

# MU Guide

## Controlling Drift of Crop Protection Materials

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The movement of crop protection materials away from their intended target poses several possible problems. Besides the economic damage to nearby susceptible crops, possible problems include less effective weed control, airborne contamination of streams and lakes, and the social and financial costs resulting from the accidental damage that drift can cause to a neighbor's ornamental or commercial plants.

Minimizing drift is a moral responsibility to neighbors and it is in one's own ethical and financial interests to protect neighbors from the potential for damage to their crops, landscape plants, gardens, lawns, and other vegetation. Drift damage to neighboring vegetation can be a serious problem depending on how that vegetation is valued and whether the damage is permanent or temporary. Crop protection materials are also poorly understood by the public, which causes anxiety and sometimes overreaction to a problem. Drift can lead to litigation, financially damaging court costs and appeals to restrict or ban the use of crop protection materials.

### Drift

Drift is the movement of crop protection materials from their intended target to any other area. Drift is sometimes referred to as *off-target placement*.

The most serious consequence of drift is the long-term effect it can have on the legal restrictions placed on the use of crop protection materials. Applicators have both a legal and ethical obligation to minimize the chance of off-target placement of herbicides. Controlling drift is a win-win activity. Properly placed crop protection materials reduce costs, protect the environment and preserve the use of these materials to provide for a safe, healthful and abundant food supply.

### Drift

Drift can be classified broadly into two categories – vapor drift and particle drift. The more common problem is particle drift, which occurs when small droplets

are blown off-target by the prevailing wind. Damage to nontarget susceptible vegetation from vapor drift is a less common problem, but can have devastating effects on areas remote from the application site.

### Vapor drift

A small amount of vapor is formed during any spraying application and usually disperses into harmless concentrations. A concentration of vapors sufficient to cause serious damage to nontarget plants is most likely to occur when winds are calm. The surprising conclusion is that light winds also warrant special precautions.

The classic example of vapor drift is herbicide damage to plants not adjacent to the application area. Vapor drift has been known to affect areas as remote as several miles from the target. Hence, the source and cause of damage to areas affected by vapor drift can be difficult to resolve and vapor drift is suspected when all other logical explanations have failed.

Although serious problems due to vapor drift are somewhat rare, the cause of vapor drift is associated with a common atmospheric condition known as a temperature *inversion*, where surface air is cooler than air immediately above. The stability of an inversion reduces mixing and allows concentrations of vapors to form above the ground. These concentrations may move slowly across the landscape until they encounter more unstable air, where they may be deposited in a large enough concentration to damage susceptible nontarget plants.

Temperature inversions are most likely to occur whenever the sun is low or at night. Recognize the potential for an inversion when winds are light or undetectable, especially during early morning hours after a clear night. Use caution when you suspect an inversion. A smoke trail provides good visual evidence of how vapors will behave. Light a smoke bomb and note the direction and behavior of the smoke. Smoke that rises and disperses is a good sign. Smoke that travels slowly near the surface indicates that conditions are favorable

for vapor drift. An hour of bright sun or a 5- to 10-degree temperature rise in the morning is usually enough to break up an inversion. Heavy cloud cover during the night acts as a blanket, which reduces radiant cooling of the earth's surface and reduces the potential for an inversion.

### Inversions

Temperature inversions, as the name implies, are a reversal of normal daytime temperature gradients in the atmosphere. During daylight hours, especially under full sun, temperatures decrease at higher altitudes. Radiant energy from the sun warms the earth by warming the soil and other surfaces. Hence, the usual condition is for air temperatures to be warmer near the ground. Because warm air rises, this condition causes the air below to mix with the air above. The mixing air causes vapor to disperse and become dilute.

A temperature inversion occurs when heat is radiated away from the earth during the night to the relative darkness of space. Surface air becomes cooler and denser than air in the upper atmosphere. When cool air is already lower than warm air, the air is stable and doesn't mix well. The stable air of an inversion causes the air to stagnate and allows vapors to become concentrated near the surface.

Vapor drift can occur with all product formulations, but is generally higher for more volatile spray formulations, e.g., esters as opposed to amines. A volatile formulation readily evaporates into small particles that are affected more by air movement than by gravity.

That old saying often heard when small rains come when it's hot and dry — "That little amount of rain we got evaporated before it hit the ground" — has some truth to it. Hot, dry air increases evaporation rates and quickly reduces droplet size, increasing the risk of drift. Spraying when temperatures are cool and humidity is high, such as during the morning hours minimizes volatilization. Wet soil increases the rate of volatilization and decreases the effectiveness of soil incorporation; both effects increase the risk of vapor drift of soil-applied volatile herbicides.

### Particle drift

Particle drift is the most recognized type of drift. Although drift can't be eliminated, particle drift can be reduced to very low levels through proper nozzle selection, equipment operation and other management choices.

Nozzle selection affects practically every aspect of particle drift. Various nozzles are available providing many choices of droplet size and spectrum. Ideally, nozzles should produce only a narrow range of droplet sizes. However, in addition to droplets about the right size for good coverage for a particular application, nozzles generally produce a few larger droplets and many smaller droplets that are prone to drift.

The term *volume median diameter* (VMD) is used to indicate the relative droplet size of a volume of spray from a nozzle. Droplet size is measured in microns. A micron is one millionth of a meter. A human hair is about 100 microns thick and not too difficult to see because it has length. Without a magnifying glass, though, particles or water droplets less than 100 microns in diameter are practically invisible.

A VMD of 400 microns means that half the volume of spray will be droplets that have a diameter of less than 400 microns and the other half of the volume of spray will be droplets larger than 400 microns. Because smaller droplets have much less volume than larger droplets, most of the droplets will be smaller than the VMD (see Figure 1).

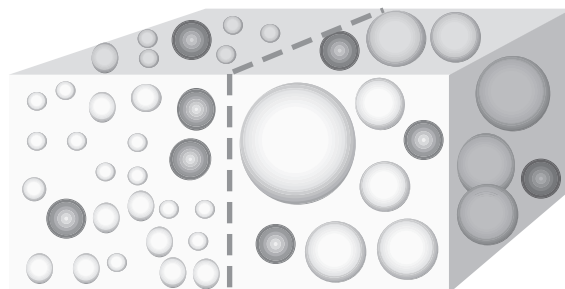


Figure 1. Many droplets in any given volume of spray have a diameter similar to the volume median diameter, or VMD (the dark droplets). Because the majority of droplets are smaller than the VMD, choose a relatively large VMD to minimize the number and volume of small droplets.

The best droplet size for a particular application is a compromise between drift reduction and adequate coverage. Particularly, droplet size should not be smaller than that adequate to obtain good coverage, because droplets that are too fine typically never reach the target anyway. The generally accepted values for various products are shown in the following table.

Size (microns)	Material type		
	Fungicides	Insecticides	Herbicides
	150–250	200–300	250–400

While smaller droplet sizes are required for good coverage of some fungicides and insecticides, the nozzle must be positioned close to the foliage for the spray to reach the target. Droplet trajectories are affected by their initial velocity and momentum; gravity; the frictional force imposed by traveling through the air; and the temperature, humidity, direction and speed of the air. Small droplets lose their momentum quickly to the frictional force imposed by traveling through the air. Droplets less than 20 microns in diameter decelerate within an inch of the nozzle and then depend primarily on the direction of the air to determine the rest of their journey. Droplets less than 200 microns in diameter decelerate within 19 inches of the nozzle.

Droplets with a diameter of 200 microns are gener-

ally considered the smallest droplets useful for herbicide applications. This threshold is determined in part by the practical setup of a spray boom with operating characteristics that provide uniform coverage. For booms with nozzles on a 20- or 30-inch spacing and with fan angles of 80 or 110 degrees, a boom height of 18–19 inches above the target is generally recommended for ideal overlap. The smallest droplet that has a reasonable chance to reach the target is about 200 microns in diameter.

## Boom setup and fan angle

Although boom height can be logically determined using information about proper overlap (100% for fan nozzles), nozzle spacing, and fan angle, no exact recommendations about boom height are usually made. Besides, when spraying in a canopy, just what is the target? — the top — the middle? It's not even clear that there is a single best recommendation for nozzle spacing, fan angle and boom height. For nozzle selection, one philosophy for minimizing drift favors producing larger droplets and concludes that the 80-degree fan operated at the proper height is superior. Another philosophy for minimizing drift favors moving the boom closer to the target and concludes that the 110-degree fan operated closer to the target for correct overlap is the superior choice. It is sufficient to say that when you are measuring from the top of the canopy, it is almost always better to be a little bit closer than your calculations indicate. This minimizes the distance that a droplet must travel before it reaches some part of the target.

## Nozzle selection

Most nozzles can provide an acceptable range of droplet sizes when operated within their rated pressure range and especially when operated near the low end of that range. Still, some nozzles have superior operating characteristics. Select a nozzle based on its intended use and the rate of flow that the nozzle is expected to supply. Select a nozzle large enough that the operating pressure is near the low end of the rated pressure range. Environmental Protection Agency registration labels for some herbicides specify nozzle type and sprayer pressure range, as well as which additives may be used and maximum wind speeds in which applications can be made.

**Flat fan nozzles** are the industry standard. They provide excellent uniformity when the fan pattern is completely overlapped by nozzles on either side (100% overlap). The characteristic fan pattern is formed as the pressurized spray solution is emitted through an elliptical orifice. This creates a thin spreading sheet of liquid that breaks up into droplets shortly after it leaves the tip. Increasing the pressure of the spray solution creates smaller droplets that are more prone to drift. Standard flat fan (SFF) nozzles are generally rated between 30 and 60 psi. Operating pressures between 30 and 40 psi are recommended to minimize production of fine droplets

to reduce drift. Pressures below 30 psi result in a poorly developed and unpredictable spray pattern unacceptable for uniform coverage.

**Extended-range flat fan nozzles**, as the name implies, can be operated over a larger range of pressures — typically 15 to 60 psi. Operating pressures between 15 and 25 psi produce large droplets less prone to drift, while maintaining a uniform spray pattern. Although the larger range of rated pressures allows a wider range of spraying speeds, avoid higher speeds that require pressures in the upper part of the range to reduce the production of driftable particles.

**Wide-angle flat fan nozzles** (110 degrees) can achieve the desired 100 percent overlap pattern at lower boom heights than the more common 80-degree flat fan. To achieve the same flow rate, a wide-angle nozzle is designed with a wider and narrower orifice. The narrower orifice produces a thinner sheet, which results in smaller droplets that are more prone to drift. However, when operated at the proper height for 100 percent overlap, the boom will be closer to the canopy and more of the smaller droplets will reach the target.

**Flooding nozzles** create droplets by splashing a stream of liquid through a round orifice onto a plate, which results in larger droplets than a flat fan nozzle when operated at low pressures. Flooding nozzles are commonly used for applying liquid fertilizer suspensions because the round orifice is less susceptible to plugging. Flooding nozzles produce a peculiar spray pattern that is difficult to overlap properly for uniform coverage. At higher pressures, a flooding nozzle will produce more driftable droplets than a properly operated flat fan. The original flooding nozzle design has been replaced with the **turbo flood** (Spraying Systems Inc.) design, which has both a pre-orifice and a turbulence chamber that reduce liquid velocity and produce larger and more uniform droplets. The improved design also produces a spray pattern that improves uniformity when overlapped properly with adjacent nozzles.

The **turbo flat fan** includes a pre-orifice that slows liquid velocity, producing larger droplets and maintaining a uniform spray pattern that provides good coverage. The turbo flat fan can also be operated over a wider range of pressures (15 – 90 psi) than a SFF nozzle. Still, avoid operating speeds that require pressures in the upper part of the range. All nozzles produce larger droplets less subject to drift when operated closer to the lower end of their pressure range. When increasing travel speed, select a nozzle with a larger orifice and operate it at lower pressures.

**Air induction nozzles** produce larger droplets by combining a pre-orifice, which reduces pressure, and a venturi, which draws air into the spray solution much like a carburetor. The air becomes entrained in the spray solution and results in larger droplets composed of water and tiny air bubbles. The exit orifice of the nozzle produces the desired spray pattern. The air-filled drops

are said to splatter as they reach the target for better coverage.

## Other technology

The usual forces that determine the course and final destination of a spray droplet are the initial momentum of the droplet, the resistance encountered as it travels through the air, and gravity. New technologies designed to improve spray deposition or reduce drift either add a new force or control an existing force.

**Electrostatic sprayers** add an electrostatic force that tends to direct droplets toward the plant canopy. While the additional effect of the electrostatic charge is minimal for large droplets, it can be sufficient to guide smaller droplets that are most prone to drift toward the canopy. Electrostatic sprayers reduce drift and increase deposition of fine droplets onto the canopy.

**Air-assist sprayers** use a curtain of air directed into the canopy to increase penetration and deposition of droplets into the canopy. Their most significant use has been in the application of insecticides and fungicides where small droplets are essential to provide good coverage and effectiveness. The air carries smaller droplets into the canopy where they are deposited in areas otherwise not accessible by their initial momentum and gravity, such as the underside of leaves and lower foliage that is typically occluded by the top of the canopy. Maximum effectiveness of air-assist sprayers is achieved only through proper adjustment of air volume, velocity and angle and depends on the type of canopy to be sprayed. When properly implemented in crop canopies, air-assist sprayers can also reduce drift.

Shields change the effects of ambient air speed and direction, which results in better placement of small droplets. The effectiveness of shields in reducing drift depends on a number of factors including the shape, size and construction of the shield; the mounting angle and location of the shield relative to the boom; and the droplet distribution and ambient air conditions in which it is applied. A poorly designed shield has the potential to increase drift in windy conditions and especially when poorly adjusted. Most shields are effective in reducing drift when a large number of small droplets are present. Shields should not be considered a substitute for selecting a nozzle that minimizes small droplets. Properly designed and implemented shields reduce drift of small droplets.

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## In Summary

Drift can be controlled by (1) maximizing droplet size and (2) minimizing the time that droplets are in the air. Following are specific strategies for achieving those goals.

- **Spray only when conditions are right!** Do not spray when wind speeds are as high as 10 mph. Use caution when winds are light and variable, especially when applications are to be made near susceptible vegetation. Also use special caution when relative humidity is below 50% and when temperatures are high. Drift is much more likely during the hottest part of the day.
- **Select boom configuration for maximum performance.** Keep the boom close to the target (soil surface or canopy) by using wide-angle nozzles. Relatively large nozzle spacing (but not greater than 30 in.) allows the use of large orifice sizes, which produce larger droplets. Booms with stabilizing carrier wheels provide more consistent boom height and result in more uniform coverage and less drift.
- **Select a reasonable application speed** that can be maintained without pushing the pressure limits of the nozzle and which doesn't cause the boom to bounce. Speeds between 8 and 12 mph are probably reasonable. Higher speeds are not only harder on equipment and difficult to maintain, but result in enough air movement to cause some drift.
- **Select the best nozzle type and size for each type of application you make and use drift reduction nozzles;** remind yourself that nozzles are cheap compared to the cost of materials and cheap compared to the yield losses or litigation costs that can result from a poor application. Most improved nozzle designs really do have superior drop size characteristics.
- **Calibrate the sprayer and replace worn nozzles.** Worn nozzles produce spray patterns and poor droplet distributions that result in poor coverage, increased drift, or both.
- **Use higher carrier rates** when possible, especially when using formulations that are more effective with higher rates anyway; some formulations require low volumes. **Follow label guidelines.** Higher carrier rates allow the use of larger nozzles, which produce larger, less drift-prone droplets when operated at the correct pressure.
- **Use drift-reduction agents** to reduce the number of small spray droplets. Many of these products are polyacrylamide materials. More is not better. Drift-reduction agents are not regulated, so use caution and take the time to determine which products have a good performance record. Your herbicide company or local dealer should have a list of drift reduction agents that they recommend. Use these lists as a guide for selecting drift control additives. Drift-control agents will also reduce coverage of the plant surface, so be sure to use drift-control products according to pesticide label directions. No drift-control agent will eliminate drift in high winds.



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