This presentation was produced by the Nevada Department of Agriculture in conjunction with the University of Nevada Cooperative Extension. This presentation was designed to provide a basic and practical understanding of pesticide drift, and is not intended to replace or supersede any relevant law or pesticide label direction. This presentation is partially based on materials provided by the Western Crop Protection Association chapter in Sacramento, California.

REMEMBER, BEFORE PURCHASING OR USING ANY PESTICIDE, ALWAYS READ, UNDERSTAND AND FOLLOW PESTICIDE LABEL DIRECTIONS, IT’S THE LAW!
The objectives are to understand:

• What spray drift is.
• How weather affects spray drift.
• The effects of droplet size on spray drift.
• How your decisions can affect spray drift.
Drift is...???

"Pesticide Drift" means the physical movement of pesticide through the air at the time of pesticide application or soon thereafter from the target site to any non- or off-target site. Pesticide drift shall not include movement of pesticides to non- or off-target sites caused by erosion, migration...or windblown soil particles that occurs after application unless specifically addressed on the pesticide product label with respect to drift control requirements.

National Coalition on Drift Minimization

Many states have their own definition of “Pesticide Drift.” The National Coalition on Drift Minimization defines Pesticide Drift as: “...the physical movement...” (read statement in slide).

Some may argue that this statement is too broad, while others may believe it is not broad enough. For this reason, this definition may change after the making of this presentation, but its meaning will most likely remain the same.
To most of us, drift caused by excessive wind speed is fairly easy to understand. In the top illustration, the aerial applicator only intends to treat the target area. Unfortunately, the product is drifting onto an unintended site. The same is true in the bottom frame. The off-target movement of a product from its intended site is called “drift.”
“Overspray” is not the same as drift. When overspray occurs, it is usually due to operator error. Overspray can occur when an applicator loses track of the target boundary, as indicated in these illustrations.
The concerns surrounding drift go beyond the obvious understanding of the importance of wind blowing a pesticide away from its intended site. When a pesticide drifts from its target site, the effectiveness of the pesticide is reduced, chemicals are wasted, and there is always the threat of off-target damage known as “drift damage.” Drift damage is especially evident when a herbicide drifts onto desirable vegetation such as trees, shrubs, adjacent crops, etc. Damage to crops or landscape plants can be very expensive, especially when farmers have to be reimbursed for damaged crops, or landscape plants have to be replaced. Other impacts of drift include reduced control, higher pesticide costs, and negative environmental impacts to water and air quality. Human health may also be negatively impacted due to pesticide drift. Drift problems which directly affect the public’s health and property can cause negative perceptions of pesticide use, especially when it occurs in densely populated areas.
As discussed in the previous slide, pesticide drift can cause serious damage. Livestock, wildlife and people can be seriously affected by drift. Drift issues can be very expensive.

This picture shows the damage caused by a herbicide that drifted onto a crop. Restitution to the farmer for his crop loss was probably very costly. When pesticides travel off-target, their effectiveness is reduced, which reduces control, which can reduce crop yields, thus resulting in revenue losses for the farmer. In addition to the damage caused by drift, complaints about negative health effects and environmental concerns also top the list of issues surrounding drift. These drift issues often make it necessary for regulatory agencies to develop stricter regulations and to assess expensive fines to violators.
As shown in this pie chart, 1/3 of all pesticide misapplications occur because of drift (the blue section of the pie).
This pie chart shows that the applicator is the number one contributing factor to drift (the blue section of the pie). This is most likely due to applicators who ignore environmental signs which contribute to drift, such as wind speed, or who use methods of application which contribute to drift. Environmental conditions and application methods which contribute to drift will be discussed shortly.
There are basically two ways drift occurs. The first is called “volatilization.” Volatilization occurs as a liquid vaporizes or evaporates and “off-gases,” or moves as a vapor, into the air. The released gas can be detrimental if the concentration is high enough and the amount of time which it affects a susceptible non-target site is long enough.

The rate at which a liquid volatilizes is directly related to the size of the spray droplets, relative humidity and air temperature. These factors will be addressed in greater detail shortly.

The second and most common way drift occurs is from the off-target movement of spray particles by the wind.
Factors affecting drift

- Spray characteristics
  - Chemical
  - Formulation
  - Additives

There are many factors which affect drift. Before purchasing any pesticide it is absolutely essential to READ AND UNDERSTAND THE LABEL DIRECTIONS. Within every pesticide label are “DIRECTIONS FOR USE” and “PRECAUTIONARY STATEMENTS.” Information pertaining to drift is addressed in these areas of the label.

If product instructions contain warnings about drift, and you are applying the pesticide in a sensitive area or don’t feel confident that you can control drift, you may want to reconsider purchasing the product and select an alternative product or means of control. Items such as proper nozzle sizes and types, wind gauges, and drift retardants should also be considered.
Proper equipment choices and application methods can significantly reduce pesticide drift potential.

- Using the correct size and nozzle type with the correct pressure, will dramatically reduce the potential for drift.
- Correct nozzle orientation or direction of spray will reduce the potential for drift.
- Maintaining the correct nozzle pressure is essential in maintaining uniform spray droplet size. The higher the pressure, the smaller the spray droplets will be. The lower the pressure, the larger the droplets will be. Droplet size is a very important factor when considering drift. The importance of droplet size will be discussed in greater detail later in this presentation.
- Another important factor in preventing drift is the distance a nozzle is from its target. The further away or higher a nozzle is from its target, the longer the spray droplets remain suspended in the air and the greater the possibility of them drifting. The closer or lower a nozzle is to its target, the less time the spray droplets remain suspended in the air and the lower the possibility of them drifting.*
- New technology is being created or invented all the time to aid in applying pesticides in a safe, cost- and time-efficient manner that also reduces the potential for drift.

*Please note: This is a general rule which may not be suitable for all application practices.
Factors affecting drift, continued

- Weather, etc.
  - Air movement (direction and velocity)
  - Temperature and humidity
  - Air stability/inversions
  - Topography

Weather conditions can change suddenly. Wind gusts and the sudden arrival of dust devils can occur without warning. In general, atmospheric disturbances in the form of wind do not usually occur until later in the day after the air has had time to warm and mix. To minimize the potential for drift, applications should be timed to correspond with periods of minimal atmospheric disturbance. This is usually during the morning hours when the winds are calm.

In the warmer months, early morning is also the time of day when temperatures are within the prescribed range for pesticide applications. Additionally, morning is when humidity is high, reducing the potential for evaporation or volatilization and subsequent drift. Exceptions to this general rule occur when weather inversions are present. Inversions will be discussed later in this presentation.

Topography can also affect the potential for drift. Applications made on the windward side of hills are more susceptible to wind gusts and drift than those made on the leeward side.
As previously mentioned, spray droplet size is an important factor when considering the potential for drift. Large droplets are less likely to drift. Their larger size causes them to fall more quickly and evaporate, or volatilize, more slowly. Additionally, larger sized droplets are less affected by wind.

On the other hand, smaller droplets remain suspended in the air longer, which increases their chance of drifting. Smaller droplets also evaporate more quickly which increases their rate of volatilization and the possibility of harmful pesticide gases developing in the air.

Smaller droplets are produced by excessive spray pressure which occurs when nozzle openings are too small for the pressure being used. In general, the higher the spray pressure, the smaller the droplets will be.

For aerial applied pesticides, another factor which affects droplet size is the speed at which the application is made. High wind speed over the nozzle openings can create a wind shear effect. As the droplets emerge, the high wind speed can shatter them into smaller droplets, thereby increasing the chance of volatilization and drift.
To assist the applicator in reducing pesticide drift, several nozzle types are available. When selecting a nozzle, it is important to remember that it must be designed for the type of pesticide and spray pressure to be used. When nozzles designed for low pressure are used under high pressure, smaller droplets will be produced which will increase the potential for volatilization and drift.

A nozzle which is designed to apply a liquid-based pesticide may not be suitable for applying a wettable powder-based product. Using the wrong nozzle can result in excessive wear and clogging, which may result in over- or under-application. In addition, the nozzle must provide the correct spray pattern and distribution of the pesticide. Nozzles should be durable and resistant to corrosion and normal wear and tear. Regular maintenance and proper calibration are also important, but are not addressed in this presentation.
To recap some of the drift reduction strategies we have discussed, remember:

• Prior to purchasing a pesticide, READ, UNDERSTAND AND FOLLOW THE LABEL DIRECTIONS. Pay particular attention to the “DIRECTIONS FOR USE” and “PRECAUTIONARY STATEMENTS” sections of the label. Make note of any specific precautions against drift and any specific products or additives needed to make a proper application.

• Select the correct nozzle type for the application and product to be applied.

• Use the correct spray pressure. And remember, the use of spray pressure that exceeds nozzle design will produce smaller sized droplets which will increase the potential for volatilization and drift.

• When possible, use lower spray pressure to produce larger droplets. Larger droplets are less likely to volatilize and drift than small droplets.

• The closer to the target the spray boom is, the less distance the spray droplet will have to travel, which reduces the time the spray droplets are subject to wind currents and volatilization.

• Pay attention to local weather conditions, especially factors affecting wind and temperature.

• New technologies are being developed which aid in reducing drift, such as the nozzle shrouds used to contain the spray directly applied to the crop, as illustrated here.

In the next section we will examine the importance of buffer zones, whether or not to use a LICENSED applicator, product selection, and the importance of humidity, temperature and temperature inversions.
Some states require buffer zones in areas where homes are near application sites, or around people who have registered as chemically sensitive. Buffer zones should always be used when applying pesticides near schools, buildings, roads, waterways and parks, to name only a few sites. Some pesticide labels require buffer zones near areas where endangered species exist or where other environmental concerns require a buffer zone. The width of the buffer zone may depend on the toxicity of the pesticide applied, state regulations, pesticide label directions, prevailing winds, proximity to sensitive or protected areas, or other factors.
Ultimately it is the applicator’s decision whether or not to spray. The applicator is responsible for selecting the proper equipment such as the correct nozzle type. The applicator is also responsible for selecting the correct application practices, such as the correct pressure, boom height, pesticide selection, drift retardant. Additionally, the applicator is responsible for ensuring that field and weather conditions are appropriate for the application and to be aware of surrounding areas that could be impacted by drift. As illustrated in a previous slide, 38 percent of all drift issues are caused by mistakes made by the applicator.
An important decision to make well in advance is who will make the application. The applicator must have experience in handling and using pesticides, as well as understanding and following label directions. The applicator needs to be familiar with the equipment, know how to calibrate it and have a good understanding of how pesticides drift and how to control it.

Some situations may require a LICENSED applicator be hired. The Nevada Department of Agriculture requires individuals who perform commercial pest control for hire to be LICENSED. For information about an individual’s or company’s license status, contact the Nevada Department of Agriculture at 775-353-3600.

Another important decision is whether to use an aircraft or “ground rig” to make an application. Large scale operations often use aircraft and ground rigs to make their applications. There are many factors to consider when determining which mode of application to use. These factors go beyond the scope of this presentation. However, when considering an aerial or ground application, drift minimization should be considered as part of the selection process. In general, for large areas, aerial applications may be more suitable, while smaller or irregularly shaped fields may require the use of a ground rig.

Large scale operations may also apply pesticides through chemigation systems. Discussion of these systems goes beyond the scope of this presentation.
If you decide to hire a pesticide applicator…

- Make sure you use a LICENSED applicator, not a CERTIFIED applicator.
  - Contract the job early.
  - Discuss the specifics of the application and any precautions about the application site.
    Give them the freedom to apply their experience and training.
- A reputable, conscientious, LICENSED applicator should provide you with a quality job.

One of the issues frequently encountered in Nevada is the confusion over the difference between a LICENSED applicator and a CERTIFIED applicator. In simplest terms, a Licensed applicator is someone who is licensed do pest control for hire. In other words, licensees can charge for their pesticide applications. On the other hand, applicators who are Certified can use, or supervise the use of, Restricted Use Pesticides. Certified applicators CANNOT DO PEST CONTROL FOR HIRE.

If a LICENSED applicator is to be hired, make sure the licensee is contacted early enough so the job can be properly planned. Make sure to discuss the application in detail and what the expectations are. Pay particular attention to any areas subject to drift or sites where bees may be present. Determine whether people who have complained about applications in the past are located in the target area. Listen to any concerns raised and try to answer all questions well in advance of the application. Cooperating with the licensee will help to make the application a success.
This slide shows what restricted use certificates and pest control licenses issued by NDOA look like. The best way to tell the difference between the two is that a Pest Control License will always have the picture I.D. of the licensee on it, much like a driver’s license. In contrast, the Certification card does NOT have the picture of the applicator on it. Ask to see the applicator’s certificate or license, which should be up-to-date.
Product selection

- One way you can reduce the potential for drift
- You may have several options on products.
- Understand the product chemistry!

As previously mentioned, the importance of product selection is an essential part of a drift management plan. There are usually several products suitable for controlling a specific pest. Prior to selecting a product, read the product label and as part of your selection process consider specific warnings and chemical characteristics regarding drift management. Whatever product you select, make sure you have the expertise and equipment necessary to make a proper application while minimizing drift. Before purchasing a pesticide make sure to READ, UNDERSTAND AND ENSURE THAT THE LABEL DIRECTONS CAN BE FOLLOWED.

Another important aspect of product selection is understanding the product’s chemistry. Some pesticides volatilize more readily than others. This is especially true with some of the “hormonal based” herbicides such as those containing 2,4-D, or a derivative thereof. The use of this family of herbicides at high concentrations or in hot weather can cause considerable volatilization. If the volatilized concentrations are high enough and linger over susceptible plants long enough, desirable vegetation adjacent to the application site can be damaged.
The picture on the left is of a row of 30-year-old black locust trees that were killed by such a herbicide volatilization event. Under high temperatures, over a period of several days, a herbicide sprayed on the adjacent field volatilized, which produced gasses that drifted in high enough concentrations to damage and eventually kill several of the trees. In the picture on the left, the healthy portion of the tree in the middle was partially shielded from the volatilizing gasses, and therefore was less affected.

In the picture on the right, note the steel fence posts on the left side frame. These fence posts represent the field’s boundary. Also note the water hemlock that was also in the path of the volatilized herbicide along with the black locust trees in the background. The twisting of the water hemlock is clear evidence of its contact with a hormonal based herbicide.

Pesticides used in agricultural, greenhouse, nursery, and forestry settings require the applicator to follow the Worker Protection Standards printed on the label. The Worker Protection Standard requirements go beyond the scope of this presentation. For information about the Worker Protection Standards, contact the Nevada Department of Agriculture at 775-353-3600.
For the most part, weather conditions can not be controlled. However, weather can be predicted. Applications should be planned with weather predictions in mind. During this presentation we have looked at the importance of wind and temperature. Another weather condition that needs to be examined is humidity. Humidity is essentially the amount of water vapor in the air. In this presentation humidity is referred to as “Relative Humidity”; or as “RH,” as shown in this illustration. The correlation between relative humidity and evaporation are inverse: the higher the relative humidity, the lower the rate of evaporation and the lower the relative humidity, the lower the rate of evaporation. It is important to understand that when applying small droplets in low relative humidity, they will evaporate much faster than when larger droplets are used. The rapid evaporation of the smaller droplets shrinks them. They become lighter, they are suspended in the air longer and are more susceptible to drift. The smaller droplets also volatilize faster than larger droplets.

Applications during low relative humidity conditions should be avoided. If applications have to be done under low relative humidity conditions, the use of larger spray droplets should be considered. The larger, heavier droplets will settle onto their intended target faster and will be less susceptible to evaporation and drift. Relative humidity is usually the highest before sunrise.
Temperature Inversions

- Under clear to partly cloudy skies and light winds, a temperature inversion can form as the sun sets.
- Under these conditions, a temperature inversion will continue into the morning until the sun begins to heat the ground.

Another important atmospheric condition to consider when planning an application is temperature inversion. Inversions form under clear or partly cloudy skies with little to no wind, usually in the fall and winter months, but can occur in Nevada at any time of the year. They usually last until the morning sun heats the ground enough to make the inversion “lift,” or until a weather front breaks them up. Inversions lift when the ground is warmed by the sun and the warm air rises, taking the cold air with it. Inversions are common in Nevada and can be troublesome, especially when pesticides are applied aerially.
The top photograph shows an inversion developing at sunset. The bottom photograph shows an early morning temperature inversion. Notice the smoke from the chimney traveling along the tops of the trees.
Under normal conditions higher altitudes are cooler and lower altitudes are warmer; however, inversions reverse this condition. As previously mentioned, inversions commonly form during clear nights in the fall and winter when cooler air becomes trapped near the ground under a layer of warmer air. The separation of the two air masses prevents them from mixing. Inversions cause problems when spray droplets become suspended in the warm air mass above the cold air mass near the ground. If the warm air moves away from the target site, it will carry the suspended spray droplets with it and deposit them someplace else. Drift problems resulting from aerial applications during inversions are not uncommon. For this reason, NO pesticide applications should be made during temperature inversions.
To reiterate, inversions affect droplets that don’t settle quickly. Because spray droplets can be suspended in an inversion, a higher potential exists for their movement off-target. Minimizing the production of small droplets will minimize the potential for drift under inversion conditions. **AVOID SPRAYING DURING AN INVERSION**
To avoid spraying during an inversion, do not spray near sunset or until an hour or so after sunrise. It may be possible to spray if low heavy clouds are present, the wind speed is greater than 5 mph at ground level, and the temperature has risen at least 5 degrees after sunrise. These conditions do not guarantee the absence of an inversion, but are good signs that it may be lifting.

Smoke bombs and smoke generators are sometimes used to determine the presence of inversions.
A temperature inversion was linked to an application of the fumigant chloropicrin in 2007 that sickened over 100 people.
The most obvious contributor to drift is wind. Due to Nevada’s mountain and valley topography and higher farming altitudes than most of the country, atmospheric instability in the form of breezes and wind is almost constant. Winds commonly travel up mountains during the day and down them during the night. The movement of currents up mountains during the day is known as “anabatic” wind movement. In the evening as the air cools the currents switch direction and the cooler air flows down mountains. The effect of cool air flowing down from a higher altitude is known as “katabasis.” These winds are usually mild.

Stronger winds occur as barometric pressure changes and weather fronts move in and out of regions. Strong surface breezes can occur as the ground heats up and the air masses mix. As wind speeds pick up, so does the potential for drift. As previously discussed, maximizing droplet size, lowering boom height, and making applications during high relative humidity can help reduce drift caused by the wind. However if wind speeds are too strong, controlling these factors will only have a limited effect on controlling drift.

Wind gauges are useful tools in managing drift, but should not be entirely relied upon when making decisions about spraying, especially when applications are to be done near sensitive sites.
It is almost impossible to spray when there is no wind. Some believe that spraying in a “dead calm” may actually increase the possibility of drift. Such conditions have infrequent winds which can blow in unpredictable directions. Some believe that mild winds blowing in a predictable direction, away from non-target sites, with gusts that do not exceed 10 mph, are the best conditions under which to apply. Ultimately, the decision of whether or not to apply is up to YOU.
When planning a spray application, the planning process is an essential part of the overall success of the application. Always allow enough time to schedule and plan an application. Time needs to be spent reviewing products and their label directions. Setting proper application dates is essential in controlling pests, especially pests that are more vulnerable to pesticides during specific life cycle phases. When planning to spray, or while designing a spray program, always consider delays due to weather, maintenance or mechanical problems and have alternate applications dates available. Try not to fall in the trap of feeling that you have to make an application RIGHT NOW! Forcing an application in poor conditions almost always leads to drift or other problems.

REMEMBER, IT IS THE APPLICATOR’S RESPONSIBILITY TO ENSURE THAT DRIFT IS MINIMIZED.
In conclusion

Minimizing spray drift is in the best interests of everyone. Do your part to keep pesticide applications on target.

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This slide set is partially based on materials provided by the Western Crop Protection Association, Sacramento, CA.

In concluding this presentation, please remember that minimizing spray drift is in the best interest of everyone. Do your part to keep chemical applications on target.