A Self-Learning Resource From MSU Extension

Pesticides and the Environment

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MONTANA STATE UNIVERSITY EXTENSION MontGuide

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Proper pesticide use results in considerable cost savings for applicators without impacting non-target organisms. Improper use of pesticides may cause economic losses due to toxicity toward non-target plants, humans, animals and water sources. This is often the result of spraying under poor environmental conditions, off-label applications or a pesticide spill.

THE UNINTENDED MOVEMENT OF PESTICIDES

off target may result in contaminated water, toxicity of desirable plants or pesticide poisoning of humans or animals. It is critical to understand how pesticides move in the environment while reading and following the pesticide product label. Applicators can further mitigate any environmental contamination by using proper integrated pest management (IPM) techniques, cleaning pesticide spills and properly storing pesticides.

Off-Label Use of Pesticides

Always read and follow the product label requirements when applying pesticides. An off-label application is an illegal application that is not made according to the pesticide product label. Some common mistakes made by applicators are:

- applications made to improper sites
- improper application rates
- failure to read and follow the Environmental Hazard or Use Precaution statements on the pesticide product label.

(USDA, Charles O'Rear, April 2008)

Site/Location on a Pesticide Label

Applicators should only purchase and use pesticides which are labeled for use on their particular spray site or location. Pesticide products which may be used for home and garden use may be labeled with generic statements such as HOME and GARDEN USE, ORNAMENTAL, or ORNAMENTAL and TURF. Other products may be labeled only for use on agricultural sites. In addition, many pesticides will list a specific crop(s) which the pesticide can be used on. Some examples include alfalfa, beans, raspberries or wheat. The use of a pesticide on a site or crop not on the pesticide product label is not only against the law but may damage or kill non-target plants.

Never use a pesticide labeled for agricultural sites on your lawn, garden or ornamentals even if specific plants are on the pesticide product label. These products often have higher toxicity than home and garden products and are only available in larger containers that homeowners often cannot safely use or store.

Improper Application Rates

Pesticides may cause damage to the environment when applicators use improper product rates. Pesticides applied above the rate indicated on the pesticide product label may cause non-target plant injury, leach into ground or surface water, or poison other beneficial arthropods, fish, birds or animals.

Applicators must read and follow the correct application rates according to the pesticide product label. Pesticide treatment rates often vary by application site or target pest. Many RTU (ready to use) formulations don't need calibration, however,

applicators should still read and follow the specific spray directions on the product label to determine how the product should be applied. RTU formulations often direct the user not to saturate plants until dripping, and most formulations recommend uniform coverage of plants.

If you are using a non-RTU formulation, remember to always calibrate your sprayers. A non-calibrated sprayer will deliver unknown application rates which may cause toxicity towards non-target plants or offer inadequate control of pests. Sprayers should be calibrated at least annually. When calibrating your spray equipment refer to the MSU Extension MontGuides, *Calibrating Ground Sprayers Using Shortcut Methods* (MT200915AG) or *Calibrating Pesticide Application Equipment* (MT200914AG). These MontGuides can be downloaded on the MSU Pesticide Education website at www.pesticides.montana.edu/Reference or ordered directly from MSU Extension Distribution (406-994-3273).

Pesticide product label recommendations are often specific.

- A pesticide product label which is labeled for use on maple trees may cause toxicity towards an off-label poplar tree.

- A pesticide product label which is labeled for use on wheat crops may cause toxicity towards off-label alfalfa.

It is illegal to apply a pesticide product above the pesticide product rate indicated on the product label.

Environmental Hazards

It is not unusual to hear of reports of negative consequences from pesticide use, including fish kills, honeybee mortality, contaminated wells, or bird mortality. The environmental hazard statement provides precautionary language to prevent negative environmental consequences from transport, use, storage, or spill of an applicators pesticide product.

The environmental hazard section is found under the general heading "Precautionary Statements," and relates to a pesticide's potential impacts on water, soil, air, beneficial insects, plants, and/or wildlife. Some statements relate to ground water advisories restricting applications in areas with shallow groundwater, while other statements include surface water advisories or non-target advisories. Non-target advisories are based on acute toxicity studies on invertebrates, birds, mammals, fish, or bees (Table 1).

Montana has a large bee-keeping industry. Due to this, care should be taken when applying broad-spectrum insecticides. Many pyrethroid insecticides can still be used if applied when bees are inactive, or if used on non-flowering crops.

Use Precautions

Many pesticide products contain restrictions under the heading, USE PRECAUTIONS, on the pesticide product label. This statement may be followed by information regarding planting restrictions, grazing, manure, or composting restrictions.

Pesticide product labels which contain *planting restriction* statements restrict the use of the pesticide on sites which will be planted or rotated to susceptible crops. Some broadleaf herbicides persist in the soil for years, thus limiting the planting of many broadleaf plants for one or more seasons.

Grazing restrictions, often due to mammalian toxicity, usually restrict the grazing of livestock for a specified period of time on sites sprayed with pesticides. Some pesticides recommend a waiting period of 48 hours prior to the resumption of livestock grazing.

Pesticides may have *plant residue or manure restrictions* on the pesticide label. Due to the persistence of some pesticides, grass clippings collected from sprayed sites should not be used as a soil amendment.

TABLE 1. Honey Bee Toxicity Groups and Cautions.

Category	Acute LD50/bee	Precautionary Statements
I	<2 micrograms	Highly Toxic to Bees
II	2–11 micrograms	Toxic to Bees (caution)
III	>11 micrograms	No Bee Caution Required

Similarly, manure should not be collected and used as a soil amendment from livestock which are grazing on sprayed sites, as the manure may cause non-target toxicity on susceptible crops at a separate location. It may be necessary to remove livestock from sprayed pastures for a period of time before collecting manure which will be used in other locations.

Direct Movement of Pesticides onto Non-Target Areas

The movement of pesticides from target site to non-target site often causes toxicity symptoms on a non-sprayed site that may not be easy to explain. Pesticides can move through drift, leaching or run-off. For more information on pesticide contaminated soil amendments see the MontGuide, *Minimizing Pesticide Contaminated Soil around the Home and Garden* (MT201008AG).

Drift

Montana applicators can expect to make hard decisions regarding spraying on windy days at some point in their lifetime. According to surveys, sixty percent of Montana private applicators indicate they sprayed when they knew it was too windy (Tharp 2009). An applicator is subject to civil or criminal penalties if they use pesticides in a manner that results in harm or reasonable potential harm to organisms or the environment from pesticide drift. The movement of pesticide through air currents is mainly influenced by droplet size, nozzle height, wind speed, and air temperature.

Droplet size: Droplet size is influenced by nozzle size and spray pressure. High pressure produces smaller droplets which increase drift, while low pressure produces larger droplets which decrease drift. An applicator should always select the coarsest droplet size which will provide sufficient coverage and pest control.

Nozzle Height: As nozzle distance is increased from the spray canopy, drift increases. Many applicators will lower spray nozzles to minimize drift. This should be used with caution as most spray patterns are sensitive to a narrow range of distances from the spray canopy. At times, applicators lowering nozzles excessively will deliver non-uniform spay patterns.

Wind: Applicators should not apply pesticides at wind speeds greater than 10 mph. Do not spray when wind is likely to carry pesticide off target.

Air Temperature: Higher temperatures reduce droplet size, thus increasing drift. Applicators should not apply pesticides at temperatures greater than 85°F. Higher temperatures may also convert some droplets to a gas through a process known as volatilization. Some volatile active ingredients are dicamba, 2,4-D esters, and clomazone.

An applicator can reduce the potential for drift by understanding weather in the spray area. High wind and extreme temperatures can often be avoided by spraying in the morning or evening hours. Temperature inversions should be avoided while applying pesticides (Figure 1).

Leaching / Runoff

The movement of pesticides through the soil is called leaching, while the movement of pesticide over the soil surface is called runoff. The ability of a pesticide to move over or through the soil depends on a pesticides characteristics, soil texture, and environmental conditions.

Pesticide movement is influenced by three characteristics including: 1) solubility, 2) persistence, and 3) adsorption potential. Solubility is the ability of a pesticide to absorb into water. Highly soluble pesticides move easier through the soil profile than non-soluble pesticides. The ability of a pesticide to persist in its original state is termed persistence. Persistence is often

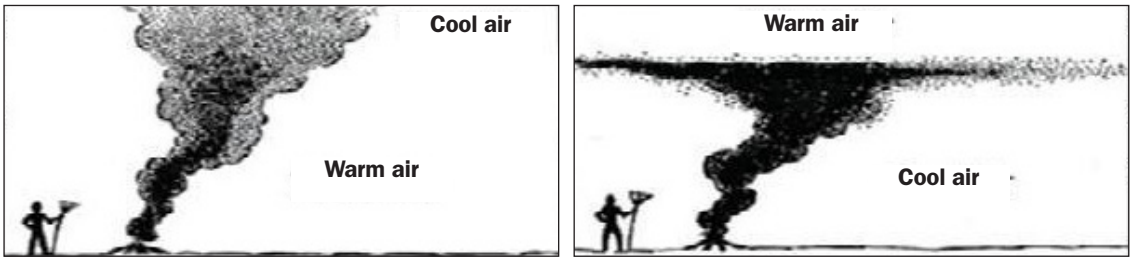

FIGURE 1. Do not spray during a temperature inversion. An inversion occurs when cold air next to the ground is trapped by warmer air above.

expressed as a pesticide's rate of decay or half-life. The third pesticide characteristic is adsorption. Adsorption occurs when a pesticide binds readily to soil particles. Pesticides with a high coefficient of adsorption bind readily to soils and move very little in the environment. Adsorption occurs when positively charged pesticide molecules bind readily with negatively charged soil molecules. The active ingredient, glyphosate, binds readily to soils, while picloram has a low coefficient of adsorption, causing it to move readily through the soil. Refer to Table 3 on page 7 to view how a pesticide's solubility, adsorption, and persistence form its overall movement potential.

Homeowners/applicators should also understand their soil characteristics. Water moves readily through sandy or porous soils, while clay soils decrease leaching and increase runoff. Organic material within the soil also can impact the movement of pesticides. Organic matter in the soil binds readily to pesticides, thus decreasing leaching. Soil low in organic matter increases infiltration into the soil profile. Some soils are classified into riparian zones, or zones with high ground water (less than 10 feet). The threat of leaching into groundwater is much higher in areas with high groundwater. Certain pesticide product active ingredients (picloram) should not be used in areas with high ground water.

A pesticide's chemical characteristics which impact the environment can be understood by reading the 'Environmental Hazards' and 'Use Precautions' statements on the pesticide product label.

An applicator may further reduce the risk of leaching or runoff by not applying pesticides immediately prior to precipitation, using check valves on all hoses used to fill tanks (to prevent back siphoning of contaminated water into well), cleaning up pesticide spills immediately, and properly storing and disposing of pesticide containers.

Integrated Pest Management (IPM)

Pesticides should not be used in all situations, especially around the home and garden where alternative pest management tactics are possible. Integrated pest management (IPM) should be used at all times to minimize pesticide use while maximizing benefits. Integrated pest management is a pest management strategy that uses a balanced combination of biological, chemical, cultural, mechanical, and regulatory methods to reduce not only pest damage but also to minimize human and environmental health risks.

Most pest situations have multiple management options available. Instead of herbicides for weed control an applicator could consider using weed resistant covers, manual pulling or promoting narrow row spacing to provide a thick weed resistant canopy. Instead of chemicals for insect control, the use of floating row covers, chickens as a natural predator, or preserving beneficial predatory insects may be desirable options for managing insect populations.

The use of all options including cultural, biological, physical, mechanical and chemical control is far superior to any single option.

TABLE 2. Pesticide persistence in soils.

Low Persistence (half-life < 30 days)	Moderate Persistence (half-life 30 - 100 days)	High Persistence (half-life > 100 days)
Aldicarb	Aldrin	Bromacil
Captan	Atrazine	Chlordane
Dalapon	Carbaryl	Lindane
Dicamba	Carbofuran	Paraquat
Malathion	Diazinon	Picloram
Methyl Parathion	Endrin	Trifluralin
Permethrin	Parathion	DDT
2, 4-D	Glyphosate	—
2, 4, 5-T	Heptachlor	—

The Breakdown of Pesticides in the Soil

Pesticide breakdown is dependent on microbial, chemical, and photo-degradation. The rate of pesticide degradation relates to the 'persistence' of a pesticide. Even when persistence is known, a pesticide's degradation rate often can only be generally determined as the degradation rate is dependent on soil pH, moisture, aeration, soil texture, and available sunlight. Pesticide persistence will give an applicator the general decay rate of the pesticide under normal environmental conditions (Table 2). For more information on the breakdown of pesticides in the soil see the MontGuide, *Minimizing Pesticide Contaminated Soil around the Home and Garden* (MT201008AG).

One of the most important degradation reactions is hydrolysis. Many organophosphates, carbamates and 2,4-D formulations are sensitive to hydrolysis from alkaline conditions. These pesticides will break down in a matter of hours when mixed with alkaline (pH > 7.5) water (Ohio State University Extension, 2003).

Pesticide Spills

Most applicators will encounter a pesticide spill at some point in their lifetime. According to Montana surveys, 65 percent of Montana private applicators neglect to clean up at least one pesticide spill at some point in their career (Tharp 2009). For this reason, it is always important to prepare for a pesticide spill by creating a spill response kit which includes:

- Telephone numbers for emergency assistance.
- Personal Protective Equipment.
- Containment tubes or pads.
- Absorbent materials such as spill pillows, sawdust, cat litter, or activated charcoal.
- A broom, dustpan, and/or shovel (depending on situation).
- Heavy-duty detergent
- A sturdy leak-proof container to catch leaks.

Always follow the ***three c's*** in the event of a chemical spill. The three c's are *control, contain,* and *clean up.* Before trying to respond to a spill, always wear personal protective equipment (PPE) to protect yourself. PPE is described on your pesticide product label.

Controlling the pesticide spill. Stop the source of the spill. For example, if the spill is from a broken hose, turn off the valve that releases pesticide to the hose. Small containers can often be placed into larger containers.

Contain the pesticide spill. Applicators should keep pesticides from spreading. Build a dam, barrier, or place self absorbent materials around the spill to contain the spill. Care should be taken to ensure pesticides don't spill into any local water source, including storm sewers, drains, creeks, ponds, or groundwater.

Never flush a pesticide spill with water as this will only transport pesticide into non-target areas.

Clean up pesticide spill. Clean up of pesticide spills includes removing the pesticide while adding neutralizing chemicals to spill area. You may use kitty litter, sawdust or floor sweeping compounds to soak up pesticides on any cement floors. After sweeping up pesticide contaminated materials, neutralize the pesticide spill site by applying household bleach (30 percent), hydrated lime, or a commercial preparation. **Do not mix bleach and lime together.** Sweep this up and place in a leak proof container.

If pesticides spill onto soil you may need to follow a different procedure. At times it is necessary to dig pesticide contaminated soil out of the ground and place in leak proof containers for hazardous waste disposal. You must remove at least the top two to three inches of soil when it becomes contaminated, and often much more soil if the pesticide has infiltrated into the soil profile. An applicator can then apply two inches of lime before covering the lime with soil. Always clean up all pesticide contaminated equipment and personal protective equipment prior to leaving the contaminated site to minimize future contamination.

Call the Montana Department of Agriculture, 406-444-5400, to report spills in excess of five gallons or 100 pounds of total pesticide mix. You may also contact CHEMTRAC for emergency response information at 1-800-424-9300.

Pesticide Storage

Pesticides should be stored in a locked and posted facility that is cool, dry, and out of direct sunlight. Never store pesticides in your home, near food, animal feed, fertilizer, seed, veterinary supplies, or other stored products.

Pesticide spills often occur where pesticides are stored. For this reason, applicators should focus on storing as little pesticide product as possible, and purchase only what you will use in the near future. Excess pesticides should never be stored or transferred in alternative pesticide containers. Always store pesticides in their original product container. Alternative containers often are not labeled properly which may lead to ingestion, misapplication, or general misuse.

Excess pesticides should only be sprayed out on a site listed on the pesticide product label at a rate listed on the product label. Excess pesticides should never be dumped into sinks, gutters, or into any field location.

Conclusions

By reading and following the product label, storing your pesticides properly, and cleaning up spills immediately, applicators should be able to minimize environmental contamination from pesticide applications. If you suspect pesticide contamination on your property contact your local MSU Extension office or the MSU Pesticide Education Program at:

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www.pesticides.montana.edu

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Tharp, Cecil I. 2009. Private Applicator Surveys – MSU Pesticide Education Program. MSU Extenstion Report. http://pesticides.montana.edu

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TABLE 3. Overall pesticide movement ratings, which take into account persistence, water solubility, and sorption potential of many common active ingredients.

Common Name	Pesticide Movement Rating	Soil half-life in Days (Persistence)	Water Solubility mg/l	Sorption Coefficient KOC
2,4-D dimethylamine salt	Moderate	10	796,000	20
Acephate	Low	3	818,000	2
Aldicarb	High	30	6,000	30
Benomyl	Low	67	2	1,900
Bifenthrin	Very Low	26	0.1	240,000
Captan	Very Low	2.5	5.1	200
Carbaryl	Low	10	120	300
Carbofuran	Very High	50	351	22
Chlorpyrifos	Very Low	30	0.4	6,070
Diazinon	Low	40	60	1,000
Dimethoate	Moderate	7	39,800	20
Endosulfan	Very Low	50	0.32	12,400
Esfenvalerate	Very Low	35	0.002	5,300
Glyphosate isopropylamine	Very Low	47	900,000	24,000
Malathion	Very Low	1	130	1,800
Methomyl	High	30	58,000	72
Methyl Bromide	Very High	55	13,400	22
Methyl Parathion	Very Low	5	60	5,100
Picloram Salt	Very High	90	200,000	16
Permethrin	Very Low	30	0.006	100,000
Simazine	High	60	6.2	130
Triclopyr amine salt	Very High	46	2,100,000	20
Trifluralin	Very Low	60	0.3	8,000

Information gathered from the National Pesticide Information Center (Oregon State University, http://npic.orst.edu/ppdmove.htm) and Ohio State University Extension.

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