In many cases, not all the information necessary to use the pesticide safely will be found on the pesticide container label, but may instead be found in the accompanying labeling. The term "*Labeling*" includes the pesticide label affixed to the container and other information that accompanies the product. Labeling can include

booklets, brochures, leaflets, and more. This is especially true for fumigant products, which almost always have a separate comprehensive *applicator's manual* that you must follow to use the product safely and legally. (Figure 3-1).

THE COMPLETE LABEL FOR THIS PRODUCT CONSISTS OF THE CONTAINER LABEL AND THE APPLICATOR'S MANUAL WHICH MUST ACCOMPANY THE PRODUCT. READ AND UNDERSTAND THE ENTIRE LABELING AND APPLICATOR'S MANUAL.

Figure 3-1. Example of text on a product label indicating that the applicator's manual is part of the complete label.

The label is the law. The "label" of a pesticide product corresponds to the label itself and any supplemental labeling referred to on the label. The label and any document referred to on the label are legally binding documents. If you fail to explicitly follow label directions, you are in violation of State and federal law.

You already know many of the requirements found on pesticide labels from Chapter 4 of the Pesticide Safety: A Study Manual for Private Applicators, Third Edition. We will review these requirements for aluminum and magnesium phosphide fumigants labeled for use on burrowing vertebrate pests.

- ***Signal Word.*** The signal word indicates the level of toxicity of the pesticide product. Burrowing vertebrate pest fumigants will display the signal word DANGER/POISON, along with skull-and-crossbones (Figure 3-2).
- **Statement of Use Classification.** Products containing aluminum and magnesium phosphide have "Restricted Use Pesticide" printed in plain sight on the label. This classification is due to the high acute inhalation toxicity of phosphine gas.
- **Formulation.** Pesticides formulated as a fumigant will generally state that on the front panel of the label, however for some products you may need to read the label further to determine if the product is a fumigant.

Figure 3-2. Signal word "DANGER" with skull-and-crossbones to indicate the toxicity level of the fumigant.

- ***First Aid.*** The First Aid section lists the symptoms of exposure as well as the emergency first aid procedures for the various routes of exposures (inhalation, *oral*, *dermal*, and eye). This information is a requirement on the pesticide label and includes emergency *decontamination procedures*. This section includes a "Note to Physicians" which provides the physician with detailed information on the adverse effects of the fumigant as well as recommendations for treatment.
- ***Precautionary Statements.*** Precautionary statements listed on the fumigant label describe the pesticide's hazard to humans, protected species, non-target organisms, and the environment, as well as the physical and chemical hazards such as risk for fire or explosion. For example, the physical and chemical hazards will include instructions on how to properly open canisters to avoid explosions, list materials incompatible with the fumigant, and covers air monitoring requirements specific to the fumigant.
- ***Directions for Use.*** The Directions for Use section on the pesticide label is generally the largest portion of the label. It includes the use restrictions, a listing of use sites and target pests, certified applicator supervision requirements, as well as requirements for a Fumigation Management Plan (FMP). The Directions for Use section of aluminum phosphide labels also include the requirements for personal protective equipment (PPE) and safety monitoring specific to the fumigant. The following information can be found in the Directions for Use section:
    - **Dosage Rate.** Aluminum and magnesium phosphide fumigant labels have a section for *dosage* on the label. This information is usually presented in a table. Often, the rate for burrowing vertebrate pest fumigations is a specific number of tablets or pellets per burrow. Always remember that you cannot exceed the highest dosage on the label.
    - **Personal Protective Equipment (PPE).** Aluminum and magnesium phosphide fumigant labels have very specific PPE requirements, especially when it comes to respirator use. Due to the acute toxicity of phosphine gas, there will be separate sections dedicated to respiratory protection, exposure limits, and industrial hygiene monitoring.
    - **Notification Requirements.** This section identifies who must be notified prior to the fumigation in

cases of accidents, emergencies, or in the case of theft of the fumigant (Figure 3-3). This includes information on the authorities, on-site workers, and incidents involving that pesticide. If required, agencies such as the fire department, local health agency, and the police department may need to be notified prior to the fumigation. Provide these agencies with the following information:

- Names and telephone numbers of all appropriate personnel in charge,
- Location, date, and time of application,
- Product and chemical name for the fumigant(s) used,
- SDS and a copy of the label,
- Required PPE and safety equipment,
- Fire hazard rating of the fumigant, and
- Fumigation Management Plan that was developed.

SECTION 14

NOTIFICATION REQUIREMENTS

14.1 AUTHORITIES AND ON-SITE WORKERS

As required by local regulations, notify the appropriate local officials (fire department, police department, etc.) of the impending fumigation. Provide the officials an MSDS and complete label for the product and any other technical information deemed useful. Offer to review this information with the local official(s).

14.2 INCIDENTS INVOLVING THESE PRODUCTS

Registrants must be informed of any incident involving the use of this product. Please call 1-800-438-6071 so United Phosphorus, Inc. can report the incident to Federal and State Authorities.

14.3 THEFT OF PRODUCTS

Immediately report to the local police department thefts of metal phosphide fumigants.

Figure 3-3. Notification requirements on a label. This section, taken from a phosphine fumigant product applicator's manual, shows that notification of local authorities may be required, especially in the case of accidents or theft of product. Note that the text refers to an "MSDS," which are now known as SDS.

- **Posting Fumigated Areas.** Burrowing pest control fumigations have specific *posting* requirements that are different from when the fumigant is used in a commodity or other fumigation. These requirements will be discussed later in the chapter.
- **Storage Instructions.** The storage instructions include information on proper storage of the fumigant. Aluminum and magnesium phosphide products react to moisture and must be stored in a locked, dry, well-ventilated area. The product labels require the storage area must be posted with placards that use the National Fire Protection Association (NFPA) hazard classification system.
- **Transportation.** Aluminum and magnesium phosphide reacts with moisture in the air, and improper transportation can result in the release of toxic phosphine gas in a vehicle and into the environment. This poses an exposure hazard to the people transporting the pesticide as well as to people nearby. These fumigants must be transported safely. The proper, secure, and safe transport of these pesticides is discussed in more detail later in this chapter.
- **Environmental Hazards.** The Environmental Hazards section of these product labels has specific instructions not to apply the fumigant to water, or to not contaminate water when cleaning application equipment. It will also state that the fumigant is very toxic to non-target wildlife.
- **Endangered Species Restrictions.** Part of your job as an applicator is to protect non-target wildlife, including protected, endangered, or *threatened species*. Product labels may have a statement requiring an applicator to consult various resources for bulletins on specific use restrictions related to wildlife and/or their habitat. These resources are discussed in detail later in this chapter. Any restrictions on these bulletins are enforced as part of the product's labeling.
- **Disposal Instructions.** This section of the label provides instructions on how to safely and properly handle unreacted or partially reacted product (such as "green dust" from aluminum phosphide products). It will also provide instructions on the proper disposal of the container.
- **Spill and Leak Procedures.** The fumigant label includes a section on spill and leak procedures as fumigant spills in general may produce high levels of phosphine gas. The label may require cleanup personnel to wear a self-contained breathing apparatus (SCBA) or equivalent if the concentration of phosphine gas is unknown when cleaning up the spill. Other options may be available if the concentration of phosphine is known. In addition, this section includes proper cleanup and container repair procedures.

Handling Fumigants

Compared to other pesticides, restricted materials are pesticides considered to have a higher potential to cause harm to public health, farm workers, domestic animals, honeybees, the environment, wildlife, or crops.

Aluminum phosphide and magnesium phosphide products are classified as restricted materials because they generate phosphine, an effective, but extremely toxic gas used to control burrowing vertebrates.

One way to categorize pesticides is based on their relative *acute toxicity*. There are four pesticide *toxicity* categories with Toxicity Category I pesticides being highly toxic based on either oral, dermal, or inhalation toxicity. Toxicity Category I pesticides must prominently display on the front panel of the package label the signal words DANGER and POISON printed in red with a *skull-and-crossbones* symbol. The Spanish equivalent for DANGER, "PELIGRO," must also appear on the labels of highly toxic chemicals. Aluminum and magnesium phosphide fumigants are Toxicity Category I pesticides due to the acute inhalation hazard of phosphine gas.

Protecting Endangered Species

In California, DPR has an *Endangered Species* project to protect federally and state listed species from pesticide uses. DPR's Endangered Species project activities include:

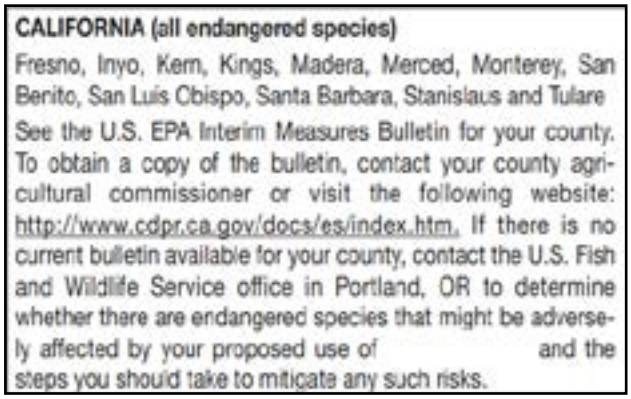
- Mapping sites occupied by federally and state threatened or endangered species,
- Evaluating the risks from pesticides to species and their habitats,
- Classifying risks from pesticides registered in California,
- Developing protection strategies to minimize risks from pesticides, as needed,
- Updating and maintaining DPR's online Pesticide Regulation Endangered Species Custom Real-time Internet Bulletin Engine (PRESCRIBE) database application, and
- Providing public outreach and applicator training on endangered species and their habitats.

DPR coordinates its endangered species protection strategies with the U.S. Fish & Wildlife Service, the National Marine Fisheries Service, the California Department of Fish and Wildlife (CDFW), the California Department of Food and Agriculture (CDFA), and the County Agricultural Commissioners (CACs).

In California, the habitats of birds, mammals, reptiles, amphibians, fish, invertebrates, and many plants are interspersed with agricultural areas. Of the federally listed species in California, the San Joaquin kit fox has the greatest overlap with agricultural areas, mostly in the San Joaquin Valley.

Phosphine gas is highly toxic to all wildlife. There are over 1,000 endangered, threatened, or other protected species in California.

Aluminum and magnesium phosphide product labels have a statement requiring an applicator to consult the U.S. EPA's *endangered species bulletins* for the area where the treatment will occur (Figure 3-4). These bulletins specify geographically specific pesticide use limitations that are intended to protect threatened and endangered species and their critical habitats. These bulletins are available using U.S. EPA's Bulletins Live! Two Application.


CALIFORNIA (all endangered species)

Fresno, Inyo, Kern, Kings, Madera, Merced, Monterey, San Benito, San Luis Obispo, Santa Barbara, Stanislaus and Tulare

See the U.S. EPA Interim Measures Bulletin for your county. To obtain a copy of the bulletin, contact your county agricultural commissioner or visit the following website: http://www.cdpr.ca.gov/docs/es/index.htm. If there is no current bulletin available for your county, contact the U.S. Fish and Wildlife Service office in Portland, OR to determine whether there are endangered species that might be adversely affected by your proposed use of and the steps you should take to mitigate any such risks.

Figure 3-4. An example of a label statement requiring users in certain areas to obtain product bulletins.

Bulletin information can also be obtained through DPR's online PRESCRIBE database, available at the link shown in Figure 3-4. This database provides information to users consistent with the U.S. EPA's Interim Measures Bulletins for Protection of Endangered Species for user selected sites and pesticides.

The database helps pesticide users determine if there are any endangered species or species' habitats in the vicinity of their pesticide use site and lists the use limitations that apply to the pesticide product(s) they intend to use (Figure 3-5, pg. 17).

Observe Use Limits for Selected Products:

Code	Use Limitations
5	Trained Applicator: Use shall be supervised by a person (wildlife biologist, county agricultural commissioner, university extension advisor, state or federal official or others) who is trained to distinguish dens and burrows of target species from those of non-target species. Use shall occur only in the active burrows of target species. The person responsible for supervision shall be aware of the conditions at the site of application and be available to direct and control the manner in which applications are made (per Section 6406 of Title 3, California Code of Regulations). Contact your county agricultural commissioner for information on training.

Figure 3-5. An example of a PRESCRIBE use limitation on the use of aluminum phosphide on vertebrate burrows.

Pre-fumigation Inspection

Both target and non-target animals inhabit burrows and at times, may even occupy the same burrow. A pre-fumigation inspection of the site is an important step in the fumigation process and is usually required as part of the Fumigation Management Plan. Information that you gather during an inspection can determine the success of the fumigation. A site inspection helps you determine how to conduct the fumigation and allows you to assess any safety concerns and plans to address them. The product label is your best guide to follow in determining what you may need to consider during the pre-fumigation inspection. Items to consider include:

- What vertebrate pests are present?
- What non-target species are present or nearby?
- Is the treatment area a potential habitat for endangered or threatened species?
- Is supervision by a person trained to distinguish dens of target and non-target species required?
- Where are the pests located?
- Is it the appropriate time of year to conduct a burrowing vertebrate fumigation (e.g., adequate soil moisture)?
- Are there weather conditions or other environmental factors which might impact the timing of the application? Generally, do not conduct burrowing vertebrate fumigations when it is too windy, too cold, or too dry.
- Is the soil type such that you will obtain a good seal (e.g., clay or loamy soil vs. sandy and rocky)?
- What equipment do you need for the fumigation?
- Are there factors outside of the target area that you need to consider? (i.e., Are there occupied structures nearby? Could there be other employees or bystanders who may be near the fumigation site?)

The label may require you to identify target and non-target dens and burrows. This is often accomplished by conducting a survey to monitor the site and to determine if any non-target animals could be harmed by the treatment. The extent of these surveys can vary. For example, sometimes a visual inspection of the treatment area conducted in the morning and afternoon 24 hours prior to fumigation is sufficient to see the many rodent and wildlife pest species that are active during daylight hours. In other situations, the inspection may involve intensive multi-day surveys. A good visual inspection involves systematically and thoroughly viewing the area to identify all burrow openings, including the main entrance and all emergency exit holes. The inspection should also identify burrows/areas that should be avoided, such as those occupied by non-target animals including threatened or endangered species.

Gas Detection Devices

There is a wide variety of gas detecting devices used to collect air samples for monitoring fumigants. Examples include *ambient air analyzers* and *detector (colorimetric) tubes*. Choose devices that can appropriately measure the levels of the fumigant you are using. Different equipment is needed for monitoring fumigant concentrations for efficacy (high concentration) monitoring vs. for safety (low concentration) monitoring. Detection devices must be used and maintained according to the manufacturer's instructions and recommendations. Many types of *detectors* require regular and periodic calibration to ensure an accurate measurement. Prior to purchasing any equipment, read the pesticide labels to determine the type of monitoring equipment needed and if a specific sensitivity is required of the equipment.

Sensory Irritation

People may experience sensory irritation if they are exposed to a certain concentration of a fumigant. Sensory irritation to fumigants can include a burning sensation or irritation of the eyes, nose, or other mucous membranes.

Pure phosphine gas is odorless. Slight or mild symptoms of exposure to phosphine include severe lung irritation, chest tightness or burning chest pain, and coughing.

You already know that some handlers notice a garlic odor associated with phosphine. However, keep in mind that this odor **is not** an adequate indicator of phosphine's presence and does not provide reliable warning of hazardous concentrations. Always use the gas monitoring device indicated on the label to accurately measure fumigant concentrations.

If at any time a fumigant handler (or other worker) experiences sensory irritation, the label specifies the action the *certified applicator-in-charge* must take. Actions may include:

- Using an Air-Purifying Respirator (APR) to complete the task (if not already wearing one),
- Changing to a full-face APR if experiencing sensory irritation while using a half-face APR, or
- Stopping work and leaving the application area.

APRs are discussed in Chapter 4.

Trigger Levels

Sometimes required actions for workers are based on *trigger levels*. Fumigant labels may specify trigger levels that require applicators to either use a respirator or leave the work area. A trigger level is a specific air concentration of fumigant that prompts or "triggers" a required action (Figure 3-6).

When Respiratory Protection Must Be Worn
Respiratory protection approved by the National Institute for Occupational Safety and Health/Mine Safety and Health Administration (NIOSH/MSHA) must be worn during exposure to concentrations in excess of permitted limits or when concentrations are unknown. Self-contained breathing apparatus (SCBA) must be worn during entry into sites that are under fumigation if the concentration of phosphine is unknown or known to exceed the Short-Term Exposure Level (STEL) for phosphine (I ppm for 15 minutes).

Figure 3-6. An example of trigger level you might find on an aluminum phosphide fumigant label.

Monitoring Requirements

In this section, we will discuss *air monitoring* intended to protect fumigant handlers and bystanders, including when and where air monitoring is required. Refer to Chapter 4 on the use of a respirator when applying aluminum or magnesium phosphide.

When to Monitor

The certified applicator-in-charge must read the label and applicator's manual and develop an air monitoring program when required by the label. For aluminum and magnesium phosphide products, air monitoring is generally conducted to determine fumigant exposure to applicators and the need for respirators.

Where to Monitor

Many labels indicate that air samples need to be taken in the "breathing zone" of applicators or handlers. The label also dictates where you need to sample the air. Many will note that samples need to be taken "in the breathing zone" of applicators or handlers. The metal phosphide labels do not define the term "breathing zone." The label for another fumigant says, "Breathing zones are defined as areas where individuals typically stand, sit, or

lie down while performing work functions."

When Workers Must Leave the Application Area

All applicators and workers should stop work and leave the application area under any of these conditions:

- The certified applicator-in-charge makes the decision to not have handlers wear an APR after experiencing sensory irritation,
- A fumigant handler experiences sensory irritation while wearing a respirator, or
- An air monitoring sample shows fumigant concentrations are above the limit for the respirators being worn (e.g., above 15 ppm of phosphine gas for canister respirators).

Transportation, Storage, and Spill Cleanup

This section covers requirements for fumigant transportation, storage, spill cleanup, and emergency response, including the management and safe disposal of containers.

Additional information on transporting pesticides (including your responsibilities and who to contact for more information), pesticide storage requirements, and spill cleanup can be found in the Pesticide Safety: A Study Manual for Private Applicators, Third Edition, Chapters 8 and 12.

Transporting Fumigants

Chemicals that pose an unreasonable risk to health, safety, and property if spilled during transport are listed by the U.S. Department of Transportation (DOT) as "*hazardous materials*." Aluminum and magnesium phosphide are classified as hazardous materials. As a result, they are subject to extensive transport regulations. Refer to both federal and state DOT regulations to determine any training, information, safety kit, and placarding requirements for transporting the fumigant. Also refer to the label for specific instructions on transporting the product. Be aware of all California laws and regulations related to the transportation of aluminum and magnesium phosphide.

Storage of Fumigants

Always follow the label instructions on where and how to store pesticides. The labels of aluminum and magnesium phosphide products require storage in a dry, well-ventilated area away from heat. The labels of some products indicate that they must not be stored in areas where temperatures can exceed 130°F because of fire risks. The storage area must be locked to keep out unauthorized people (especially children) and animals. The labels also require you to not store the products in buildings where humans or domestic animals may reside.

In addition to label requirements, you also need to comply with all State, county, or local regulations related to the storage of fumigants.

Before entering any pesticide storage area, run an exhaust fan first to remove *vapors* that may have built up inside. As with any pesticide, always store fumigants in areas separate from food and feed. For safety, store aluminum and magnesium phosphide products sealed in their original containers.

Pesticide Storage Posting

The fumigant label and California's regulations require you to post the pesticide storage area. California regulations require pesticide storage posting signs to be readable at 25 feet. The sign must state:

DANGER
PESTICIDE STORAGE AREA
ALL UNAUTHORIZED PERSONS KEEP OUT
KEEP DOOR LOCKED WHEN NOT IN USE

The notice must be repeated in an appropriate language other than English when it is reasonable to anticipate that persons who do not understand the English language will be near or in the storage area.

The aluminum and magnesium phosphide labels also require posting placards that use the National Fire Protection Association (NFPA) classification system (Figure 3-7). NFPA placards provide information specific to a chemical including its health hazards (blue diamond), flammability (red diamond), chemical stability (yellow diamond), and special precautions or hazards that employees may be exposed to (white diamond). These placards are important because they also act as an immediate warning system for emergency service personnel to help them identify the kinds of material present and the dangers they pose.

Figure 3-7. An example of an NFPA placard.

Spills and Leaks

The fumigant labeling will provide you with both general and detailed instructions on how to respond to pesticide spills, leaks, and fires. The label will tell you:

- When you need to wear a respirator,
- Whether the material can be salvaged, and
- What actions to take to minimize the risks to others.

If a spill, leak, or other sudden release occurs, evacuate the immediate work or storage area. Always put on appropriate PPE before attempting to move the leaking or damaged container outdoors or to an isolated area. Be familiar with and follow label instructions for handling leaks. Follow label requirements, such as using monitoring equipment to determine the concentration of the fumigant in the ambient air. Until the safe concentration threshold on the label is met, anyone entering the area must wear an approved respirator.

The aluminum and magnesium phosphide labels advise to not use water at any time to clean up a spill. Water that comes into contact with any unreacted metal phosphide will greatly accelerate the production of phosphine gas which could result in workers and bystanders being exposed to unsafe concentrations of the fumigant and/or fire hazards.

Move any leaking or damaged aluminum or magnesium phosphide containers outdoors or to an isolated location and work upwind if possible. As discussed in Chapter 1, get immediate medical attention for anyone who has been exposed to the fumigant, even if exposure symptoms are not readily apparent.

If aluminum flasks have been punctured or damaged causing them to leak, the product label may suggest the temporary repair of the container with aluminum tape or transfer of the product from the damaged flask to a sound metal container which should be sealed and properly labeled as aluminum phosphide. The label will also provide guidance on the cleanup of recent spills (e.g., spills that have occurred within a few minutes) as well as old spills and instances when the occurrence of the spill is unknown.

Major Spills

The cleanup of a major spill may be difficult for an individual to do by themselves, or if an applicator is unsure what protocols to follow. Always follow state and/or local procedures. Contact the local agencies (fire department and police department) and the local CAC office for further assistance and information. Refer to the product label, applicator manual, and Safety Data Sheet (SDS) of the product that has been spilled for guidance on spill and cleanup procedures. You can also call the *Chemical Transportation Emergency Center (CHEMTREC)* at (800) 424-9300.

Emergency Response Plans

California regulations require employers to have an Accident Response Plan at the fumigation worksite to provide instructions to protect employees during situations such as spills, fire, and leaks. At least two essential pieces of information should be included in the Accident Response Plan. The first should be information regarding the security of the area where the problem occurred, such as securing the area to prevent potential exposure

until help arrives. The second is information on whom to contact in the event of a problem. Contacts may include the operator of the property, fire department, heath department, or hazardous materials response team.

The aluminum and magnesium phosphide labels, as a part of the Fumigant Management Plan (FMP), will direct you to prepare a written Emergency Response Plan. The Emergency Response Plan contains explicit instructions on procedures to follow in case of an emergency as well as the names and telephone numbers of local authorities who need to be notified if phosphine levels in an area reach concentrations that could be dangerous to bystanders and/or domestic animals. FMPs will be covered in more detail later in this chapter.

Safe Disposal of Leftover Fumigant

All registered pesticide labels state "Improper disposal of excess pesticide is a violation of Federal Law." You need to properly dispose of highly toxic compounds (including pesticides), so they do not cause harm to people or the environment.

Leftover aluminum or magnesium phosphide products require different handling procedures for disposal in comparison to other pesticides.

Be aware of confinement of partially spent residual dust (as in a closed container), or the collection and storage of large quantities of dust. Never store spent residual phosphide dust in a confined space or closed container. Unreacted aluminum or magnesium phosphide may release small amounts of phosphine gas and confinement of the gas may result in a fire hazard. The label will spell out specific procedures for the proper deactivation of leftover product.

Management of Empty Containers

As with other pesticides, the label is your best source of information on the proper disposal of empty containers of aluminum and magnesium phosphide products.

The flasks and pails that contained aluminum or magnesium phosphide are nonrefillable containers. Do not reuse the containers for any purpose. Follow label instructions for triple rinsing or remove lids and expose to air until the residue in the flasks or pails is reacted. Afterwards, the containers may then be recycled, reconditioned, or punctured and disposed of in a sanitary landfill. Remember that you cannot recycle pesticide containers of any material (e.g., aluminum, paper, or plastic), even if they are triple rinsed, with household recycling.

Fumigation Management Plans (FMPs) and Recordkeeping

The success of the fumigation is not only dependent on your ability to do your job, but also upon carefully following all rules, regulations, procedures required by the product label, California regulations, and permit conditions required by your local CAC. A *Fumigation Management Plan (FMP)* is an organized, written description of the site and required steps involved for an application to help the certified applicator-in-charge ensure a safe, legal, and effective fumigation. FMP's are meant to protect the fumigator(s), on-site staff, the public, and the environment by assisting the certified applicator-in-charge in planning out the fumigation and complying with pesticide product label requirements.

The certified applicator-in-charge of the fumigation must complete an FMP before the fumigation takes place. When developing an FMP, refer to the applicator's manual for the specific requirements for the fumigant you are using. The certified applicator-in-charge is responsible for coordinating with the owners and/or the responsible employees of the site to be fumigated to develop an FMP and to ensure that the FMP is accurate, completed, readily available for review, and followed.

Below are some important components to consider when developing an FMP. As always, read and follow the pesticide label and the entire applicator's manual of the fumigant you are using for specific instructions before preparing the FMP.

- The Planning and Preparation section of the FMP requires you to document site and application information, including:
    - Inspect the area to determine its suitability for fumigation,

- Ensure the use site is listed on the label,
- Determine and describe the purpose and type of fumigation,
- Contact information and credentials for the certified applicator-in-charge,
- Contact information for the operator of the property being fumigated, and
- Determine the dosage, temperature, humidity, wind speed, and exposure time.

- The Personnel section includes:
  - Written confirmation that all personnel in and around the area have been notified **prior to application**,
  - Making sure all fumigation personnel have read the applicator's manual and are aware of potential hazards and emergency plan, and
  - Establishment of a meeting area for all personnel in case of an emergency.
- The Notification section includes:
  - Confirmation that the appropriate local authorities (e.g., CAC, fire, or police departments) have been notified prior to the release of the fumigant, and
  - A written Emergency Response Plan that contains procedures to follow in case of an emergency and the names and telephone numbers of authorities and other people to contact if levels of the fumigant in an area exceed safe levels and can be dangerous to bystanders and/or domestic animals.
- The Monitoring section of the FMP requires you to document safety monitoring. This includes:
  - Keeping a log or manual of monitoring records for each fumigation site. This log must, at a minimum, contain the timing, number of readings taken, and level of concentrations found in each location.
  - When monitoring, document even if there is no phosphine gas present above the safe levels. ln such cases, subsequent monitoring is not routinely required. However, spot checks must be made occasionally, especially if conditions change significantly.
- The Application procedures section includes use restrictions, dosage rates, fumigation period, PPE, specific procedure for closed vs. open burrow systems, environmental hazards, and endangered species restrictions.
- The *sealing* procedures section would include how the different open or closed burrow systems are sealed and posting information.
- Finally, the post-application operations section includes requirements to inspect treated areas within 1 to 2 days following treatment, recordkeeping requirements, and *warning sign* removal.

FMPs can be complex. To assist you, many fumigant manufacturers provide templates for the FMP. If you need more information or assistance for the FMP, you can contact the manufacturer, the dealer you purchased the fumigant from, or your local CAC's office.

The certified applicator-in-charge is responsible for verifying the accuracy of the FMP. The FMP should be present at the use site for review by applicators, first responders, and CAC staff. The FMP and related documentation, including monitoring records, must be maintained for a minimum of 2 years.

Fumigation Posting Requirements

Only trained and authorized pesticide handlers wearing the appropriate PPE are allowed into the site during application. The certified applicator-in-charge is responsible for ensuring that unauthorized persons are not allowed in or near the fumigation site.

For burrowing vertebrate control fumigations with aluminum phosphide, the label requires fields to be posted with signs which must contain:

- The signal words "DANGER/PELIGRO" and the skull-and-crossbones symbol,
- The words "DO NOT ENTER/NO ENTRE,"
- The product name and EPA registration number of the fumigant,

- A 24-hour emergency response number, and
- The contact number of the certified applicator responsible for the application.

The signs should be no smaller than 9" by 11" and must stand at least 18" above the ground. Signs must be made of substantial material that can be expected to withstand adverse weather conditions and all information on the sign must be legible.

California regulations require the words "DANGER/PELIGRO" and "KEEP OUT/NO ENTRE" to be readable at 25 feet. The signs must be visible at all points of entry to the treated area, including each road, footpath, walkway, or aisle that enters the treated field, and each border with any worker housing within 100 feet of the treated field. If there are no usual points of entry, then the signs must be posted at each corner of the treated area. If the treated area is adjacent to an unfenced public right-of-way, the signs must be posted at each end of the treated area and at intervals of no more than 600 feet along the border of the treated area and the right-of-way. The signs must be posted before the application begins but shall not be posted unless the application is scheduled to begin within 24 hours. Signs should remain posted for a minimum of 2 days after the final treatment and can only be removed by the certified applicator-in-charge (or their employer, if the certified private applicator is an employee).

Fumigant Application Conditions, Methods, and Timing

Fumigants are one of the most acutely toxic pesticides and must be handled with caution. Fumigating under the right weather conditions, with adequate soil moisture, and using the correct methods and timing will help ensure a safe and effective application.

Soil Conditions and How Fumigants Disperse in the Application Zone

As discussed earlier, aluminum or magnesium phosphide placed in a burrow will react with moisture in the soil to produce phosphine gas, which is about 20% heavier than air. To obtain effective control, the phosphine gas must spread through the burrow tunnels to any side tunnels, food storage areas, and nests within the system. The application may be less effective in sandy and rocky soils, given that sandy soils have high porosity and rocky soils likely have frequent cracks in the soil.

Soil moisture is also important. Always ensure that the soil is moist enough before application. In addition to assisting in the production of phosphine gas, moist soils will help keep the fumigant in the tunnels. Dry soils will not contain the fumigant since the cracks and spaces in the dry soil will allow the fumigant to escape. This results in a less effective fumigation and a more dangerous situation for the applicator and bystanders if the fumigant moves into the air. It is best to fumigate when soil moisture is high, such as in springtime, to ensure activation of the aluminum or magnesium phosphide and a good soil *seal*.

You can use a simple soil ball test to assess soil moisture: dig in the soil to a depth that is level with the burrow system, grab a sample of dirt, and ball it up. If the soil sample does not hold together, then the soil is too dry, indicating that the soil will not be able to effectively contain the fumigant. Always follow label directions for locating and blocking or plugging all burrow entrances to minimize, to the extent possible, the amount of fumigant that escapes the burrow.

Application Timing

Temperature, wind, and soil moisture may affect the timing of the application. In addition to fumigating when soil moisture is high, such as in the springtime, the habits of the target pests may also influence the efficacy of a fumigation during certain times of the year. For example, planning a fumigation to control California ground squirrels during their period of winter *hibernation* or summer *estivation* (dormancy induced by the heat and dryness of summer) is not advised. During these periods of dormancy, ground squirrels plug the burrow tunnel near their nest with soil. This blockage cannot be seen from the surface and protects the squirrel from the lethal effect of the toxic gas. Fumigation to control both California and Belding's ground squirrels is highly effective in the early months of the year when they are very active, though this time may be shorter with Belding's ground squirrels compared to the California ground squirrel.

Application Rate

Always follow label instructions to ensure that you are using the correct dosage. One aluminum phosphide product label lists the dosage rate as 2 to 4 tablets or 10 to 20 pellets per burrow opening. Since pellets are 20% smaller than tablets and release 20% less gas, more pellets are needed to obtain the same amount of phosphine gas in the burrow. The label may also indicate that you use lower rates for smaller burrows and/or when soil moisture is high and use higher rates for larger burrow systems and when soil moisture is relatively low. You may also need to consider temperature, humidity, and wind speed and direction when determining the appropriate dosage rate.

Applying more than the dosage rate indicated on the label increases the risk of human exposure due to excess phosphine gas release. Using dosages more than permitted by the label is not only unsafe, but also against the law. In contrast, applying less than 2 tablets or less than 10 pellets of this product is wasteful and can result in the ineffective control of the pest and/or the development of pest resistance. Always follow the dosage indicated on the label, correctly measure the fumigant, and accurately report the amount of product used.

Application Methods & Equipment

For burrowing vertebrate pest fumigations with aluminum or magnesium phosphide, the application method and equipment will vary based on the characteristics of a species' burrowing system (i.e., open burrow system or a closed burrow system). Always make sure to review the label and use the proper application methods based on the burrow system.

Open Burrow Systems

For species with open burrow systems (such as ground squirrels and voles in some situations), place the prescribed number of aluminum phosphide tablets or pellets as far back into the burrow opening as possible then pack crumpled paper (e.g., newspaper) into the burrow entrance. Using crumpled paper prevents the soil from covering the tablets or pellets, permitting them to react more readily with the moist soil to produce phosphine gas. Rocks, clods of soil, cardboard, etc. may also be used for this purpose. Shovel soil to cover the paper to seal the burrow entrance tightly. Be sure to seal all untreated entrances by shoveling and packing soil and/or sod to completely seal the opening.

The label indicates you inspect treated areas one to two days following treatment for signs of activity of the *target pest* species. Reapply to all reopened burrows.

Closed Burrow Systems

If the species has a closed burrow system (such as pocket gophers and moles in some situations), locate the main underground runway by probing with a smooth-sided rod 12 to 18 inches from a fresh mound. Once you have identified the main runway, add the required number of pellets or tablets through the probe hole. Do not treat the burrow if the soil is extremely dry or if there are no signs of recent gopher or mole activity.

Close the probe hole and create a tight seal by using a clod of soil or a sod plug to cover the hole, or by using the heel of your shoe to push sod and/or soil over the surface opening. If the probe hole is more than one inch in diameter, place crumpled paper in the hole before closing it with soil or sod.

Inspect the treated area two days after treatment for continuing pest activity by poking holes in the main runways of the burrow systems and flag the holes you create. Two additional days later, go back to the flags to check the holes you created. If the target pest closes the hole, that indicates they are still active in that burrow. You should retreat all reclosed burrow systems on both sides of the plug.

Equipment Compatibility

As noted in Chapter 1, phosphine gas reacts with copper and certain metallic salts. Because of how aluminum and magnesium phosphide are normally applied for burrowing vertebrate pest fumigations, equipment compatibility is typically not an issue in most situations. Because handlers directly handle aluminum phosphide tablets or pellets, or magnesium phosphide plates, proper safety procedures and use of correct PPE is a must.

Chapter 3 Review Questions

Correct answers are given on page 51.

1. One of the tools to find endangered species use limitations for burrowing vertebrate fumigant products is _____.
    a. a California Fish and Wildlife brochure
    b. the label
    c. PRESCRIBE

2. Chemicals that pose an unreasonable risk to health, safety, and property if spilled during transport are listed as _____.
    a. hazardous materials
    b. restricted pesticides
    c. toxic materials

3. Aluminum and magnesium phosphide products should be stored in a _____.
    a. warm, damp, enclosed area
    b. dry, well-ventilated area away from heat
    c. humid, well-ventilated area away from cold

4. The document requiring employers to provide instructions to protect employees during situations such as spills, fire, and leaks is known as a/an _____.
    a. Accident Response Plan
    b. Hazard Mitigation Plan
    c. Spill Response Plan

5. When must the certified applicator-in-charge complete the Fumigation Management Plan (FMP)?
    a. before the fumigation takes place
    b. after the fumigation takes place
    c. during the fumigation

Chapter 4: Personal Protective Equipment (PPE)

General PPE Requirements

In this chapter, we will discuss some basic information on PPE used in burrowing vertebrate pest fumigations. We will also discuss respirators in more detail in this chapter. Always follow the specific label instructions regarding PPE for the product you are using. California regulations require the employer to provide the employee with the required PPE. The employer must also inspect and clean PPE daily, and repair and replace PPE when needed. The employer must also make certain that PPE is stored in a pesticide free place. Employees must properly wear the equipment provided. Never take PPE into your home.

Always wear the proper PPE to protect yourself from exposure to the fumigant. Typical PPE that is required for fumigation with aluminum or magnesium phosphide are dry gloves of cotton or other material (i.e., leather) if contact with the fumigant is likely, and National Institute for Occupational Safety and Health (NIOSH) approved respiratory protection, when fumigant concentrations exceed permitted levels or are unknown.

Chapter 7 of the Pesticide Safety: A Study Manual for Private Applicators, Third Edition, covered the care, cleaning, and storage of PPE (including respirators). The same general principles apply to PPE used in phosphine fumigation with some specific exceptions.

As covered in the Pesticide Safety: A Study Manual for Private Applicators, Third Edition Chapter 7, *chemical-resistant* gloves are usually required when handling most pesticides. However, aluminum and magnesium phosphide product labels specifically require handlers to wear dry gloves of cotton or other material to prevent skin contact. This is because aluminum and magnesium phosphide can be activated by skin moisture and phosphine gas can get trapped under waterproof or chemical-resistant gloves. The trapped phosphine gas can cause severe skin irritation and burns or can be *absorbed* through the skin. Cotton gloves allow airflow so that fumigant gases won't be trapped against, and burn, the skin. Always make sure to keep your gloves dry during use to prevent the moisture from converting aluminum or magnesium phosphide you are handling to phosphine gas.

The labels of aluminum or magnesium phosphide products require you to aerate used gloves and other clothing that may be contaminated in a well-ventilated area prior to laundering. Avoid inhaling steam from the washer or dryer when cleaning your PPE.

California regulations specify that leather gloves used to apply aluminum or magnesium phosphide are considered cleaned when they have been aerated for 12 or more hours.

PPE Exceptions for Aluminum and Magnesium Phosphide

We will cover two exceptions to California regulations on PPE requirements for employees handling aluminum and magnesium phosphide.

Eye Protection

California regulations require that employers make certain that their employees wear protective eyewear in many situations when handling pesticides, even if the pesticide label does not. However, California's regulations also exempt employers from this eye protection requirement when employees apply solid fumigants, such as aluminum or magnesium phosphide, to vertebrate pest burrows.

Coveralls

For pesticides other than fumigants, California regulations require employers to make certain that their employees wear coveralls if the pesticide has the signal word "DANGER" or "WARNING," even if the pesticide label does not. However, with fumigants, such as aluminum and magnesium phosphide, employers are exempt from this coverall requirement, despite the products having a "DANGER" or "WARNING" signal word.

Respiratory Protection Requirements

It is important to know when you are required to use a *respirator* when applying aluminum or magnesium phosphide fumigant product to a burrow. The product labels require:

- If the concentration of phosphine gas is **unknown** or is greater than 15 parts per million (ppm), handlers must wear a NIOSH-approved self-contained breathing apparatus (SCBA).
- If the concentration of phosphine gas is **known** to be between 0.3 and 15 ppm, handlers must wear a NIOSH-approved full face *canister respirator* – phosphine canister combination.
- If the concentration of phosphine gas is **known** to be less than 0.3 ppm, no respiratory protection is required.

The applicator is required to use the respiratory protection specified on the label. The label and the results of monitoring fumigant concentrations using gas detection devices will help you to determine what type of respirator to wear, if any. Safety monitoring with gas detection devices was covered in Chapter 3.

Respirator Types

Respirators come in different shapes and sizes. Broadly, respirators can be divided into two main types: atmosphere-purifying (or filtering) respirators, and atmosphere-supplying respirators. We will briefly cover these two respirator types in this study manual. For a more detailed discussion on respiratory protection and examples of these respirators, refer to Chapter 7 of the Pesticide Safety: A Study Manual for Private Applicators, Third Edition.

Air-purifying Respirators

These respirators filter out contaminants in the air. Air-purifying respirators have an air purifying element (e.g., a cartridge) that filters specific contaminants from the air passing through the element. There are three main types of air-purifying respirators.

- *Particulate* respirators are the simplest, cheapest, but least protective of these respirators (Figure 4-1). These respirators only filter out particles (dust, mists, and fumes). They do not protect against gases like phosphine.
- Chemical cartridge or canister respirators include a facepiece or mask and a piece that filters out specific gases and vapors in the air through chemical filters called cartridges or *canisters*. These filters are protective provided their absorbing capacity has not been used up. The facepiece is secured to your head with straps. The facepiece can be a half-face, which only covers your mouth and nose; or a full-face, which also covers your eyes.
- Powered air-purifying respirators (PAPRs) use a battery-operated fan to force filtered air through a hose to the user's hood or mask. They are easier to breathe through, but they require a fully charged battery to work properly. They use the same type of filters/cartridges as other air-purifying respirators.

For quick and easy recognition of the different cartridge types, each type is color coded to indicate their limitations and approved uses (Table 4-1, pg. 29). Cartridges have an expiration date. You should not use a cartridge past its expiration date regardless of whether or not it was ever unsealed. You should crush expired cartridges before discarding them so no one can reuse them.

NOTE: Approved respirators are manufacturer and model specific. Parts, cartridges, or filters cannot be interchanged between different manufacturers. Using any part of a respirator that was not part of the approved assembly means the respirator is no longer "NIOSH-approved."

Figure 4-1. Particulate respirators. Never use dust/mist respirators, including "N-95s", for any fumigant work. (Photo © UW-Madison Pesticide Applicator Training Program).

Cartridge and Canister Replacement

Because the air-purifying elements (cartridges and canisters) have a finite capacity to remove contaminants from the air, they

need to be replaced periodically to keep you protected. The most important factors affecting how long cartridges or canisters will last are: the specific fumigant, its concentration in the air, and how long the cartridge or canister is exposed to the fumigant. California regulations requires employers to ensure the air purifying elements, or the entire respirator (if disposable), are replaced according to the following criteria:

1. At the first indication of fumigant odor, taste, or irritation,
2. When any End of Service Life Indicator (ESLI) indicates the cartridge has reached its end of service life,
3. According to pesticide specific label directions,
4. According to pesticide specific directions from the respirator manufacturer, or
5. In the absence of any of the above pesticide-specific instructions or indications, cartridges must be replaced at the end of each day's work period.

NOTE: Most respirator manufacturers will instruct users to change air-purifying elements at the "first indication of odor, taste, or irritation." This generic manufacturer statement should not be viewed as a direction regarding service life.

In most cases, pesticide specific cartridge replacement information is not available. However, for a limited number of chemicals that have use in other industries (e.g., phosphine gas), this information may be available from the respirator manufacturer.

Table 4-1. Respirator cartridge color chart.

Color Coding for NIOSH Approved Respirator Cartridges and Canisters ***ALWAYS Consult the Pesticide Label for Respirator and Cartridge Selection***	
Used for:	**Assigned Color**
Organic Vapors	**BLACK**
Ammonia	**BRIGHT GREEN**
Acid Gases	**WHITE**
Organic Vapors (OV) and Acid Gases	**YELLOW**
Organic Vapors (OV), Ammonia, Acid Gases	**OLIVE/BROWN**
High Efficiency (HE) Filter, P100 Filters	**MAGENTA**
Organic Vapors **AND** High Efficiency (HE) Filter, P100 Filters	**BLACK** **MAGENTA**
Organic Vapors (OV), Acid Gases **AND** High Efficiency (HE) Filter, P100 Filters	**YELLOW** **MAGENTA**
Organic Vapors (OV), Ammonia Acid Gases **AND** High Efficiency (HE) Filter, P100 Filters	**OLIVE/BROWN** **MAGENTA**

Atmosphere-supplying Respirators

Atmosphere-supplying respirators provide clean air from an independent source unlike cartridge respirators that purify surrounding air. There are two types of atmosphere-supplying respirators. Both have a full-face mask (or hood) that delivers clean air to the wearer. The main difference between these two types is in how the air gets to the wearer.

- *Self-contained breathing apparatus (SCBA)*: SCBAs have a compressed air tank that you carry on your back. Because you carry your air, you have the mobility of a canister mask and more unrestricted movement than with a supplied-air respirator. However, the weight and bulk of a SCBA often makes work strenuous and difficult. Do not confuse this with SCUBA (self-contained underwater breathing apparatus). These systems are very different. You cannot interchange their uses.
- *Supplied-air respirator (SAR)*: SARs do not require filters or cartridges to remove the gas because they provide an outside source of clean air from a stationary source through a long hose, such as a pump or large

stationary air tank (Figure 4-2). However, the length of available hose restricts the range of the wearer's mobility. The maximum hose length is usually 300 feet. The air is supplied to a facepiece, helmet, hood, or a complete suit depending on the level of protection needed. However, there are drawbacks to SARs as well. The long hose can get kinks, be cut, or get damaged in a way that cuts off your air supply. The long hose can also restrict movement. If the hose attaches to an air pump, you must locate the pump in an area where safe, fresh air is available.

Respiratory Protection Program

When the pesticide label, restricted material permit conditions, regulations, or workplace policy requires an employee to use respiratory protection, employers are required to do the following to protect the health and well-being of employees:

- Designate a "Respirator Program Administrator"
- Prepare a written respiratory protection program with worksite specific procedures for:
  - Selecting respirators,
  - Medical evaluations of individuals using respirators,
  - Fit testing procedures for tight fitting respirators,
  - Procedures for proper use in routine and emergency situations,
  - Cleaning, storing, inspecting, repairing, maintaining, and replacing respirators,
  - Procedures for air-supplying respirators (if applicable),
  - Training employees on the proper use of respirators, and
  - Procedures for effectiveness evaluation.

After a written program is in place, the employer must:

- Work with a physician or other licensed healthcare professional to determine medical fitness of employees to wear a respirator, or any conditions that the employee must follow to wear a respirator,
- Train employee(s) on the use of the respirator, and retrain employees annually thereafter,
- Fit test employee(s) on the respirators they will be wearing prior to use, and annually thereafter,
- Maintain records of the program for three years,
- Document annual consultations with the employee(s) on the effectiveness of the program, and
- Annually review the program, making adjustments as necessary.

NOTE: The requirements of a Respiratory Protection Program are very detailed, and this study manual only provides a brief overview. Refer to 3 CCR section 6739 or your local CAC for more information.

Medical Evaluation

California regulations require a medical evaluation of any employee who may have to wear a tight fitting respirator (such as a half-or full-face respirator, or a SCBA) while handling pesticides. Some product labels may require a medical evaluation of **all handlers**. The evaluation must be performed by a licensed medical professional to ensure that the employee is healthy and physically able to use the respirator.

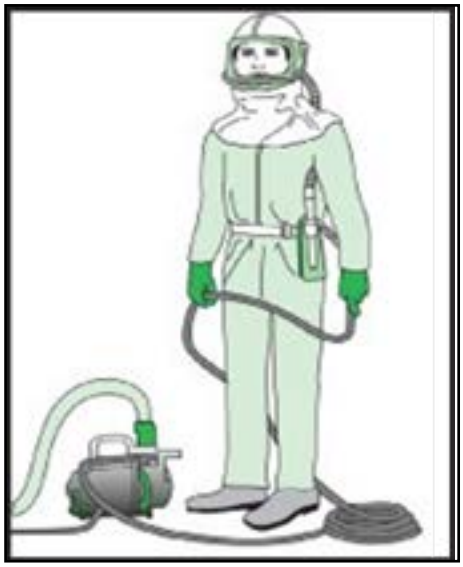


Figure 4-2. Supplied Air Respirators (SAR). This type of atmosphere-supplying respirator weighs less than a SCBA and provides longer use. (Illustration © National Pesticide Applicator Certification Core Manual, NASDA)

After a preliminary screening with a questionnaire, or an equivalent medical examination, a medical practitioner may determine that a more in-depth examination is required. For example, a fumigant handler who, at screening, is suspected by the medical professional of having a heart condition may be required to undergo a complete physical examination before they are fit tested for a respirator. Handlers who need to wear respirators must be reexamined by a healthcare professional if their health status, respirator type, or use conditions change.

Respirator Fit Testing

After being cleared by a qualified medical practitioner to wear a respirator, California regulations requires employers to *fit test* employees with the specific tight fitting respirator that you will use. California regulations require employees be fit tested before the employee is allowed to use a respirator for the first time and then re-tested at least annually to ensure the respirator continues to protect the employee. Aside from confirming fit, a fit test will verify that the respirator is both comfortable and will adequately protect the user. Follow-up fit testing is required when:

- The style of the facepiece has changed,
- The respirator size, model, or brand has changed,
- There is a physical change in the person's face (e.g., weight change or dental work) that would affect fit,
- The respirator's fit is unacceptable,
- The user requests a fit test, or
- Employer policy requires it.

There are two types of fit tests for respiratory protection equipment: "qualitative" or "quantitative." The qualitative test relies on an individual's senses to detect and/or react to a test agent, such as involuntary coughing to an irritant smoke or smelling a distinctive and pungent oil. The quantitative test assesses the effectiveness of the respirator by using an instrument to measure the amount of leakage into the respirator and does not require an individual's reaction to a test agent. For more information on fit testing requirements, refer to 3 CCR section 6739.

Be aware that facial hair will prevent a tight fit between the respirator mask and face. Facial hair should be removed from areas of the face where there should be a seal between the skin and the mask. You should shave these areas prior to fit testing and whenever you use respiratory protection equipment.

Respirator Training, Inspection, and Cleaning

Training

In addition to required pesticide handler training, employees using respirators must be trained on the following topics:

- Why respirators are required,
- Respirator limitations,
- How to inspect your respirator before use,
- How to put on and remove respirators, and
- How to conduct a seal check.

The training must be provided prior to the employee's use of a respirator. Respirator training is repeated annually thereafter.

Inspection

Inspect your respirator prior to each use. This includes checking of function, tightness, and condition of the various parts including facepiece, head straps, valves, and connecting tube to make sure they are in working order. Cartridges, canisters, and filters should be replaced periodically depending on the length of time and frequency used. They should also be replaced whenever they are damaged, soiled, or cause noticeably increased breathing resistance. Do not rely on odor or taste.

Conduct a seal check (also called a *fit check*) before each use. This test will ensure that your respirator forms a complete seal around your face. Shave any facial areas that may prevent a good seal between your skin and the mask.

Employers must check SCBA cylinders to ensure there is one or more air cylinder charged to at least 80% at the start of the workday.

Cleaning

Be sure to clean your respirator according to manufacturer instructions after each use. Inspect your respirator regularly and store it properly.

Chapter 4 Review Questions

Correct answers are given on page 51.

1. What type of gloves are required to handle aluminum phosphide products?
    a. cotton gloves
    b. neoprene gloves
    c. rubber gloves

2. When is no respiratory protection required when applying an aluminum or magnesium phosphide product?
    a. When the concentration of phosphine is known to be greater than 15 ppm.
    b. When the concentration of phosphine is known to be between 0.3 ppm and 15 ppm.
    c. When the concentration of phosphine is known to be less than 0.3 ppm.

3. What is the first thing an employee must do before performing activities that require wearing a respirator?
    a. have an industrial hygienist perform a fit test
    b. undergo a medical evaluation
    c. attend SCBA training

4. How often must employee respirator training be conducted?
    a. every year
    b. every 2 years
    c. every 3 years

Chapter 5: Factors to Consider in Burrowing Vertebrate Pest Fumigation

Fumigants can affect all forms of life. This applies to aluminum and magnesium phosphide used to fumigate burrows of vertebrate pests since any animal in the burrow can be killed if exposed to the fumigant.

Correct pest identification is an important factor in deciding which control method or methods you will use to manage the burrowing vertebrate pest problem. That is also why it is very important to understand the habitats and habits of the pest before choosing fumigation as the control method. Different pests vary in how they respond to certain control methods. For example, moles and pocket gophers can inhabit the same areas but it can be difficult to differentiate the damage caused by each species.

Knowing your target pest is extremely important. It can make the difference between good pest control and no control. Besides identifying your target pest, knowing their biology and life cycle is also key to good pest management. These factors are covered in more detail in Chapter 6, Burrowing Vertebrate Pest Identification.

A *burrow fumigation* will only kill the pests inside the burrow. A pest population outside the treated burrow can serve as a reservoir population and can result in the vertebrate pest reinfesting the treated burrow once the fumigant has dissipated.

Pests can develop resistance to fumigants as they would to other pesticides. The same tactics of resistance management you use for other pesticides apply to fumigants as well. To help reduce the development of *pesticide resistance* you should incorporate the following practices:

- Practice Integrated Pest Management (IPM): combine all available control measures into a practical pest management program.
- Use fumigants only when necessary: over time, a pest population may develop resistance when you use that fumigant against it. If you use the fumigant, even when not needed or appropriate, you may unnecessarily increase the likelihood of pesticide resistance developing in the pest population.
- Always follow the proper dosage rate and exposure time specified on the label.

Refer to Chapter 1 of the Pesticide Safety: A Study Manual for Private Applicators, Third Edition for more information on IPM including biological, mechanical, physical, cultural, and chemical control methods; developing pest management programs; and preventing pesticide resistance. The next section will discuss the control methods as they apply to burrowing vertebrate pest control.

Integrated Pest Management Control Methods in Burrowing Vertebrate Pest Control

Integrated Pest Management involves the use of various control methods, alone or in combination, to manage a pest. Included below are examples of each control method.

- An example of a **biological control** method for pocket gophers would be making or purchasing owl nesting boxes to encourage owls to nest in the area where pocket gopher infestations occur. However, since pocket gophers rarely leave their burrows, biological control methods are not a particularly effective method for pocket gopher control.
- An example of a **mechanical control** method for vole trapping is using regular mouse traps along vole runways, burrow openings, and nests. Traps can be effective if the populations are very low or confined to a small area. However, it often requires a large number of traps that need to be monitored daily. Any dead voles need to be disposed of either in a plastic bag in the trash or by burial. This method is not the most

practical form of control for large production agricultural settings.

- An example of a **physical control** for rats is using stainless steel mesh fabric to seal any cracks, gaps, holes, and crevices to stop the rats from entering. *Exclusion* is often the easiest and most cost effective long term way to manage pests, but it does not work in all settings.
- An example of a **cultural control** method for ground squirrels would be removing piles of brush and debris that provide cover for the animals when they retreat from predators, which will discourage ground squirrels from nesting in an area.
- An example of a **chemical control** method is the use of pesticides to control pests. Options for burrowing vertebrate pests often include the use of pesticides, including toxic baits containing *toxicants* such as rodenticides and gas cartridges.

NOTE: Several rodenticides are federal Restricted Use Pesticides, and many are California restricted materials requiring a permit from your local CAC.

In an IPM program, the use of pesticides should be your last choice, and only after all other options have been considered. You must also consider the possible impact on the environment and wildlife, including risk to threatened and endangered species. Before applying for a restricted material permit you need to consider all feasible alternatives to using a pesticide or burrowing vertebrate fumigant. Consult with your licensed Pest Control Adviser (PCA) or other expert for assistance.

As part of a comprehensive IPM program, fumigants are another chemical control option to control burrowing vertebrate pests. Advantages and disadvantages of this option are discussed below.

Advantages of Using Aluminum or Magnesium Phosphide for Burrowing Vertebrate Pest Control

Some advantages of aluminum and magnesium phosphide over trapping or other pesticides (such as rodenticide baits or gas cartridges) include:

- They are easy to use. Applicators can treat active burrows and seal them without requirements to perform pre-baiting or carcass search and removal.
- Phosphine gas has several environmental advantages over rodenticide baits. Unlike rodenticide baits, phosphine has little residual toxicity since chemicals do not linger in the burrow. Fumigated burrows can be reoccupied after the fumigant has dissipated without risk of injury to the new occupant. Compared to baits containing toxicants, phosphine gas presents little risk of secondary exposure to phosphine by non-target animals that prey on and consume the vertebrate pest. Secondary exposures of wildlife to second-generation anticoagulant rodenticides (SGARs) have been widely documented.
- Aluminum and magnesium phosphide products registered in California have a wide range of application temperatures allowing use throughout much of the year. The product label will provide information on the minimum temperature in which to apply the product.

Disadvantages of Using Aluminum or Magnesium Phosphide for Burrowing Vertebrate Pest Control

There are also disadvantages to using these fumigants to control burrowing vertebrate pests. The disadvantages include:

- Aluminum and magnesium phosphide applications can be costly. Researchers estimate burrowing vertebrate fumigations cost 5 to 10 times more in labor/product than rodenticide baits to treat the same amount of ground.
- Use of these fumigants is usually on small acreages, sparse populations, or as a cleanup following use of toxic bait.
- The phosphine gas released also poses risks to applicators as well as bystanders. Applicators are often required to use specialized PPE.
- Phosphine gas does not target specific pest animals. Any animal in the burrow will be killed, whether it is a

targeted animal or not. It is imperative to recognize the signs of burrow occupations by non-target wildlife in order to avoid accidental exposure. Non-target animals, such as coyotes and owls, may inhabit burrows that were previously occupied by the target pest. Non-target animals can also create burrows that resemble the target pest burrows. Know the federally and state protected species (e.g., California tiger salamander, California red-legged frog, blunt-nosed leopard lizard) that you may encounter when fumigating burrows. Label restrictions to protect endangered species and threatened species is covered in Chapter 3.

- When these products are applied to rocky soils the resulting phosphine gas may escape the burrow through cracks and spaces in the soil. When applied to dry soils there will be a delay in the conversion of the product into phosphine gas. These situations make the fumigant less effective and create a more dangerous environment for the applicator, bystanders, and non-target species.
- Since phosphine gas has no residual effect, neighboring pest populations, as well as neighboring non-target animal species, can reoccupy the treated burrows. Control as much ground occupied by the target pest species as possible to reduce the risk of pest species reoccupying treated burrows. Coordinated community based efforts may improve long-term success.

Fumigation Preparation

Many of the tasks involved in preparing for a burrow fumigation with aluminum or magnesium phosphide have been covered. Private applicators using or supervising the use of aluminum or magnesium phosphide products to control burrowing vertebrate pests must:

- Possess a valid Private Applicator's Certificate and the additional Burrowing Vertebrate Pest Fumigation Certification,
- Verify that the fumigant is registered for use in burrow fumigation,
- Obtain a restricted material permit from the local CAC's office and submit a Notice of Intent prior to the application,
- Evaluate the use site and the application's impact on surrounding properties,
- Prepare a site-specific written Fumigation Management Plan,
- Train employees on pesticide safety, including safe use and handling techniques,
- Wear the appropriate PPE including respiratory protection (if required),
- Post warning signs, and
- Have gas-monitoring devices available.

The list above is not all-inclusive.

The use of aluminum and magnesium phosphide for burrowing vertebrate pest control in California is strictly regulated. Consult the product labeling and the restricted materials permit for a comprehensive list of requirements.

Assessing the Burrow to Protect Non-Target Wildlife

Even if you have conducted the required pre-fumigation survey of an area, you should still take steps to confirm that the target pest occupies the burrow prior to applying the fumigant. Treatment of empty burrows or burrows occupied by non-target animals is not only illegal, it is also a waste of time and money. You can determine if fumigation is an appropriate method to control the burrowing vertebrate pest by evaluating various factors, including the presence of the pest's scat (feces or dropping), the size and shape of the burrow entrance, the burrow's architecture, and by knowing the signs of inactive burrows.

Signs of inactive burrows include:

- cobwebs in the entranceway(s),
- absence of signs of recent excavation (such as loose soil),
- complete or partial collapse of the burrow, and

- lack of fresh scat around the entrance.

You can also test an active burrow by plugging the entrances with soil and returning in a few days to see if the entrances are cleared again. Be aware that non-target species inhabiting an old burrow may reopen entrances and that it is critical to confirm that the pest species, and not a non-target species, is occupying the burrow before fumigating.

Typical burrow entrance diameters for some target burrowing vertebrate pest species in California are:

- Yellow-bellied marmot: greater than 5 inches
- Ground squirrel: 2 to 4 inches
- Pocket gopher: 3 to 4 inches
- Mole: 2 inches

If you encounter a burrow that does not match the typical burrow entrance size of a target burrowing vertebrate pest, postpone the fumigation until you can confirm that the target species occupies the burrow. Non-target animals, such as the San Joaquin kit fox, have been known to inhabit the burrows of ground squirrels and other burrowing animals if the burrow entrance is wide enough. The San Joaquin kit fox is an endangered species.

Chapter 5 Review Questions

Correct answers are given on page 51.

1. Which is an advantage to using phosphine gas over rodenticide baits?
    a. The cost of phosphine gas products.
    b. Phosphine gas only affects the target pest.
    c. Phosphine gas presents little risk of secondary exposure by non-target animals.

2. Which is an example of a biological control method for Integrated Pest Management (IPM)?
    a. trapping
    b. using owl nesting boxes
    c. removing brush piles and debris

3. What is the typical burrow entrance diameter for a pocket gopher in California?
    a. 1 to 2 inches
    b. 3 to 4 inches
    c. 5 to 6 inches

Chapter 6: Burrowing Vertebrate Pest Identification

Pest Identification

This study manual will briefly cover the pests listed in the labeling for aluminum phosphide products: ground squirrels, pocket gophers, voles, moles, chipmunks, deer mice, and Norway and roof rats. In California, the applicator manuals of aluminum phosphide products state that these products cannot be used to control chipmunks. The information presented in this study manual is not meant to be a definitive pest identification guide.

You can identify burrowing vertebrate pests by their morphology (physical characteristics, mound characteristics, or the damage they may cause). In addition to the information in this study manual, other resources to help you identify burrowing vertebrate pests include the Vertebrate Pest Control Research Advisory Committee's (VPCRAC) Vertebrate Pest Control Handbook, the University of California Statewide IPM Program's Pest Notes Library, and the University of Nebraska's The Handbook: Prevention and Control of Wildlife Damage.

Correct pest identification and evaluating the available control methods are key to successfully managing burrowing vertebrate pests. Consult pest experts, such as your Pest Control Adviser (PCA) or a UC Extension Farm Advisor, for assistance with correctly identifying pest species and evaluating control options. If the best control method is fumigation, always read, understand, and follow the pesticide label, the applicator manual, and the restricted material permit conditions.

Ground Squirrels

"California ground squirrels" refers to *Otospermophilus beecheyi* and the subspecies *Otospermophilus beecheyi douglasii*. These squirrels can be found in nearly all regions of the state. These squirrels prefer open grasslands but are also commonly found in grain fields, irrigated pastures, meadows, open fields, and around home and residential areas. California ground squirrels are typically 14 to 20 inches in length, including their tail. Adults weigh between 21 to 30 ounces with the males being slightly larger than the females. Their fur is brown with white and gray markings on their backs, and they have a white ring around each eye (Figure 6-1).

Figure 6-1. Adult California ground squirrel. (Photo by Monica Dimson, UCCE Orange County)

Another ground squirrel species, the Belding's ground squirrel (*Urocitellus beldingi*), lives in the northeastern part of California. Belding's ground squirrels may inhabit and cause problems in agricultural areas (particularly alfalfa and hay production fields) by building burrows that present a hazard and by damaging the soil. They are smaller than California ground squirrels (about 8.5 inches long and weigh 9 to 19 ounces). Their fur is brownish gray to reddish brown with no stripes, mottling, or other markings. Belding's ground squirrels are less colonial and their burrows are more dispersed.

Differentiating these two ground squirrel species is essential as the management and control strategies between each species may differ. Similarly, you should also be able to differentiate between ground squirrels and tree squirrels. One way to differentiate ground squirrels from tree squirrels is how they react when startled. Tree squirrels retreat up a tree whereas ground squirrels always retreat to their burrow.

Ground squirrels are social animals that form colonies and live in open burrow systems. Ground squirrel burrow openings are about 4 to 6 inches in diameter, with multiple openings connecting a series of tunnels. From the surface, a ground squirrel burrow system may look like a series of small holes (Figure 6-2, pg. 42). These burrow holes are connected to a series of tunnels and chambers. Tunnels can be between 5 and 30 feet in length and 2 to 3 feet below ground. Ground squirrels are active from midmorning to late afternoon, although they have

two periods of inactivity each year: winter hibernation and summer estivation. During these periods of dormancy ground squirrels plug the burrow tunnel near their nest with soil.

Figure 6-2. Typical California ground squirrel burrows on waterside slope of a clayey levee. (Department of Civil and Environmental Engineering. University of California, Berkeley, CA.)

Breeding season for California ground squirrels is dependent on climate and location. Those that live in colder areas at higher altitudes will hibernate longer, thus postponing the breeding season. In areas where the weather is warmer, breeding season can last from January to July. Female California ground squirrels reach sexual maturity at about one year of age and produce one litter per year with an average of 5 to 8 young per litter.

Moderate to high density populations of California and Belding's ground squirrels are often considered serious agricultural pests. California ground squirrels cause damage by stripping bark from trees, eating parts of branches and feeding on the fruit, nuts, and grain of the crops. They feed on a variety of greenery including grasses, plants, seeds, fruits, nuts, and grains. They damage grain and forage crops such as cotton, alfalfa, sugar beets, and lettuce, especially during the seedling stages. Fruit and nut crops such as almonds, pistachios, oranges, prunes, and walnuts are also susceptible to damage caused by California ground squirrels. Belding's ground squirrels can cause extensive damage with their burrows in rangeland forage, irrigated pastures, alfalfa, wheat, oats, barley, and rye. Ground squirrels also cause damage to irrigation systems by gnawing or chewing irrigation lines, boxes, wires, and sprinkler heads. Their burrows can weaken levees, ditch banks, earthen dams, and undermine roadways and buildings. These burrows also pose safety hazards to workers and livestock and can damage farm equipment.

Pocket Gophers

Burrow fumigation is also used to manage and control pocket gophers. The most prevalent species in California is the Botta's pocket gopher (*Thomomys bottae*). These gophers range from 6 to 10 inches in length and can be identified by their large cheek pouches (or pockets, hence the name "pocket" gophers). They have short, fine fur, small eyes and ears, and four large incisors (Figure 6-3). These rodents are adapted to digging and life underground. Pocket gophers have lips that close behind their incisors to keep dirt out of their mouths when digging.

Pocket gophers do not hibernate, although you will not often find them outside of their burrows unless they are foraging, pushing dirt out of their burrow, or relocating. Pocket gopher burrows are closed burrow systems. They can be easily identified by the crescent-shaped mound of dirt surrounding the plugged-up entrance to their burrow (Figure 6-4, pg. 43). Their burrow openings range from 2.5 to 3.5 inches in diameter and the burrow itself can cover an area up to 2,000 square feet.

Figure 6-3. Pocket gopher in California. (Photo by Jack Kelly Clark, UC IPM Program)

These rodents reach sexual maturity in about one year and produce 1 to 3 litters per year with a litter consisting of 5 to 6 offspring. Pocket gophers are typically solitary and are only found with other pocket gophers during breeding season and when raising young.

Dry soil is typically a poor pocket gopher habitat as the burrow systems can collapse more easily compared to moist soil. Pocket gophers also prefer moist soil because they normally feed on plant roots they come across while creating their burrows. This can cause significant damage to grassy areas such as crop fields, orchards, etc. Plants with a vigorous root system can usually tolerate pocket gopher damage. However, plants with taproots, such as alfalfa and other grain crops, are more prone to damage by pocket gophers. Pocket gophers also cause damage to citrus and nut tree orchards, especially during the sapling stage. In colder climates, where snow and ice are

present, pocket gophers may feed on the bark of fruit and/or nut trees, stripping the bark and girdling the tree causing production losses. Additionally, pocket gophers can damage irrigation systems by chewing and gnawing plastic water pipes, wires, and plastic valve boxes.

Pocket gopher mounds can nick and dull the blades of mowing and harvesting equipment and damage them. These mounds also pose a physical hazard to workers and livestock.

Voles

Of the six vole species that are found in California, the most prevalent are the California vole (*Microtus californicus*) and the Montane vole (*Microtus montanus*). Voles, also commonly referred to as meadow mice, are often confused with house mice due to their small size (roughly 5 to 8 inches in length including the tail), short legs, seemingly hairless tail, small beady eyes, and small round ears (Figure 6-5). Voles spend most of their time in their burrows and are active from ground level to about 6 to 8 inches below ground. Vole burrows are shallow, open burrow systems that are typically no larger than 200 square feet, with entrances that can range from 1.5 to 2 inches in diameter (Figure 6-6). Vole burrows can be identified by the runways connecting burrow entrances that are typically hidden with grass, leaves, and other materials. You can also find vole scat in the runways and near the burrow entrances. Fresh vole scat is green in color and measures approximately 3/16 inch in length.

Figure 6-4. Pocket gopher burrow. (Photo by Roger A Baldwin, Assistant Cooperative Extension Specialist, UC Davis)

Voles are reproductive throughout the year, although their typical breeding season is in the spring. Female voles reach sexual maturity between 35 and 40 days and have about 8 litters per year with each litter consisting of 4 offspring on average. While voles reproduce often and produce large broods, their lifespan is only about one year.

Voles can cause damage to field crops and vineyard crops. Vole populations as high as 1,000 voles per acre have been reported in alfalfa fields, causing significant damage. Voles can also cause significant damage in small tree orchards, such as pears, where they will girdle the tree by gnawing or feeding on the bark around the base of the tree. Although voles typically damage trees at the base or beneath the soil, they can climb low hanging tree limbs and cause damage up higher on trees. Vole damage is recognizable by irregular shaped gnaw marks (which are typically 3/8 inch long and 1/8 inch wide) and tree girdling which can cause abnormal yellowing of the leaves, slow fruit development, and decreased fruit yield (Figure 6-7, pg. 44).

Figure 6-5 (left) and Figure 6-6 (right). (Left) Vole. (Photo by J. K. Clark, UC Integrated Pest Management, UC Regents). (Right) Vole burrow entrances. (Photo by Roger A Baldwin, UC Integrated Pest Management, UC Regents).

Chipmunks

In California, aluminum phosphide products are not labeled or registered for use to control chipmunks. There are numerous chipmunk species belonging to the genus *Neotamias* in California, including the California chipmunk (*Neotamias obscurus*) and the most widespread species, the yellow-pine chipmunk (*Neotamias amoenus*).

The various chipmunk species present in California can weigh from 1 to 5 ounces and measure from 3 to 7 inches with tail lengths from 2 to 5.5 inches. They usually have white and black stripes running down their head and back (Figure 6-8). The species range in coloration from bright yellow to grayish and they have pouches in their cheeks to carry food. Chipmunks are closely related to ground squirrels and are often confused with ground squirrels despite being smaller in size. Chipmunk tracks can be identified by the five-toed rear footprint and four-toed front footprint. Chipmunks are also known for their frequent, loud vocalizations or "chirps." Female chipmunks have a high pitched mating call that sounds similar to chirping birds. Breeding season for these small rodents occurs once in the spring and once in the summer. Typically, chipmunks produce a litter consisting of 4 to 5 offspring and the average lifespan of chipmunks is 2 to 3 years.

Figure 6-7. Vole damage to tree trunk. (Missouri Botanical Garden)

Chipmunks are active during the day in the spring, summer, and fall, but hibernate underground in the winter. They will store nuts and seeds in their burrows during the late summer and early fall to prepare for colder months in which they cannot go out to forage for food. There are only a few species that hibernate all through the winter as most chipmunks do not store a layer of fat in preparation for hibernation and must leave their burrow on warmer winter days to forage.

Chipmunks have open system burrows but create two different types of open system burrows, one for foraging and one for nesting. Their foraging burrows tend to be much closer to the surface so that they can quickly escape danger, while their nesting burrows extend as deep as three feet underground to provide adequate shelter for their young and for themselves during hibernation. These burrows can be destructive when built underneath structures, including those where produce is stored. Structures such as greenhouses may be damaged by chipmunks if the greenhouse is in or near wooded areas, a habitat preferred by chipmunks. Additional damage comes from chipmunks digging for plant roots and uprooting plants. Chipmunks may get into food and grain storages, but chipmunks rarely cause economic damage to crops.

Figure 6-8. The Yellow-pine chipmunk. (Photo by Sam May, Flickr)

Deer Mice

There are numerous mice species in California. For this study manual, we will focus on the Deer mouse (*Peromyscus maniculatus*), the most significant species in California. Mice come in different sizes ranging from 1 to 7 inches in length, between 0.5 and 1 ounce in weight, and can vary in color from white to brown or gray. The Deer mouse is brown with a white belly, white legs, and white feet (Figure 6-9, pg. 45). Deer mice can be distinguished from house mice by their larger size, larger eyes and ears, and bicolored tail. Deer mice are typically found outdoors in fields, forests, or agricultural areas. Mice that live outdoors create open burrow systems with openings that measure about 2.5 centimeters (cm) in diameter for shelter and safety. Deer mice will also use abandoned squirrel burrows and bird nests.

Deer mice can breed year-round. Female Deer mice reach sexual maturity between 4 and 7 weeks of age and can produce a new litter every three weeks. The brood size for each litter ranges from 4 to 12 offspring. The lifespan of Deer a mouse is about 1 to 2.5 years. With litter sizes of up to 12 young, potentially every three weeks, and a relatively long lifespan, you can see how quickly mice can infest an area. Signs of a Deer mouse infestation include droppings that are up to 0.6 cm in length with pointed ends, 1 to 1.9 cm footprints or 2 mm tail tracks, grease stains from their fur, 4 cm or less entrance holes, and 1 to 2 millimeter (mm) wide gnaw marks on wiring, insulation, or other items. In addition, Deer mice are identifiable by their distinct odor and fluorescent urine. Deer mice can cause physical damage by chewing through electrical and irrigation wiring. In agricultural set-

tings, Deer mice mostly cause damage to seeds. They will feed on seeds in row crops and commonly dig up planted seeds such as melon and alfalfa. High populations of Deer mice may also cause damage to almonds, avocados, citrus, pomegranates, and sugar beets. Deer mice have been known to interfere with establishment efforts of coniferous forest (or the reforestation of conifer forests) by feeding on seedlings and causing efforts to slow or even fail. Deer mice also cause damage to and contaminate stored produce and grains. Deer mice can also transmit some viral diseases and endoparasites to people.

Norway Rats

Sometimes referred to as the brown rat or sewer rat, the Norway rat (*Rattus norvegicus*) creates open burrow systems around buildings, under debris or piles of wood, and in fields with areas of high moisture. These burrows contain nests often lined with scraps of paper, insulation, and other shredded materials. These rats weigh approximately 12 to 16 ounces and are about 16 inches in length, including their tail. You can identify Norway rats by their blunt snouts, small beady eyes, small ears, shaggy fur, and scale-like tail that is shorter than the length of the body and head combined (Figure 6-10). Do not confuse the Norway rat with the Roof rat (*Rattus rattus*). The Norway rat is larger and more aggressive than the Roof rat.

Figure 6-9. Deer mouse. (Vertebrate Pest Control Research Advisory Committee)

The breeding season of Norway rats peaks in the spring and the fall, although they are capable of breeding year-round. Female Norway rats reach sexual maturity between 2 and 3 months of age and have 4 to 6 litters per year with 8 to 12 offspring per litter. These rodents have an average lifespan of about one year. They are social animals and prefer to live in colonies. Norway rat families can have several connected burrows with one main hole that is used as an entrance and an exit, as well as a few additional emergency exit holes.

You can recognize Norway rat infestations by the presence of shiny black capsule-shaped scat with blunt ends that measure on average 3/4 inch in length. Norway rats' hind foot tracks measure about 3/4 to 1 inch and they leave a trail from dragging their tail in between their feet. Their burrows can be identified by their smooth walls with entrances that are 2 to 4 inches in diameter.

Norway rats cause damage to asparagus, avocados, citrus, corn, olives, melons, squash, nuts, and grain and cereal crops. Most damage inflicted by Norway rats are to post-harvest or food storage. One rat eats approximately 20 to 40 pounds of feed per year. Besides eating stored produce and grains, Norway rats contaminate stored food which will usually have to be destroyed. They can also chew on electrical lines and hoses to damage engines and equipment.

Roof Rats

Roof rats (*Rattus rattus*) are sometimes referred to as black rats or ship rats. They are smaller than Norway rats and their tails are longer in comparison to the length of their head and body. These rats average 12 to 16 inches in length from the nose to the tip of the tail and weigh 5 to 9 ounces. You can identify these rats by their brownish black coloration, long and thin body, pointy nose, large eyes, protruding ears, and black, scaly tail (Figure 6-11, pg. 46).

Figure 6-10. Illustration of a Norway rat. Note the blunt snout. (Jack Kelly Clark, UC IPM Program)

Roof rats breed year-round provided conditions are favorable, and breeding peaks in the spring and fall months. Female Roof rats reach sexual maturity at 3 to 5 months of age and can produce five litters per year consisting of 5 to 8 offspring per litter. The Roof rat's lifespan is approximately one year. Roof rats do not burrow often, as they are exceptional climbers and prefer to nest in areas up high, such as trees. On rare occasion, in hot and dry climates, Roof rats may create nests in shallow burrows underneath structures or trees. Signs of Roof rat infestation include long cylindrical

droppings (measuring about 1/2 inch with pointed ends), gnaw marks, and greasy rub marks.

Figure 6-11. Roof rat (Rattus rattus). (Vertebrate Pest Control Research Advisory Committee)

Roof rats are more likely to cause crop damage than Norway rats. Roof rats are exceptional climbers and can cause damage to commodities such as citrus, avocados, pomegranates, and nut crops. Aside from feeding on fruit and rendering it unmarketable, Roof rats also cause damage by chewing on tree limbs causing branches to die. Roof rats, like the Norway rat, can also contaminate stored food (e.g., grains, fruits, and seeds) with their feces. Roof rats can also chew on, and damage, electrical and irrigation wires.

Moles

Unlike the species discussed above that taxonomically belong to the order Rodentia, moles belong to a different order, order Eulipotyphla. However, because moles also burrow, people may think they are also rodents. In California, there are four species of moles: the shrew mole (*Neurotrichus gibbsii*), the broad-footed mole (*Scapanus latimanus*), the coast mole (*Scapanus orarius*), and the Townsend's mole (*Scapanus townsendii*). These moles mostly inhabit the Sierra Nevada mountains and the California coast. Moles spend a majority of their lifetime underground in their closed burrow systems. They are approximately 5 to 8 inches in length and can be identified by their cylindrical bodies, silvery gray coloration, velvety fur, small eyes, discrete ears, pointed muzzles, seemingly hairless tails, reduced hind limbs, and short forelimbs with giant, six-fingered paws that are specialized for digging (Figure 6-12).

These mammals are active year-round with activity increasing during wet weather and surface activity decreasing during periods of extreme heat, cold, or drought. Moles are solitary, except during the breeding season, which typically spans the late winter to early spring months. Moles reach sexual maturity at about 10 months of age. Males search for females using high pitched mating calls and by exploring new territory. Female moles typically produce one litter per year consisting of roughly 3 to 4 pups. Moles live to be about three years of age.

Mole burrows can be identified by mounds (Figure 6-13) and surface runways that are visible above ground and form as a result of dirt that is pushed to the surface as moles dig their tunnels. These soil mounds are typically volcano shaped with no entrance or exit holes. Moles create surface feeding burrows located just beneath the surface of the ground to forage on insects, earthworms, and other soil invertebrates. When these runways are created, they form ridges that are visible from above ground. These mounds and ridges are most common in shaded portions of grassy areas and similar sites.

Mole damage is mostly due to their burrow systems. When creating their burrows, moles can uproot plants and other greenery. Moles often inhabit the same areas as pocket gophers and can be found in neglected orchards or grain crops where insects are present.

Figure 6-12 (left) and Figure 6-13 (right). (Left) Photo of a Townsend's mole emerging from its burrow. (Photo by Jerry P. Clark, UC Invertebrate Pest Management). (Right) Mole mound. (Vertebrate Pest Control Research Advisory Committee).

Below is a summary of the physical characteristics of the burrowing vertebrate pests we covered in this study manual.

Table 6-1. Comparison of species covered in this chapter.

Species	Weight	Total Length	Tail	Ears	Color	Appearance	Burrow Entrance Average Diameter
California ground squirrel	21-30 oz	14-20”	Somewhat bushy, 5.5-9” long	Tall and conspicuous	Brownish grey and dusky	White ring around each eye	4-6”
Belding’s ground squirrel	9-19 oz	8.5”	Not bushy, 2.5” long	Small, not very prominent	Brownish-gray to reddish brown	Brownish-gray to reddish-brown	4-6”
Botta’s pocket gophers	4.2-8.8 oz	6-10.6”	Short, 2-2.4” long	Small external ear	Varies from white to black	Lacks black strip down the middle of the back	2.5-3.5”
California vole	1.3-2.9 oz	6-8.5”	Bicolored	Small, hidden in fur	Olive to brown	Often confused with house mouse	1.5-2”
Montane vole	1.3-3 oz	5.5-8.5”	Indistinctly bicolored	Small, not visible, hidden in fur	Brown with grey or yellow	Dark brownish which fades to grey or white on the underparts	1.5-2”
Moles	3-4 oz	5-8”	1 ¼”	Small, not visible, hidden in fur	Black-to-brownish-gray	Paddle-shaped feet and prominent digging claws	1-2”
Chipmunk	>4 oz	7-11”	3-4”	Small, rounded	Bright yellow to grayish	Often confused with ground squirrels	2-3”
Deer mouse	0.5-1 oz	1-7”	Sharply bicolored	Large ears and eyes	White to brown to gray	Larger eyes and ears than house mouse	1”
Norway rat	12-16 oz	16”	Dark above & pale below, Shorter than body	Protruding ears	Brownish or reddish grey, whitish grey belly	Stocky	2-4”
Roof rat	5-9 oz	12-16”	Black, scaly, longer than body	Protruding ears	Brownish-black	Long and thin body, large eyes	2-4”

Chapter 6 Review Questions

Correct answers are given on page 51.

1. In California, a special use restriction prohibits the use of aluminum phosphide products to control _____.
    a. chipmunks
    b. mice
    c. pocket gophers

2. Which burrowing vertebrate pest creates a crescent-shaped mound of dirt surrounding the plugged entrance to the burrow?
    a. California ground squirrel
    b. Montane vole
    c. Botta's pocket gopher

3. Which pests' burrow contains nests often lined with scraps of paper, insulation, and other shredded materials?
    a. Deer mouse
    b. Norway rat
    c. Roof rat

4. Which burrowing vertebrate pest creates a volcano shaped mound with no entrance or exit holes to the burrow?
    a. Montane vole
    b. Botta's pocket gopher
    c. Townsend's mole

Review Question Answers

Chapter 1
1. a
2. c
3. b
4. c

Chapter 2
1. c
2. c

Chapter 3
1. c
2. a
3. b
4. a
5. a

Chapter 4
1. a
2. c
3. b
4. a

Chapter 5
1. c
2. b
3. b

Chapter 6
1. a
2. c
3. b
4. c

Glossary

Absorb, Absorbed	(1) The entrance or taking up of a pesticide into a body through the skin, eyes or mouth. (2) In the case of a fumigant, when the molecules penetrate into a material (commodity, soil, wood, etc.).
Active ingredient	The chemical or chemicals in a pesticide formulation that are biologically active and are capable, in themselves, of preventing, destroying, repelling, or mitigating insects, fungi, rodents, weeds, or other pests. The remainder of the product consists of one or more inert ingredients (such as water, solvents, emulsifiers, surfactants, clay and propellants), which are there for reasons other than pesticidal activity.
Acute toxicity	A measure of the capacity of a pesticide to cause injury as a result of a single exposure.
Air monitoring	The use of sensitive gas monitoring devices during fumigation to accurately gauge the dosage of the fumigant and/or to detect leaks from the application site.
Ambient air analyzer	A type of monitor that uses infrared light to detect and measure gas fumigant concentrations. Also called "IR analyzer."
Applicator's manual	Most, if not all fumigant labels direct the applicator to use the product's applicator's manual. That manual is much longer and contains more detailed instructions on use of the product than the label attached to the product. Just as for the label, the manual is a legally binding document and you must follow the instructions explicitly.
Atmosphere-supplying respirator	A device that draws air from outside a fumigation area or uses canisters of pressurized air to supply a worker with breathable air. The latter is also called a self-contained breathing apparatus (SCBA).
Boiling Point	The temperature at which the vapor pressure of a liquid equals the pressure surrounding the liquid and the liquid changes into a vapor. Or, simply, the temperature at which a liquid becomes a gas.
Burrow fumigation	A type of fumigation used to control certain vertebrates in burrows outdoors.
CCR	California Code of Regulations
California Department of Pesticide Regulation (DPR)	The state lead agency responsible for regulating the use of pesticides in California.
Canister	A device used with a respirator that contains chemical components that absorb specific gases. Each canister is color coded with stripes to indicate limitations and approved uses.
Canister respirator	A respirator that uses canisters to remove toxic fumes from air.
Certified applicator	A person who has demonstrated, through an examination process, the ability to safely handle and apply highly hazardous restricted pesticides.
Certified applicator-in-charge	A certified applicator who has supervisory authority over the fumigant application. Note that U.S. EPA uses the term "site supervisor."
Chemical-resistant	A material that allows no measurable movement of the pesticide through it during use.
CHEMTREC	The chemical transportation emergency center. This organization operates a 24-hour information hotline for pesticide spills, fires, and accidents. 1-800-424-9300.
Concentration	The amount of a substance in a given weight or volume.
Corrosion	The cause of damage by chemical action such as when a substance oxidizes (e.g., rusts) a metal surface, or corrodes like an acid. Some fumigants are especially corrosive to certain metals.
County Agricultural Commissioner (CAC)	The official in each county in California who has the responsibility for enforcing the state and federal pesticide regulations and issuing permits for restricted-use pesticides. County agricultural commissioners and their staff frequently inspect pesticide applications and application sites and conduct investigations into complaints of pesticide misuse.
Decontamination procedures	The most important step in reducing potential injury when someone has been exposed to a pesticide. Decontamination procedures involving thoroughly washing the exposed skin with soap and water or flushing the exposed eye with a gentle stream of running water.
Dermal	Pertaining to the skin. One of the major ways pesticides can enter the body to possibly cause poisoning.
Detector tubes	A glass tube that shows a color change in the presence of a specific gas. Tubes are specific for different fumigants. Also called "colorimetric tubes."

Detectors	A generic term for any of various monitoring tools used to measure the presence of a substance (e.g., concentration of phosphine in air).
Directions for Use	The instructions found on pesticide labels indicating the proper procedures for mixing and application.
Dosage	The addition of an ingredient or the application of an agent in a measured dose. In terms of fumigation, it is the number of ounce-hours (or gram-hours) accumulated during the exposure period.
Endangered species	Any species that is in danger of extinction throughout all or a significant portion of its range (i.e., normal area it lives in).
Endangered species bulletin	A part of EPA's Endangered Species Protection Program. Bulletins referenced on the product label that set forth geographically specific pesticide use limitations for the protection of threatened and endangered species and their designated critical habitats.
Estivation	The state or condition of dormancy induced by the heat or dryness of summer.
Exclusion	A pest management technique that uses physical or chemical barriers to prevent certain pests from getting into a defined area.
Exposure	When an individual comes into contact with a pesticide either through your skin, eyes, ingestion, or breathing it (or its vapors) in.
First aid	The immediate assistance provided to someone who has received an exposure to a pesticide. First aid for pesticide exposure usually involves removal of contaminated clothing and washing the affected area of the body to remove as much of the pesticide material as possible. First aid is not a substitute for competent medical treatment.
Fit check	An on-the-spot check to make sure that a fit-tested respirator or self-contained breathing apparatus (SCBA) still fits correctly. A fit check should be done each time the respirator or SCBA is worn.
Fit test	A qualitative test that must be done before you use a respirator or SCBA for the first time and which will determine whether or not the device fits well enough to adequately protect you during use.
Flammability	The ability to support combustion (i.e., the process of burning). A substance that easily catches fire. "Inflammability" has the same definition.
Formulation	A mixture of active ingredient combined during manufacture with inert materials. Inert materials are added to improve the mixing and handling qualities of a pesticide.
Fumigant	Pesticides in a gaseous state used to penetrate porous surfaces to control pests in containers, enclosed areas, storage facilities, and soil. Fumigants are toxic when absorbed or inhaled.
Fumigation	The process of using a fumigant to control certain pests by exposing them to an atmosphere of toxic gas inside an enclosed area.
Fumigation Management Plan (FMP)	A written plan for a specific fumigation that is prepared before the start of the fumigation.
Gas / gases	A state of matter consisting of particles that have neither a defined volume nor defined shape. As vapors, gases do not leave residues.
Green dust	Term found on aluminum phosphide labels. This is the partially reacted dust remaining from when the aluminum phosphide reacts with moisture in the air. Partially reacted dust is greenish in color, while the spent residual dust is greyish white in color.
Handler	For the scope of this study manual, this is a person who applies or assists with the application of aluminum or magnesium phosphide to control burrowing vertebrate pests; who maintains, services, repairs, cleans, or handles equipment used in these activities; who works with unsealed pesticide containers; or who performs other handling activities specified by the product label. It does not include inspection, sampling, or other similar official duties performed by local, state, or federal officials.
Hazard	The amount of danger to people or the environment posed by a pesticide or other toxic material.
Hazardous materials	Materials, including many pesticides, that have been classified by regulatory agencies as being harmful to the environment or to people. Hazardous materials require special handling and must be stored and transported in accordance with regulatory mandates.
Hibernation	To be or become inactive or dormant.
Humidity	A moderate degree of wetness, especially of the atmosphere.
Inhalation	The method of entry of pesticides through the nose or mouth into the lungs.

Integrated Pest Management (IPM)	A pest management program that uses life history information and extensive monitoring to understand a pest and its potential for causing economic damage. Control is achieved, when practical, through multiple approaches including prevention, cultural practices, pesticide applications, exclusion, natural enemies, and host resistance. The goal is to maintain long-term suppression of target pests with minimal impact on non-target organisms and the environment.
Label	The information, including directions for use, restrictions, requirements and safety procedures, printed on or attached to the pesticide container or wrapper. This information is legally binding.
Labeling	The pesticide container label and all associated materials, including supplemental labels, special registration labels, other items referred to on the label (i.e., applicator's manual), and other manufacturer's information such as brochures and fliers.
Molecular weight	A measure of the sum of the atomic weight values of the atoms in a molecule.
Oral	Through the mouth, this is one of the routes of entry of pesticides into the body.
Particulate	Microscopic particles of solid or liquid matter suspended in the air. NOT the same as a vapor or gas.
Permit conditions	Stricter requirements than those on a pesticide's labeling or in California law and regulation. Permit conditions are issued by the CAC and must be followed.
Personal protective equipment (PPE)	Devices and apparel worn to protect the body from dermal, eye, and inhalation exposure to pesticides or pesticide residues. These include coveralls, eye protection, gloves and boots, respirators, aprons, and hats.
Pesticide	Any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any insects, rodents, nematodes, fungi, or weeds, or any other forms of life declared to be pests, and any other substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant. In California, spray adjuvants are also considered pesticides.
Pesticide resistance	The genetically acquired ability of an organism to tolerate the toxic effects of a pesticide.
Posting	The placing of signs around an area to inform workers and the public that the area has been treated with a pesticide.
Precautionary statement	The section on the pesticide labels where human and environmental hazards are listed; personal protective equipment requirements are listed here, as well as first aid instructions and information for physicians.
Private applicator	A person who uses or supervises the use of a pesticide on property owned, leased, or rented by him or her, or his or her employer for the purpose of producing an agricultural commodity.
Property operator	Shorthand for "operator of the property" as defined in Title 3, California Code of Regulations. This term means a person who owns the property and/or is legally entitled to possess or use the property through terms of a lease, rental contract, trust, or other management arrangement.
Regulations	A rule or order issued by an executive authority or regulatory agency of a government and having the force of law.
Residue	Traces of pesticide that remain on treated surfaces after a period of time.
Respirator	A device that filters out pesticide dusts, mists, and vapors to protect the wearer from respiratory exposure during mixing and loading, application, or while entering treated areas while the airborne concentration of fumigants is above the safe concentration as prescribed by the pesticide label. These may either provide a source of clean air (an air-supplying respirator) or filter out particles and/or vapors from contaminated air (an air-purifying respirator).
Restricted material	California classification for highly hazardous pesticides, including federal restricted use pesticides and certain other pesticides that can be purchased, possessed, and used only by certified applicators.
Restricted materials permit	A permit, issued by the County Agricultural Commissioner, to authorize certified applicators to purchase, possess, and use California restricted materials.
Restricted-use pesticide (RUP)	A pesticide designation by U.S. EPA because it may generally cause, without additional regulatory restrictions, unreasonable adverse effects on humans, domestic or wild animals and/or the environment (including injury to the applicator). A restricted-use pesticide may be used only by a certified applicator or non-certified handlers under the direct supervision of a certified applicator (some product labels may require all handlers to be certified applicators).

Risk	Risk, in terms of pesticide exposure, is a measure of the likelihood that a person will be harmed by the pesticide and its particular use. It is a product of both the pesticide's toxicity and the amount of exposure in terms of volume of pesticide and length of time.
Route of exposure	The way a pesticide gets onto or into the body. The four routes of exposure are dermal (on or through the skin), ocular (on or in the eyes), respiratory (into the lungs), and ingestion (through swallowing).
Safety Data Sheet (SDS)	An information sheet provided by a pesticide manufacturer describing chemical qualities, hazards, safety precautions, and emergency procedures to be followed in case of a spill, fire, or other emergency.
Seal / sealing	To enclose an area so that fumigant gas cannot escape too quickly. A good seal will contain a lethal amount of gas long enough to kill the target pests.
Self-contained breathing apparatus (SCBA)	A type of respirator that supplies fresh air from an outside or portable source such as a cylinder under pressure. Air enters a mask that tightly covers the entire face.
Signal word	One of three words (DANGER, WARNING, CAUTION) found on every pesticide label to indicate the relative hazard of the chemical.
Site	The area where pesticides are applied for control of a pest.
Skull-and-crossbones	The symbol on pesticide labels that are highly poisonous. Always accompanied by the signal word "DANGER" and the word "POISON."
Solubility	The property of a substance to dissolve in another substance (e.g., salt dissolves in water).
Supplied-air respirator (SAR)	A device that supplies air from a compressed air tank that is located outside of the fumigation area. SARs permit people to enter oxygen-deficient areas or areas where there are highly toxic pesticide vapors.
Symptom	Any abnormal condition following a pesticide exposure that can be seen or felt or that can be detected by examination or laboratory tests.
Target pest	The organism toward which pest control measures are being directed.
Temperature	A degree of hotness or coldness measured on a definite scale.
Threatened species	A group of organisms likely to become endangered in the foreseeable future.
Toxic	Acting as, or having the effect of, a poison. A toxic substance is one that can cause harm to organisms or the environment.
Toxicant	A substance that, at a sufficient dose, will cause harm to a living organism.
Toxicity	A measure of the capacity of a pesticide (or other substance) to cause injury. That injury can occur soon after the exposure (acute) or appearing later than 24 hours following pesticide exposure (delayed and/or chronic effects).
Trade name	A brand name of a pesticide. The same active ingredient may be sold under different trade names; for example, Weevil-cide® is a trade name for aluminum phosphide.
Trigger levels	The air concentration of a fumigant that triggers the requirement for a fumigant handler to use specific respiratory protection in order to continue working in the area being fumigated.
U.S. Environmental Protection Agency (U.S. EPA)	The federal agency responsible for registering pesticides and regulating pesticide use in the United States.
U.S. EPA registration number	The number assigned to a pesticide by the U.S. EPA. This number must appear on the pesticide label of all registered pesticides.
Vapor	A substance in the gaseous state as distinguished from the liquid or solid state. As a vapor it exists in the air as separate molecules.
Vapor pressure	The pressure exerted by vapor molecules in equilibrium with its condensed phases (solid or liquid) at a given temperature in a closed system. The pressure exerted by a liquid or a solid as it volatilizes (becomes a gas).
Vertebrate	Animals that contain a backbone.
Warning sign	A sign that must be posted at all external entrances and all sides of a structure warning that the structure is being fumigated. Sometimes "sign" and "placard" are used interchangeably.

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