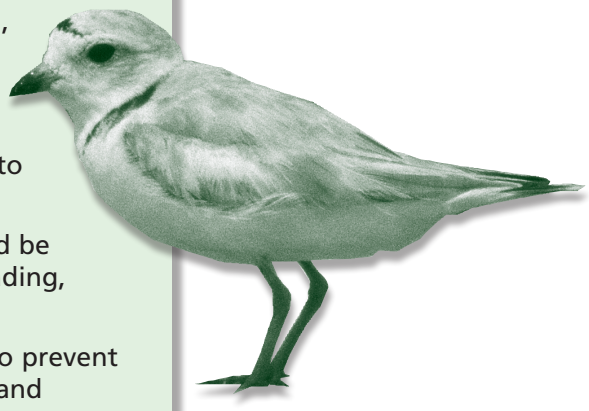
CHAPTER 7

PESTICIDES IN THE ENVIRONMENT

LEARNING OBJECTIVES

After studying this chapter, you should:

- Understand environmental consequences of pesticide application while considering all relevant factors (e.g., types of terrain, drainage patterns, soil, presence of non-target organisms and endangered species, drift, weather, groundwater and surface water).
- Understand how to prevent pesticide drift, runoff, or loss to unintended areas of the environment.
- Know how to identify potentially sensitive areas that could be adversely affected by pesticide application, mixing and loading, storage, disposal, and equipment washing.
- Understand the importance of implementing procedures to prevent residue accumulation associated with mixing and loading and equipment washing.
- Understand when to adjust or delay an application to minimize environmental impact and maximize effectiveness.



Governmental agencies as well as the general public are becoming increasingly concerned about the harmful effects of pesticides on the environment. Initially, hazards to humans were the primary reason for the EPA to classify a pesticide as a restricted-use product. Now, more and more pesticide labels list environmental effects such as contamination of groundwater or toxicity to birds or aquatic organisms as reasons for restriction. The EPA requires extensive environmental testing when it evaluates pesticide applications submitted by manufacturers for the registration of new pesticides. The agency is also taking a close look at environmental effects when it reevaluates existing pesticide registrations.

THE ENVIRONMENT

The environment comprises everything that is around us. It includes not only the natural elements that the word "environment" most often brings to mind but also people and the manufactured components of our world. Neither is the environment limited to the outdoors—it also includes the indoor areas in which we live and work.

The environment is much more than the oceans and the ozone layer. It is air, soil, water, plants, animals, houses, restaurants, office buildings, and factories, and all that they contain. Anyone who uses a pesticide—indoors or outdoors, in a city or on a farm—must consider how that pesticide affects the environment. The user must ask two questions:

1. Where is the pesticide going to go in the environment after it leaves its container or application equipment?
2. What effects can this pesticide have on those non-target sites it may reach in the environment?

PESTICIDE CHARACTERISTICS

To understand how pesticides move in the environment, you must first understand certain physical and chemical characteristics of pesticides and how they determine a pesticide's interaction with the environment. These characteristics are solubility, adsorption, persistence, and volatility.

Solubility

Solubility is a measure of the ability of a pesticide to dissolve in a solvent, usually water. Pesticides highly soluble in water dissolve easily. These pesticides are more likely to move with water in surface runoff or by movement through the soil water than are less soluble pesticides.

Adsorption

Adsorption is the process whereby a pesticide binds to soil particles. Adsorption occurs because of an attraction between the chemical and soil particles. Typically oil-soluble pesticides are more attracted to clay particles and organic matter in soil than are water-soluble pesticides. Also, pesticide molecules with positive charges are more tightly adsorbed to negatively charged soil particles. A pesticide that adsorbs to soil particles is less likely to move from the spray site than a chemical that does not adsorb tightly to the soil.

Persistence

Persistence is the ability of a pesticide to remain present and active in its original form for an extended period before breaking down. A chemical's persistence is described in terms of its half-life, a comparative measure of the time needed for the chemical to break down—the longer the half-life, the more persistent the pesticide. These residues are sometimes desirable because they provide long-term pest control and reduce the need for repeated applications. However, some persistent pesticides applied to soil, plants, lumber, and other surfaces or spilled into water or on soil can later harm sensitive plants or animals, including humans. It is especially important to prevent persistent pesticides from moving off-site through improper handling, application, drift, leaching, or runoff.

In addition to presenting a hazard to persons and non-target animals entering a treated area, application of persistent pesticides may lead to the presence of illegal residues on rotational food or feed crops. Check the label for statements about the persistence of the pesticide and for replanting restrictions. The rate of pesticide degradation relates to the persistence of the pesticide.

Pesticide Degradation

Degradation processes break down pesticide compounds into simpler and

often less toxic chemicals. Some pesticides break down very rapidly—in a matter of days or even hours. Others can be detected in the environment for a year or more.

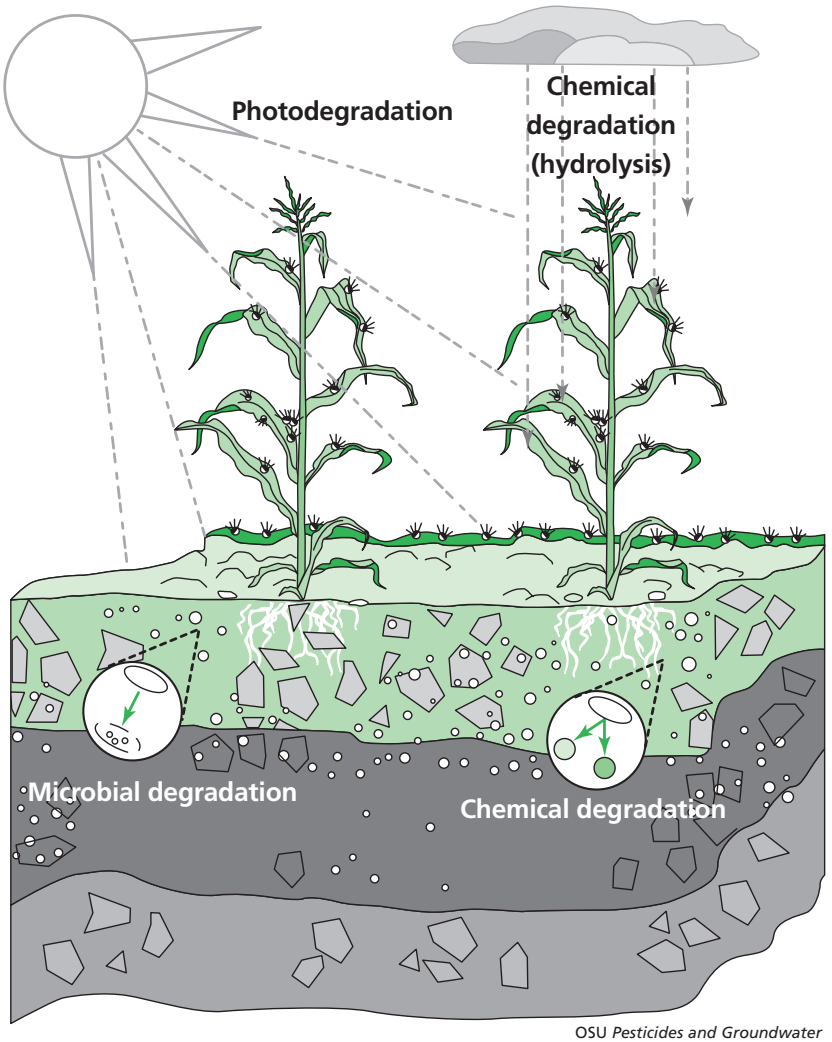
Pesticides are broken down or degraded by the following processes:

- **Chemical degradation**—the breakdown of chemicals by processes that do not involve living organisms, most commonly by **hydrolysis**, a chemical reaction with water.
- **Microbial action**—the process in which chemicals are degraded by soil microorganisms, such as fungi or bacteria.
- **Photodegradation**—the breakdown of chemicals in reaction to sunlight.

Water and temperature both affect the breakdown of pesticides. Warm, wet conditions can increase the speed of pesticide breakdown; cool, dry conditions slow down the degradation process.

Volatility

Volatility is the tendency of a pesticide to turn into a gas or vapor. Some pesticides are more volatile than others. The chance of volatilization increases as temperatures and wind increase. Volatility is also more likely under conditions of low relative humidity.



OSU *Pesticides and Groundwater Contamination*

Figure 7.1
Breakdown of pesticides in the environment.

HOW PESTICIDES MOVE IN THE ENVIRONMENT

Pesticides that move away from the targeted application site, either indoors or outdoors, may cause environmental contamination. Pesticides move in several ways—in water, in air, attached to soil particles, and on or in objects (see Figure 7.2).

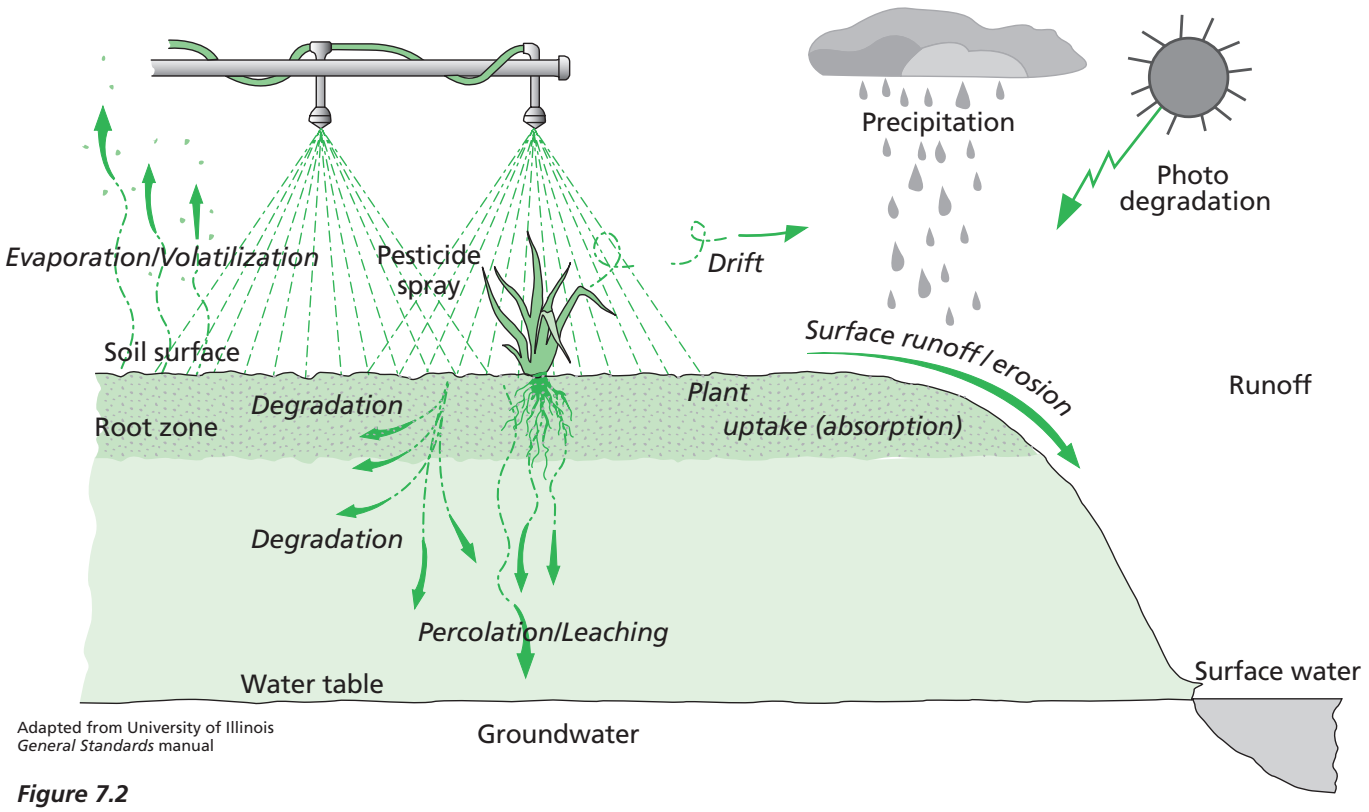
Movement in Air

Pesticide movement away from the application site by wind or air currents is called **drift.** People who mix, load, and apply pesticides outdoors usually are aware of the ease with which pesticides drift off-site. Those who handle pesticides indoors may not realize how easily some pesticides move off-site in the air currents created by ventilation systems and by forced-air heating and cooling systems. Pesticides may be carried off-site in the air as spray droplets, vapors, or solid particles, even on blowing soil particles.

Movement in Water

Most pesticide movement in water is either by surface movement off the treated site (**runoff**) or by downward movement through the soil (**leaching**). Runoff and leaching may occur when:

- Too much pesticide is applied or spilled onto a surface.
- Too much rainwater or irrigation water moves pesticide through the



Adapted from University of Illinois *General Standards* manual

Figure 7.2
Fate of pesticides in the environment.

soil off-site or into groundwater.

- Highly water-soluble or persistent pesticides are used.

Runoff water in an outdoor environment may move into drainage systems, streams, ponds, or other surface water, where the pesticides can be carried great distances. Pesticides that leach downward through the soil may reach groundwater. Besides runoff and leaching, pesticides also can enter water through drift.

In an indoor environment, water containing pesticides can flow into floor drains and contaminate water systems. A careless act such as dumping a pesticide or rinsate down a sink or toilet can contaminate an entire sewage or water-treatment facility.

Some pesticides can leach in indoor environments. In a greenhouse, for example, pesticides may leach through the soil or other planting medium and contaminate other greenhouse surfaces.

Look for special instructions on the label that warn of pesticide hazards caused by the movement of pesticides in water.

Movement on or in Objects, Plants, or Animals

Pesticides can move away from the application site when they are on or in objects or organisms that move (or are moved) off-site. When pesticide handlers bring home or wear home contaminated personal protective equipment, work clothing, or other items, residues can rub off on carpeting, furniture, and laundry items, and onto pets and other people.

Pesticide **residue** is the pesticide that remains in the environment after an application or a spill. Pesticide residues may be on treated crops, feed products, or livestock. The breakdown time ranges from less than a day to many years, depending mostly on the chemical structure of the pesticide's active ingredient.

PREVENTING PESTICIDE DRIFT

Drift can be defined simply as the airborne movement of pesticides to non-target areas. Off-target movement can be in the form of spray droplet drift, vapor drift, or particle (dust) drift. Studies have shown that a significant percentage of pesticides may never reach the intended target site because of drift. It is impossible to eliminate drift totally, but it is possible to reduce it to a tolerable level.

Where significant drift does occur, it can damage or contaminate sensitive crops, poison bees, pose health risks to humans and animals, and contaminate soil and water in adjacent areas. Applicators are legally responsible for the damages resulting from the off-target movement of pesticides. All persons and animals should be removed from the area where pesticides are being applied.

Spray Drift

Spray drift refers to the off-target movement of a pesticide during a liquid application. This is the result of small spray droplets being carried off-site by air movement. Spray drift occurs more frequently than the other two types of drift because almost all spray applications result in some off-target movement.

Avoid most problems associated with spray drift by paying close attention to ***spray droplet size*** and the ***wind direction and speed***. Larger spray droplets are less likely to drift than smaller ones. Typically, larger nozzle orifices and lower pressures produce larger droplets (see Table 7.1). However, some new nozzles, such as the venturi or air-induction nozzles produce larger droplets when used at higher pressures (above 40 psi).

The **viscosity** (thickness) of the liquid affects droplet size. The viscosity of a liquid is a measure of its resistance to flow. For example, mayonnaise is more viscous than water. As the viscosity of the liquid increases, so does the droplet

Table 7.1
American Society of Agricultural Engineers (ASAE) Standard (S-572) characteristics of spray droplets with code, categories, symbols, and approximate micro sizes and relative comparisons.

Table 7.1 Characteristics of Spray Droplets

ASAE[1] Standard				Comparative Size		
Symbol	**Category**	**Code**	**Approx. VMD[2]**	**Relative Size**	**Comparative Size**	**Atomization**
VF	Very Fine	Red	<100		Point of Needle (25 microns)	Fog
F	Fine	Orange	100–175		Human Hair (100 microns)	Fine Mist
M	Medium	Yellow	175–250		Sewing Thread (150 microns)	Fine Drizzle
C	Coarse	Blue	250–375			
VC	Very Coarse	Green	375–450		Staple (420 microns)	Light Rain
EC	Extremely Coarse	White	>450		#2 Pencil Lead (2000 microns)	Thunderstorm

[1]American Society of Agricultural Engineers.
[2]Volume Median Diameter.

size, thus reducing the potential for off-target movement. Formulations such as invert emulsions have a thick consistency that aids in reducing drift. Other formulations produce some spray drift when water droplets begin to evaporate before reaching the intended target. As a result, these droplets become very small and light and may move from the target site. Thus, invert emulsions have less water loss and more of the pesticide reaches the target. Several drift control additives can help reduce the potential for drift. The number of large droplets can be increased by using certain additives and thickeners. Remember, always follow the label directions about using any spray adjuvant intended for minimizing drift.

Air movement is the most important environmental factor influencing the drift of pesticides from target areas. The movement of air is influenced by the temperature at ground level and the temperature of the air above it. Warm air at the soil surface is expected to occur more often when the sun is higher in the sky and shining on the soil. Inversion conditions result when warmer air above traps cooler air located near the surface of the ground (Figure 7.3). These conditions are more likely to occur in the early morning or evening. Except in the case of temperature inversions, the early morning and evening are often the best times to apply pesticides because windy conditions are more likely to occur around midday when the temperature near the ground increases. This causes hot air to rise quickly and mix rapidly with the cooler air above it, favoring drift. The best time to spray is when the spray droplets move slowly upwards in the absence of windy or inversion conditions.

Low relative humidity and/or high temperatures also can increase the potential for spray drift. Under these conditions, the evaporation rate of water increases, resulting in smaller spray droplets that drift more easily. Avoid spraying during these times.

Reduce outdoor drift problems by spraying when the wind speed is low, by leaving an untreated border or buffer area in the downwind target area, and by spraying downwind from sensitive areas such as residential properties, schools, crops, waterways, or beehives. For reducing drift indoors, pest control operators must consider the air circulation patterns inside of buildings. Turn fans and air-conditioners off and close vents where necessary to prevent pesticides from drifting to other areas of the structure. Using low-volatile or non-volatile pesticides and by using only low-pressure treatments can reduce indoor pesticide drift problems.

Temperature Inversions

Applications made under low-wind conditions can sometimes result in more extensive drift than those made under high winds. Drift that occurs over long distances (over a mile) is most often the result of applications made under stable atmospheric conditions such as **temperature inversions.**

A temperature inversion exists when the air at ground level is cooler than the temperature of the air above

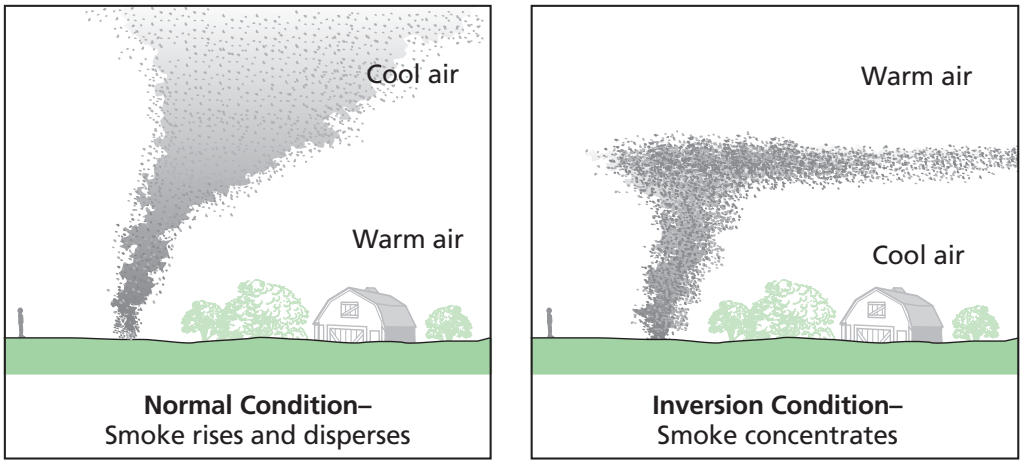


Figure 7.3
Dispersion of smoke particles under normal and inversion conditions.

Adapted from U. of C. *The Safe and Effective Use of Pesticides*

it. Under these conditions, the air is considered stable because there is little or no vertical air movement. Almost all air movement associated with inversions is sideways (lateral). This results in a high concentration of small spray droplets suspended in this layer of cool air near the ground. These droplets can then be carried long distances, especially if wind speeds increase. When the spray droplets settle out, they are still concentrated enough to cause potential damage or harm.

Inversions can occur at any time of the day and at any height above the ground, but they most often develop during the early evening hours as the ground temperature begins to cool and the warm air has already risen. They intensify during the night and may persist until midmorning, when the ground has warmed sufficiently to start the vertical mixing of air, causing a dilution and separation of suspended spray droplets. Consequently, applications made during early evening, night or morning hours under what appear to be ideal conditions can result in highly damaging drift that can move long distances. This is especially true if the humidity is high.

These stable air conditions (inversions) can be recognized by observing the movement of dust or smoke. If the dust or smoke rises little from its source and tends to hang in the air, an inversion is probably present or in the process of developing (see Figure 7.3). Another method of detecting inversions is to place a thermometer at ground level and a second thermometer high above the ground and compare the difference in temperature. If the temperature at ground level is below that found at the elevated thermometer, a temperature inversion exists. Do not apply pesticides under such conditions.

Vapor Drift

Vapor drift refers to the movement of pesticides as gaseous vapors from the target area. Some pesticides are volatile and can change readily from a solid or liquid form into a gas under the right conditions. This most often occurs with high air temperatures. Pesticides that have volatilized into a vapor or gas may drift farther and for a longer time than they would have as spray droplets. Only those pesticides that are able to volatilize are susceptible to vapor drift. As air temperatures increase, the likelihood that these pesticides will volatilize and drift also increases.

Whenever possible, choose a pesticide formulated as a low-volatility product. Avoid applying volatile pesticides on hot days. Some products can even volatilize several hours after application, so beware if high temperatures are predicted for later in the day (Figure 7.4). Many products carry precautions against applying these products when temperatures are above 85 degrees F or expected to reach 85 degrees. Remember to check label precautions for product-specific concerns about vapor drift.

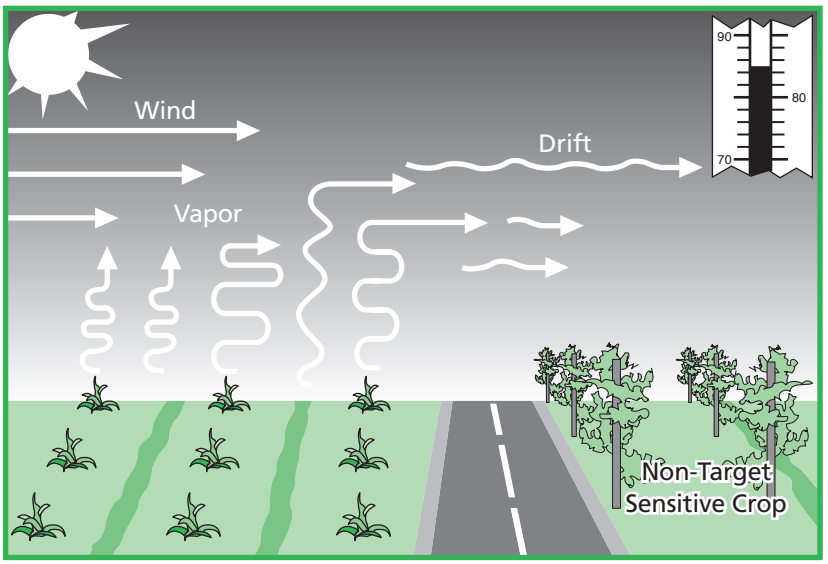


Figure 7.4
Vapor drift of pesticides is more likely to occur as heat and wind increase and the relative humidity decreases.

Particle Drift (Dust Drift)

Particle drift refers to the movement of solid particles from the target area by air during or just after an application. These solid particles may include pesticides formulated as dust or soil particles to which pesticides are attached. Some pesticides can remain active on soil particles for long periods after they are applied. If particles are blown off the target area, contamination or damage to sensitive areas can occur. To prevent particle drift from nearby outdoor pesticide applications from entering a building, be

sure to close all windows, vents, and turn off all circulating fans, forced-air heating systems, and air-conditioning units.

Univeristy of California Statewide IPM Porgram

Particle drift in a field.

For indoor applications of pesticides, reduce particle drift by turning off fans, forced-air heating systems, and other air-circulating equipment. Check pesticide labels for statements related to these concerns.

Applicator Responsibility

The applicator is ultimately responsible for managing drift. Applicators must assess the vulnerability of neighboring properties and those areas downwind of the application site. Evaluate weather conditions for temperature inversions, wind direction, and wind speed before making the all-important decision about whether to spray. The applicator may have to make adjustments to the application equipment to reduce spray drift. Consider using low-volatile formulations or adding a drift-control additive or thickener to help minimize drift. (For further discussion on equipment designed to minimize drift, see Chapter 11.) A good drift management program includes a combination of all drift-reducing techniques available for a particular application.

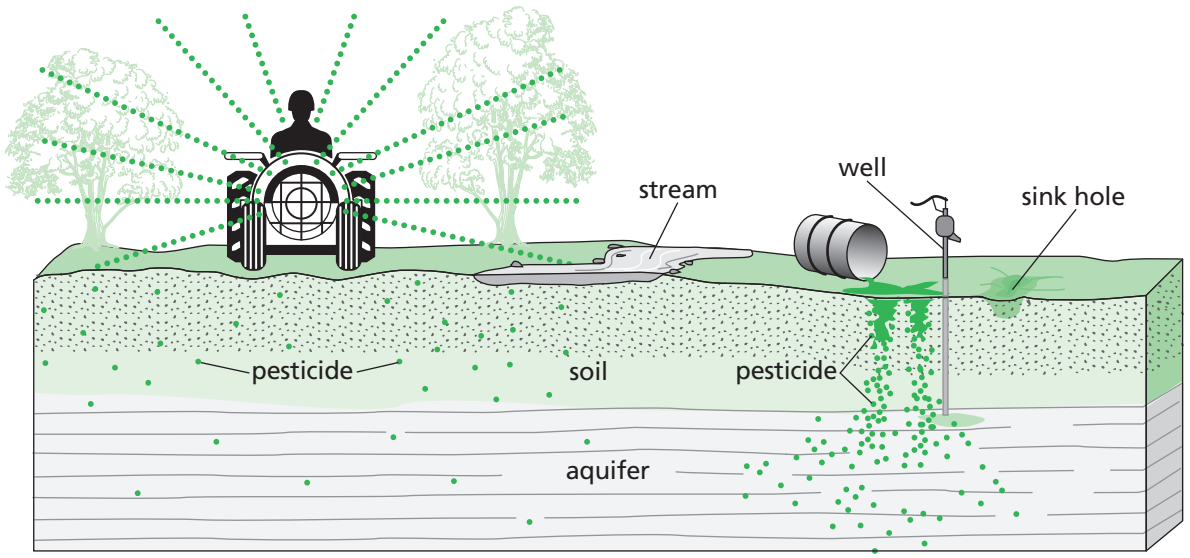
Applicators who apply pesticides indoors are also responsible for preventing drift. They must ensure pesticides do not move beyond the target site and that all people and animals are kept out of the treatment area according to label instructions.

SOURCES OF WATER CONTAMINATION

Surface water or groundwater contamination results from either **point-source** or **non-point-source** pollution (see Figure 7.5). Non-point-source pollution from pesticide applications has most commonly been blamed for pesticide contamination in the outdoor environment, but studies are revealing that water contamination also results from point-source pollution. Point-source pollution comes from a specific, identifiable place or location, such as:

- A pesticide spill entering a storm sewer.
- Back-siphoning of pesticides.
- Contaminated surface water entering sinkholes.
- Repeated spilling of pesticides at mixing and loading sites.
- Careless spilling of wash water at equipment cleanup sites.
- Improper handling of spills and leaks at storage sites.
- Improper disposal of containers, rinsate from containers, and excess pesticides.

Non-point-source pollution comes from a widespread area. The movement of pesticides into streams or groundwater following a broadcast application to an agricultural field, large turf area, or right-of-way is an example of non-point-source pollution. Indirect or non-point-source contamination of groundwater can occur when contaminated surface streams interact with shallow groundwater through subsurface flow. Normally, surface water becomes contaminated when water runs off treated fields. Runoff risk is the greatest when heavy rains immediately follow a pesticide application.



Adapted from U. of C. *The Safe and Effective Use of Pesticides*

Figure 7.5
Non-point-source pollution comes from a widespread area and point-source pollution comes from a specific identifiable place or location.

Pesticide Contamination of Surface Water

Surface water is often a source of drinking water. Therefore, pesticide contamination of surface water (ditches, streams, rivers, ponds, and lakes) is a health concern. Pesticides that move in runoff water or with eroded sediment may contaminate plants and animals located downslope and may reach sources of surface water.

Factors affecting runoff and erosion rates include slope, vegetative cover, soil characteristics, volume and rate of water moving downslope, temperature, and rainfall amount and intensity. These factors influence how much water runs off and how much moves into the soil (infiltration).

Runoff may be a problem for most outdoor application sites. In areas treated with any type of pesticide, it is critical that runoff does not carry the pesticide into water sources or other vulnerable areas.

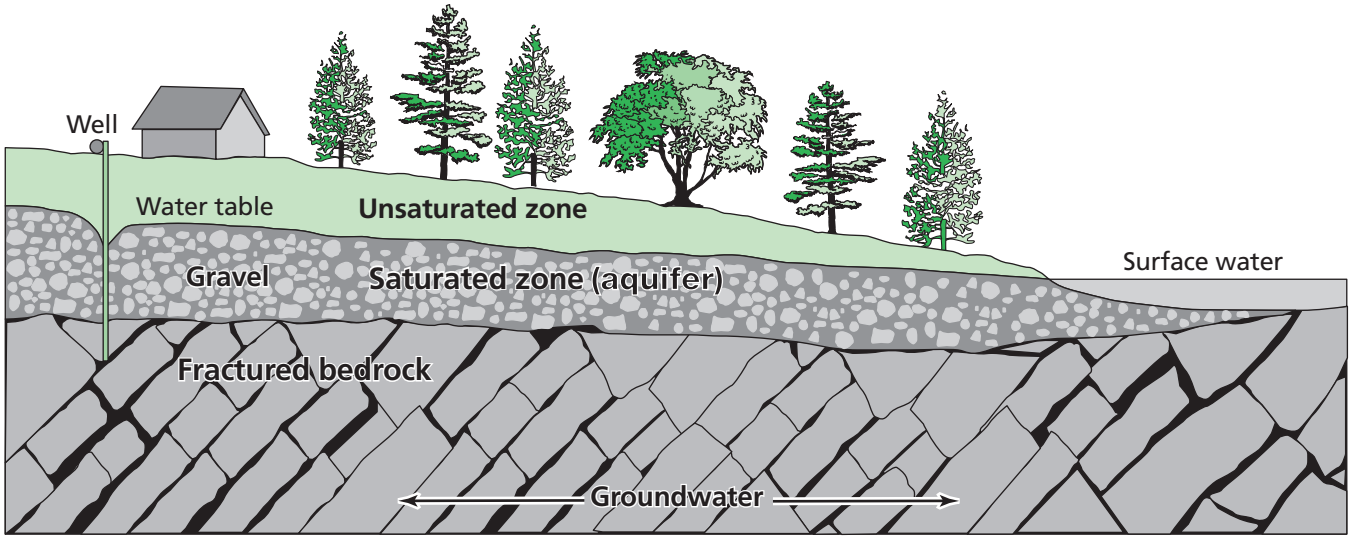
Pesticide Contamination of Groundwater

Groundwater provides 70 percent of the water used for public and private water supplies, irrigation, and industry. Like surface water, groundwater needs to be protected from contamination. Once groundwater is contaminated, correcting the problem is difficult or even impossible. Groundwater is found underground in cracks in the bedrock and in the spaces between soil particles, gravel, and rocks, and is the source of water for wells and springs.

The layer of soil, sand, gravel, or fractured bedrock in which all available spaces are filled with water is the **saturated zone.** The boundary between the saturated zone and the overlying unsaturated rock and soil is known as the **water table.** The overall geologic formation from which groundwater can be drawn is called an **aquifer** (see Figure 7.6).

Leaching

Some pesticides reach groundwater by moving through the soil in a process called **leaching.** For a pesticide to leach into groundwater, it must move down through the soil in water and resist binding to soil particles and breaking down into non-toxic compounds. A pesticide's chemical and physical characteristics influence its ability to leach into groundwater. A pesticide soluble in water can move in water into surface water or groundwater. Persistent pesticides are likely to leach and contaminate groundwater. Pesticides having high solubility, low adsorption, and/or persistence typically have a label statement informing the applicator of leaching concerns. A pesticide that adsorbs or binds itself strongly to soil particles will not leach as easily. In addition to the characteristics of the pesticide, soil properties and environmental conditions also affect the



Adapted from Penn State *Pesticide Education Manual*

Figure 7.6
Where groundwater occurs.

likelihood and extent that a pesticide will leach.

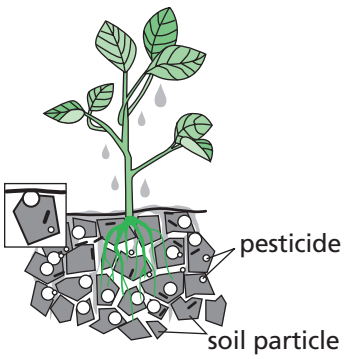
Soil Properties

Four soil properties influence a pesticide's potential for leaching—texture and structure, organic matter, depth to groundwater, and geology.

Texture and Structure

Soil texture is the relative proportions of sand, silt, and clay-sized particles. Percolating water moves faster in sandy soils, and fewer binding sites are available for the adsorption of dissolved chemicals when compared to clay or silt soils. Though sandy soils are more prone to pesticide movement, leaching may also occur in clay or silt soils.

Soil structure is the shape or arrangement of soil particles. It plays a big role in determining the size and shape of the pores through which water moves. Small amounts of pesticides may also move through soil cracks,



sandy soil (large pores)

clay soil (small pores)

Table 7.2 Soil Properties

TEXTURE (affects movement of water particles)	ORGANIC CONTENT (measures volume of water and soil's ability to adsorb pesticides)	PERMEABILITY (measures speed of water's downward movement)
coarse (sand)	**low organic content=** faster water flow and little adsorption of pesticides	↓ **high permeability** (fast flow)
smooth (clay, silt)	**high organic content=** higher water retention and greater adsorption of pesticides	↓ **low permeability** (slow flow)

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worm holes, and root channels. These features are referred to as macropores.

Organic Matter

Organic matter consists of decaying plant material. The higher the soil organic matter content, the greater the soil's ability to hold both water and adsorbed pesticides. Pesticides held in the root zone are less likely to leach into groundwater and may be taken up by plants.

Depth to Groundwater

Areas with a shallow water table have a greater chance for groundwater contamination because less soil is available to act as a filter, resulting in fewer opportunities for the pesticide to be degraded or adsorbed. When you musts use pesticides in areas where the groundwater is close to the surface, select a pesticide having a low leaching potential and take extra precautions during mixing, application, and cleanup.

Geology

The **permeability** of the geologic layers lying between the surface of the soil and the groundwater is also an important factor. Highly permeable materials such as gravel deposits allow water and dissolved pesticides to move downward to groundwater freely. Layers of clay, which are much less permeable, can inhibit and slow the downward movement of water.

PREVENTING SURFACE WATER AND GROUNDWATER CONTAMINATION

To help prevent surface water and groundwater contamination, the EPA requires that all pesticide products with directions for outdoor uses must include the environmental hazard statement on the label: "Do not apply directly to water, or to areas where surface water is present, or to intertidal areas below the mean high water mark. Do not contaminate water supplies when cleaning equipment or disposing of equipment washwaters." Pesticides, which have the potential to be found in groundwater, must bear groundwater warning statements on their labels. Groundwater statements on labels help applicators choose appropriate pesticides where soils are sandy or where extra precautions are needed to reduce contamination risk.

You can reduce the risk of point- or non-point-source contamination greatly by following best management practices (BMPs). BMPs are effective, commonsense practices that emphasize proper mixing, loading, application, and disposal of pesticides. Following these procedures greatly reduces the potential for pesticides to cause adverse effects on the environment.

Use IPM principles—Apply pesticides only when and where necessary, and only in amounts adequate to control pests. Following IPM principles, use non-chemical control methods whenever possible. When using pesticides:

- Determine the type of pest and the density of the pest population and the proper control method.
- If a pesticide is necessary, select the least toxic product that will provide adequate control.
- Calibrate pesticide application equipment regularly.
- Use spot treatments or band applications, if possible, to reduce pesticide use.

Identify vulnerable areas—The presence of sandy soil, sinkholes, wells, streams, ponds, and shallow groundwater increases the chance of groundwater contamination. Avoid pesticide application in these locations, if at all possible. Never dispose of empty pesticide containers in sinkholes or dump or rinse sprayers into or near sinkholes (see Chapter 10). Also exercise care to avoid contamination of streets, storm sewers, drainage ditches, and other potential sources of runoff to streams and waterways. Do not under

any circumstances clean tanks or intentionally discharge water from a tank of any vehicle into a street, along a road, or into a storm drain.

Do not mix and load near water— Carry out mixing and loading as far as possible (at least 50 feet) from wells, lakes, streams, rivers, and storm drains. When possible, mix and load the pesticides at the site of application. Consider using a sealed permanent or portable mixing and loading pad to prevent seepage into soil.

M.J. Weaver, Virginia Tech Pesticide Programs

Maintain an air gap between the discharge end of the water supply line and the spray tank to prevent backflow of pesticides.

Keep pesticides away from wells— Do not store or mix pesticides around wells. Poorly constructed or improperly capped or abandoned wells can allow surface water containing pesticides and other contaminants direct entry into groundwater. These wells are sometimes located in or near treated fields and other application sites.

Avoid back-siphoning— Back-siphoning is the reverse flow of liquids into a fill hose. It sucks tank contents back into the water supply. Back-siphoning starts with a reduction in water pressure and can draw very large quantities of pesticide directly into the water source. This happens when the end of the water hose is allowed to extend below the surface of the spray mixture when filling a spray tank. The simplest method of preventing backflow is to maintain an air gap between the discharge end of the water supply line and the pesticide solution in the spray tank. Keep the air gap at least twice the diameter of the discharge pipe. Another method for preventing back-siphoning is to use an anti-backflow device or check valve (see Chapter 10).

Ed Crow, Maryland Department of Agriculture

Use an anti-back flow device (check valve) to prevent back-siphoning.

Improve land use and application methods— Terraces and conservation tillage practices can reduce water runoff and soil erosion. Ideally, leave as much plant residue as possible on the soil surface to lessen erosion. Where conservation tillage is not possible, reduce runoff potential by incorporating pesticides into the soil to lower the concentration of product on the soil surface. In ornamental plantings, consider using mulches to reduce water runoff and soil erosion.

Grass buffer strips are very effective in reducing pesticide runoff because they trap sediment containing pesticides and slow runoff water, allowing more runoff water to infiltrate the soil. Leaving untreated grass strips next to streams, ponds, and other sensitive areas can trap much of the pesticide running off of treated areas.

Time pesticide applications according to the weather forecast— Pesticides are most susceptible to runoff from heavy rains or irrigation during the first several hours after application. To avoid overspraying an area and causing drift, check the pesticide label for application precautions or restrictions during windy conditions. Wind speed, temperature, and humidity all affect the off-target movement of pesticides.

Select products wisely— Whenever possible, use pesticides that are less likely to leach. Read labels for leaching warnings.

Handle pesticides safely— Follow these guidelines to prevent surface or groundwater contamination:

- Immediately contain and control pesticide spills.
- Check application equipment regularly for leaks or damage.
- Mix and load pesticides away from water sources.
- After the pesticide application is complete, follow label directions for proper equipment cleanup and container disposal.
- After applying granular pesticides, sweep or blow any granules from sidewalks, driveways, or patios onto the treatment area.

Clean sprayers at the application

site, whenever possible, and at a safe distance from wells, ponds, streams, and storm drains. Spray the rinsate on the treated area or on another site listed on the pesticide label, or use in the next tank mix. Be sure not to exceed label rates.

PREVENTING PESTICIDE EFFECTS TO SENSITIVE AREAS AND NON-TARGET ORGANISMS

To prevent adverse effects on the environment, pesticide users must be aware of sensitive areas, non-target plants and animals (especially endangered species), and harmful effects on habitat.

Sensitive Areas

In addition to water sources, sensitive areas include sites where living things could easily be injured by a pesticide. Outdoor sensitive areas include:

- Schools, playgrounds, recreational areas, hospitals, and similar institutions.
- Habitats of endangered species.
- Apiaries (honeybee sites), wildlife refuges, and parks.
- Areas where domestic animals and livestock are kept.
- Ornamental plantings, public gardens, and sensitive food or feed crops.

Sensitive areas indoors include:

- Where people live, work, shop, or are cared for.
- Where food or feed is processed, prepared, stored, or served.
- Where domestic or confined animals live, eat, or are otherwise cared for.
- Where ornamental or other sensitive plants are grown or maintained, such as in malls and buildings.

Sometimes pesticides must be deliberately applied to a sensitive area to control a pest. Only applicators who are competent in handling pesticides should perform these applications.

At other times, the sensitive area may be part of a larger target site. Whenever possible, take special precautions to avoid application to the sensitive area. Leaving an untreated buffer zone around a sensitive area is a practical way to avoid contaminating it.

In still other instances, the sensitive area may be near a site used for mixing and loading, storage, disposal, or equipment washing. The pesticide user must take precautions to avoid accidental contamination of the sensitive area. Check the label for statements that alert you to special restrictions around sensitive areas.

Scott Bauer, USDA ARS

Sensitive area—apiary.

Pesticide Effects on Non-target Organisms

Pesticides may affect non-target organisms directly causing immediate injury, or may produce long-term consequences through environmental pollution. When pesticides build up in the bodies of animals or in the soil, they accumulate. If you use the same mixing and loading site or equipment cleaning site over a long period, pesticides are likely to accumulate in the soil. When this occurs, plants and animals that come into contact with the soil may be harmed. The following sections discuss the effects of pesticides on non-target plants; bees and other beneficial insects; and fish, wildlife, and livestock.

USFWS

Sensitive area—wildlife habitat.

C. Randall, MSU

Sensitive area—playground.

Non-target Plants

Nearly all pesticides can cause plant injury due to chemical exposure (**phytotoxicity**), particularly if they are applied at too high a rate, at the wrong time, or under unfavorable environmental conditions. Phytotoxicity can occur on any part of a plant—roots, stems, leaves, flowers, or fruits. Most phytotoxic injury is due to herbicides. Damage to crops or other plants in

Edward Crow, Maryland Department of Agriculture

Avoid pesticide effects to non-target plants.

USDA

Avoid spraying when bees are actively foraging.

adjacent areas is primarily caused by drift, though it may sometimes be a consequence of surface runoff.

Bees and other Beneficial Insects

Bees pollinate many fruit, seed, vegetable, and field crops. Applicators must be aware of bee activity when planning pesticide applications. Preventing bee loss is the joint responsibility of the applicator, the grower, and the beekeeper. Before applying pesticides toxic to bees, notify beekeepers in the area so they can protect or move their bee colonies. Minimize losses of bees to insecticide poisoning by following a few basic principles:

- Read the label and follow label directions.
- Determine whether bees are foraging in the target area so you can take protective measures.
- Whenever possible, use pesticides and formulations least hazardous to bees. Emulsifiable concentrates are safer than powders and dust formulations. Granules are the safest and least likely to harm bees. Microencapsulated pesticides pose the greatest risk to bees.
- Choose the least hazardous application method. Ground applications are less hazardous to bees than aerial applications.
- Apply chemicals in the evening or during early morning hours before bees forage. Evening applications are generally safer to bees than morning applications. If unusually warm evening temperatures cause bees to forage later than usual, delay the pesticide application.
- Do not spray crops in bloom except when necessary.
- Do not spray when weeds or other plants around the treatment site are in bloom.
- Do not treat an entire field or area if spot treatments will control the pest.

Craig Koppie, USFWS

Pesticides can be harmful to all kinds of animals.

Pesticides can harm other beneficial insects in addition to bees. Often these beneficial insects are valuable allies in keeping pest populations below damaging levels. A pesticide application often harms the beneficial insect population as much as the target pest, so do not spray when beneficial insects are in the target area except when absolutely necessary.

Fish, Wildlife, and Livestock

Pesticides can be harmful to all kinds of animals. Most injuries occur from the direct effects of acute poisoning. Fish kills often result from water pollution by a pesticide. Fish kills are most likely to be caused by insecticides, especially when small ponds or streams are under conditions of low water flow or volume.

Bird kills resulting from pesticide exposure can occur in a number of ways. Birds may ingest pesticide granules, baits, or treated seeds; they may be exposed directly to sprays; they may consume treated crops or drink contaminated water; or they may feed on pesticide-contaminated insects and other prey. Granular or pelleted formulations are a particular concern because birds and other animals often mistake them for food. Other formulations (liquid) may be safer when birds and other wildlife are in or near the treated area. Place baits properly so they are inaccessible to pets, birds, and other wildlife.

Animals can also be harmed when they feed on plants or animals carrying pesticide residues. Predatory birds or mammals feeding on animals killed by pesticides are a special concern. Pesticide residues remaining on or in the bodies of the dead animal may harm predators. This is called **secondary poisoning.** Check the pesticide label for statements about secondary poisoning.

The less obvious effects that occur from long-term exposure to pesticides

are a major concern. For example, certain pesticides have been banned because of fish and bird kills and reproductive failures of several bird species.

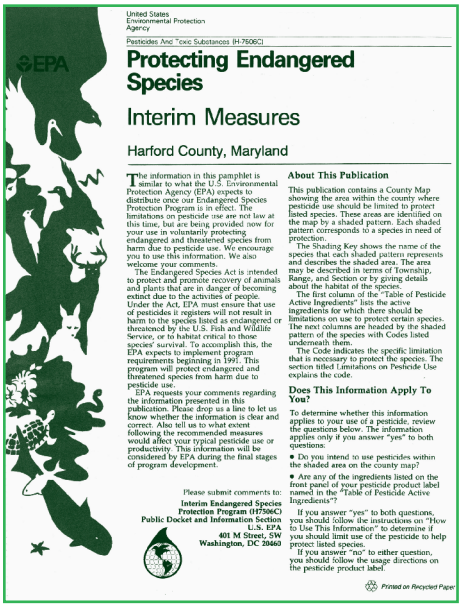
The most important source of livestock poisoning by pesticides has been through contaminated feed, forage, and drinking water. Contamination often occurs as a result of improper or careless transportation, storage, handling, application, or disposal of pesticides.

PROTECTING ENDANGERED SPECIES

Certain plants and animals have been identified as endangered or threatened species. Make every effort to avoid causing harm to these populations. Because all living things are part of a complex, delicately balanced network, the removal of a single species can set off a chain reaction that affects many others. The full significance of an extinction is not always readily apparent, and the long-term effects are often difficult to predict.

An **endangered species** is one on the brink of extinction throughout all or a significant portion of its range. A **threatened species** is one likely to become endangered in the foreseeable future. The reasons for a species' decline are usually complex, and thus recovery is difficult. A major problem for most wildlife is the destruction of habitat, usually the result of industrial, agricultural, residential, or recreational development.

Each state is responsible for implementing the federal Endangered Species Protection Program in cooperation with the EPA to protect endangered and threatened species from the harmful effects of pesticides. Under this program, pesticide products that might adversely affect an endangered species carry a label statement instructing applicators to consult a county bulletin to determine if they must take any special precautionary measures when using the product. The EPA develops these bulletins, which identify precautionary measures required in each county where one or more pesticides could affect an endangered or threatened species. Precautionary measures may include buffer strips, reduced application rates or timing restrictions, or an applicator might be prohibited from using the pesticide within the identified habitat altogether. Check with your state lead agency, local Extension Service, or the EPA web site (www.epa.gov) to find out the status of available county bulletins.


United States
Environmental Protection
Agency

Pesticides And Toxic Substances (H-7506C)

EPA

Protecting Endangered Species

Interim Measures

Harford County, Maryland

The information in this pamphlet is similar to what the U.S. Environmental Protection Agency (EPA) expects to distribute once our Endangered Species Protection Program is in effect. The limitations on pesticide use are not law at this time, but are being provided now for your use in voluntarily protecting endangered and threatened species from harm due to pesticide use. We encourage you to use this information. We also welcome your comments.

The Endangered Species Act is intended to protect and promote recovery of animals and plants that are in danger of becoming extinct due to the activities of people. Under the Act, EPA must ensure that use of pesticides it registers will not result in harm to the species listed as endangered or threatened by the U.S. Fish and Wildlife Service, or to habitat critical to those species' survival. To accomplish this, the EPA expects to implement program requirements beginning in 1991. This program will protect endangered and threatened species from harm due to pesticide use.

EPA requests your comments regarding the information presented in this publication. Please drop us a line to let us know whether the information is clear and correct. Also tell us to what extent following the recommended measures would affect your typical pesticide use or productivity. This information will be considered by EPA during the final stages of program development.

Please submit comments to:
Interim Endangered Species Protection Program (H7506C)
Public Docket and Information Section
U.S. EPA
401 M Street, SW
Washington, DC 20460

About This Publication

This publication contains a County Map showing the area within the county where pesticide use should be limited to protect listed species. These areas are identified on the map by a shaded pattern. Each shaded pattern corresponds to a species in need of protection.

The Shading Key shows the name of the species that each shaded pattern represents and describes the shaded area. The area may be described in terms of Township, Range, and Section or by giving details about the habitat of the species.

The first column of the "Table of Pesticide Active Ingredients" lists the active ingredients for which there should be limitations on use to protect certain species. The next columns are headed by the shaded pattern of the species with Codes listed underneath them.

The Code indicates the specific limitation that is necessary to protect the species. The section titled Limitations on Pesticide Use explains the code.

Does This Information Apply To You?

To determine whether this information applies to your use of a pesticide, review the questions below. The information applies only if you answer "yes" to both questions.

- Do you intend to use pesticides within the shaded area on the county map?
- Are any of the ingredients listed on the front panel of your pesticide product label named in the "Table of Pesticide Active Ingredients"?

If you answer "yes" to both questions, you should follow the instructions on "How to Use This Information" to determine if you should limit use of the pesticide to help protect listed species.

If you answer "no" to either question, you should follow the usage directions on the pesticide product label.

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Consulting a county bulletin is necessary for pesticides that might adversely affect endangered species.

SUMMARY

Regulation is necessary in the use and classification of pesticides because of their potential hazard to humans and the environment. An important part of using pesticides responsibly is considering where the pesticide is going once it leaves the container and whether there might be any adverse effects on non-target sites, plants, or animals. The user must understand the characteristics of the pesticide (its solubility, volatility, adsorption, and persistence) and how the pesticide might move in the environment (as in the air by drift or through water by leaching and runoff) to know how to prevent unwanted effects.

If pesticides are applied correctly at the right time, in the right location, and with the proper application technique, the user can do a lot to prevent drift, runoff, and leaching. You can reduce or prevent drift by considering the method of application, the spray droplet size, and the speed and direction of the wind. In general, applying pesticides closer to the ground and using larger droplets reduces drift potential. Other factors to consider for preventing drift include the physical

Jim Reid, USFWS

Endangered species need to be protected from pesticides.

properties of the liquid, air stability, humidity, and temperature, and the volatility of the pesticide formulation.

Pesticides that enter groundwater and surface water through runoff and leaching present a hazard to aquatic organisms, plants, and wildlife, and may enter drinking water. Factors affecting runoff include slope, vegetative cover, soil characteristics, volume and rate of water moving downslope, temperature, and rainfall amount and intensity. Some of these factors also affect leaching of pesticides as do soil properties: texture and structure, organic matter content, the depth to groundwater, and the geology of the area. Consider these factors before applying pesticides in an area. Several techniques or "best management practices" can prevent groundwater and surface water contamination from pesticides, such as identifying vulnerable areas, not mixing or loading near water, keeping pesticides away from wells, and avoiding back-siphoning.

Other important environmental considerations arise in sensitive areas. These are areas where pesticides present a greater risk of injury, such as to schools, playgrounds, endangered species habitats, and ornamental plantings. If it is necessary to make an application in these areas, make sure the pesticide applicator is well trained and knows how to apply the pesticide properly to reduce risk to people, plants, or animals in the area. Non-target organisms include plants, bees and other beneficial insects, fish, wildlife, and livestock. To avoid exposing non-target organisms to pesticides, applicators must know when and how exposures might occur and adjust their application practices accordingly. To prevent harmful effects on habitats, pesticide handlers also must avoid the buildup of pesticides at a site. For example, using the same mixing, loading, and cleanup site over a long time will result in the accumulation of pesticides in the soil. Pesticide handlers need to alternate locations for these activities or use some kind of containment system such as a mixing and loading pad to prevent pesticide buildup.

Pesticide handlers must be aware of any endangered or threatened species inhabiting the area to be treated. Always check the label for statements on endangered and threatened species. It may be necessary to consult a county bulletin that details the procedures for protecting them. It is the pesticide handler's responsibility not only to follow label directions but also to use the best management practices that present the least risk to the environment while achieving effective pest control.