
Mitigating Spray Drift
Pesticide Stewardship Conference
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Boise, ID

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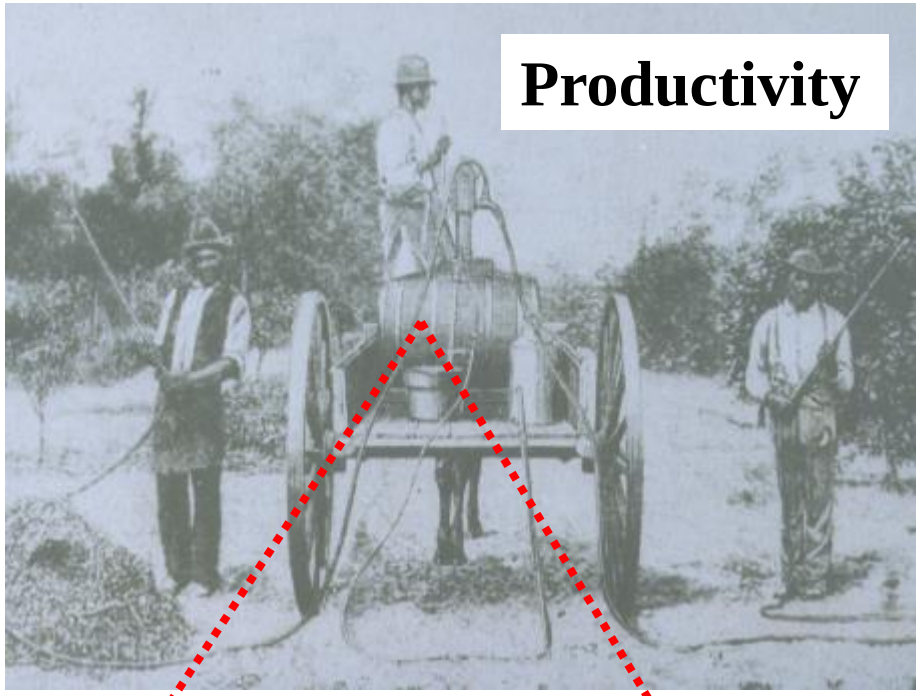
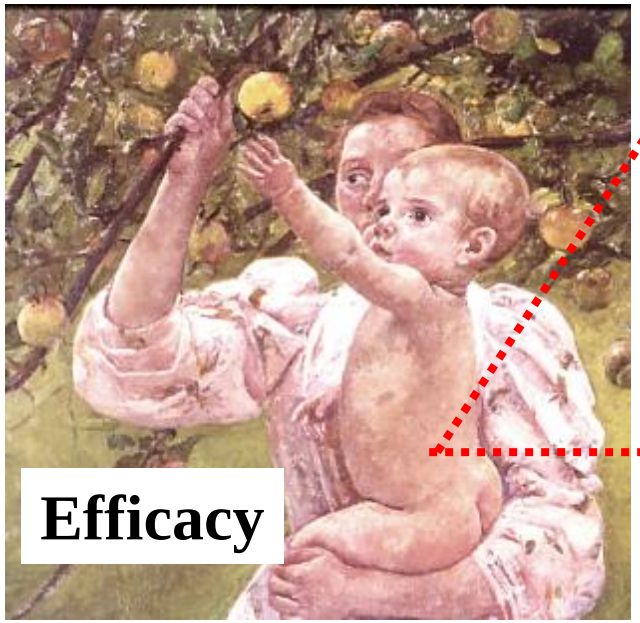
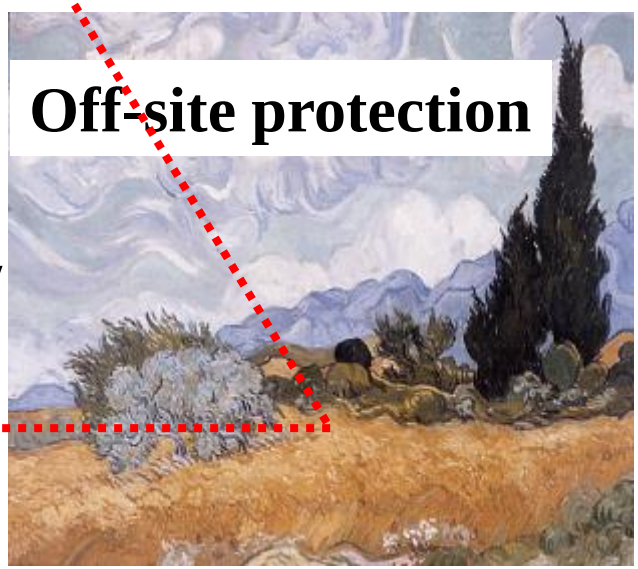
Mitigating Spray Drift

The application triangle





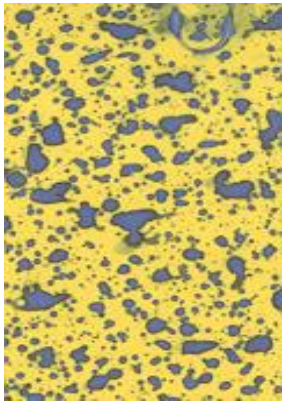
balance

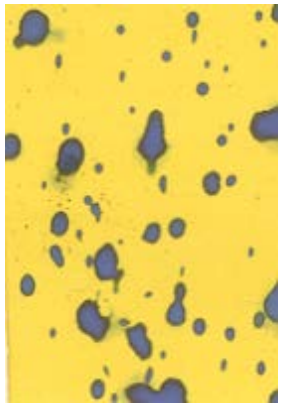


Courtesy of Ken Giles, U of CA at Davis

Spray Droplet Management!

- Need Knowledge Of The Product Being Used.
- Herbicide, Fungicide, Insecticide
  - Systemic
  - Contact
- What Is The Target?
  - Soil
  - Grass
  - Broadleaf (Smooth, Hairy, Waxy)
  - Leaf Orientation – Time Of Day
  - Penetration Into Canopy





Spray Droplet Technology

Drop Size: microns - µm

One micron (µm) =1/25,000 inch
1/1000 millimeter

Comparison Of Micron Sizes For Various Items: (approximate values)

- Pencil Lead 2000 µm
- Paper Clip 850 µm
- Staple 420 µm
- Toothbrush Bristle 300 µm
- Sewing Thread 150 µm
- Human Hair 100 µm

Volume Distribution

- D_{V10} or $D_{V0.1}$
- D_{V50} or $D_{v0.5}$ or VMD
- D_{V90} or $D_{V0.9}$
- % volume<100 µm
- % volume<200 µm

How do we get to the numbers we typically deal with?

Using some measurement system, the **percentage** of the **total spray volume** that is **in each droplet size range** is determined.

Wind Tunnel Testing

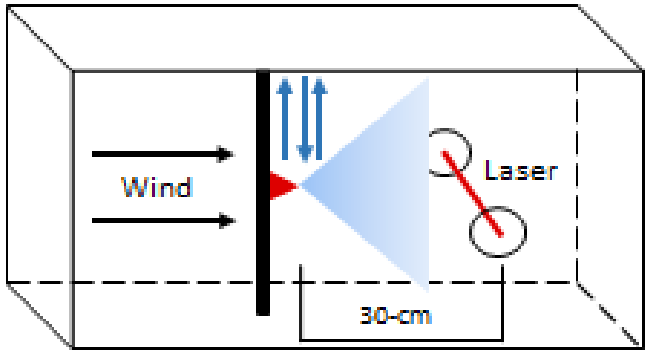
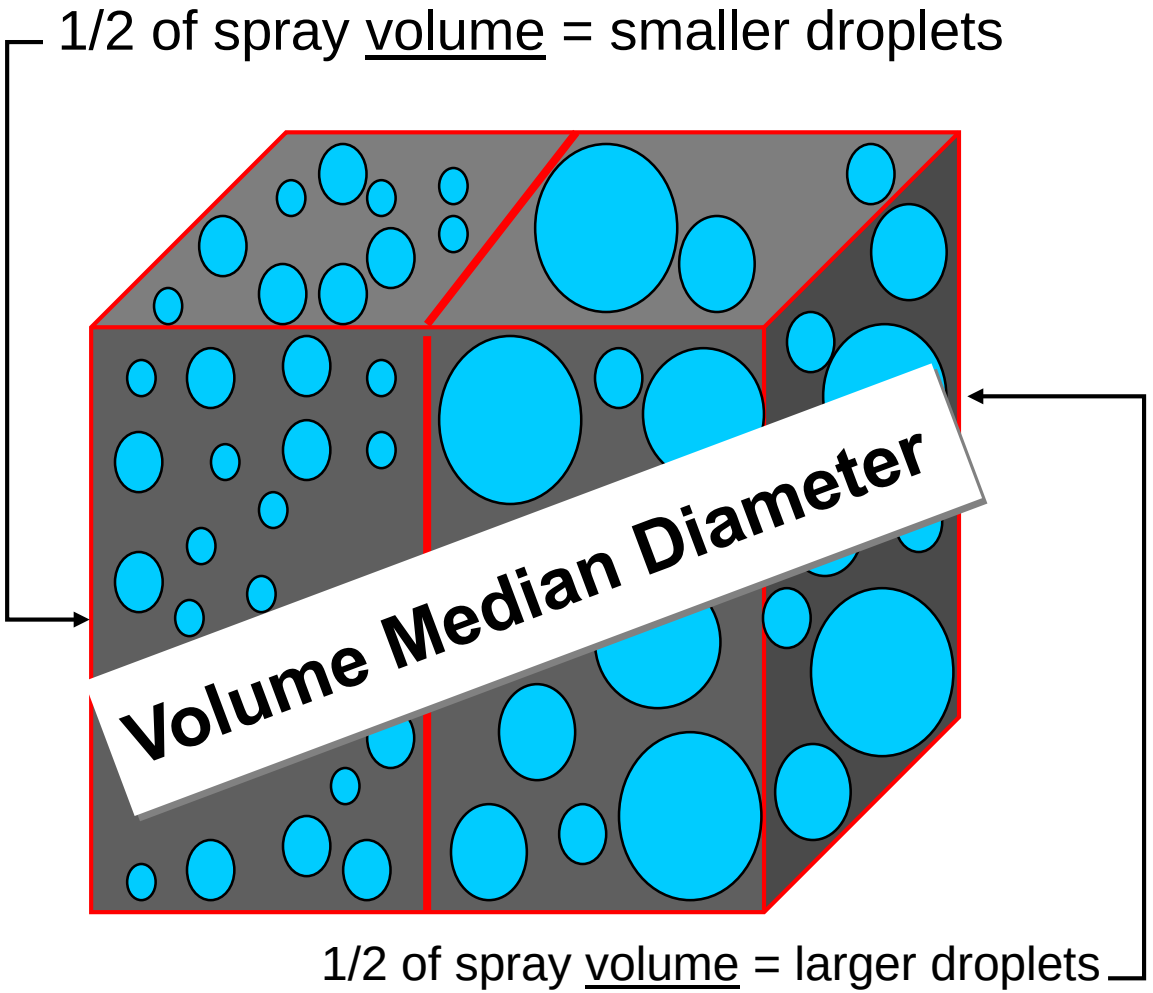
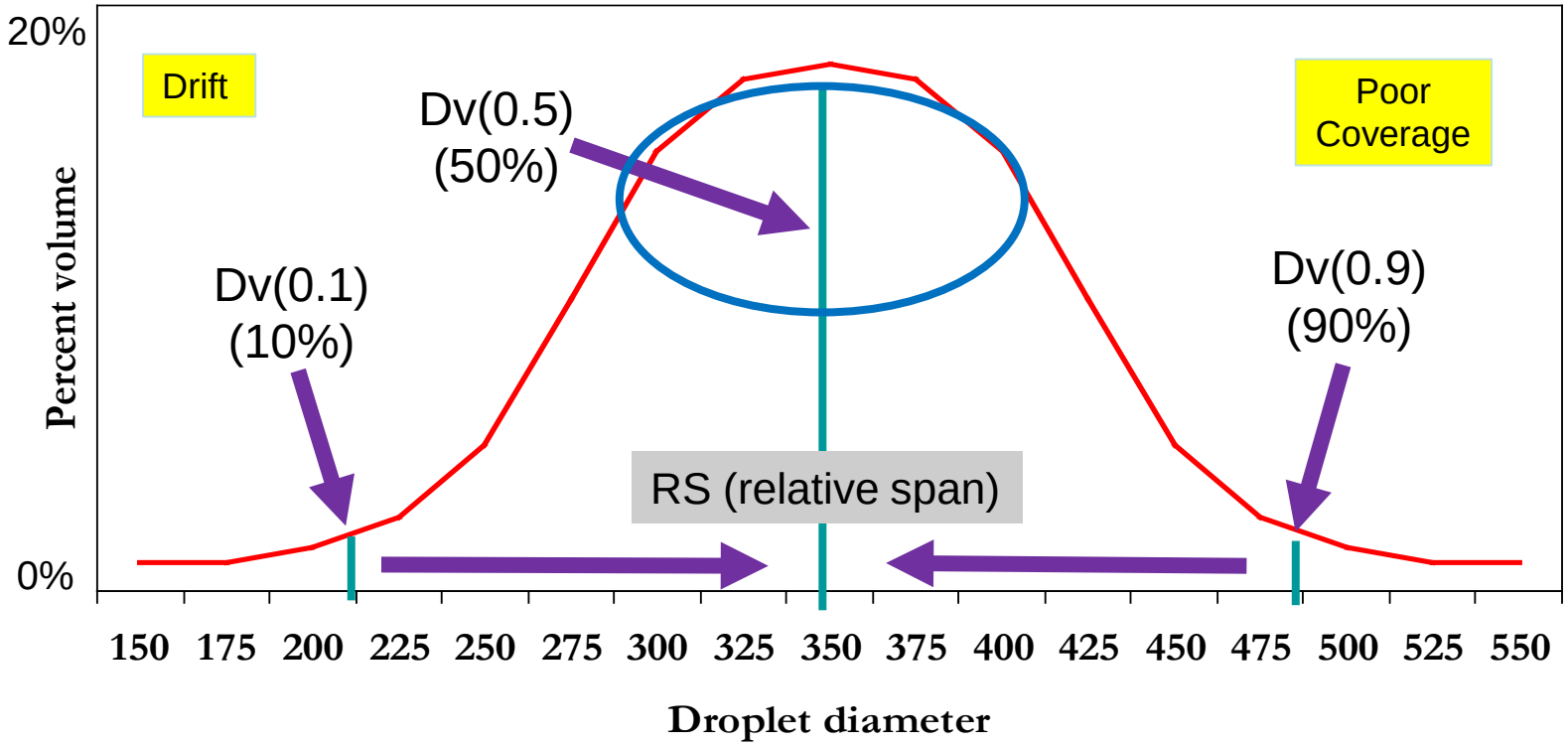


Figure 2. Illustration of the low-speed wind tunnel and laser diffraction system used for droplet spectrum analysis.


1/2 of spray volume = smaller droplets
Volume Median Diameter
1/2 of spray volume = larger droplets

Cumulative Volume Distribution



DROPLET SIZE MAKES A DIFFERENCE

ADVANTAGES AND DISADVANTAGES OF VARIOUS DROPLET SIZES

Equivalent droplet volume in each quadrant*

100 MICRON

ADVANTAGES

+ Excellent coverage
+ Low droplet bounce/shatter

DISADVANTAGES

- Very fast evaporation
- Quick drying time on leaf
- Very high drift potential
- Poor canopy penetration

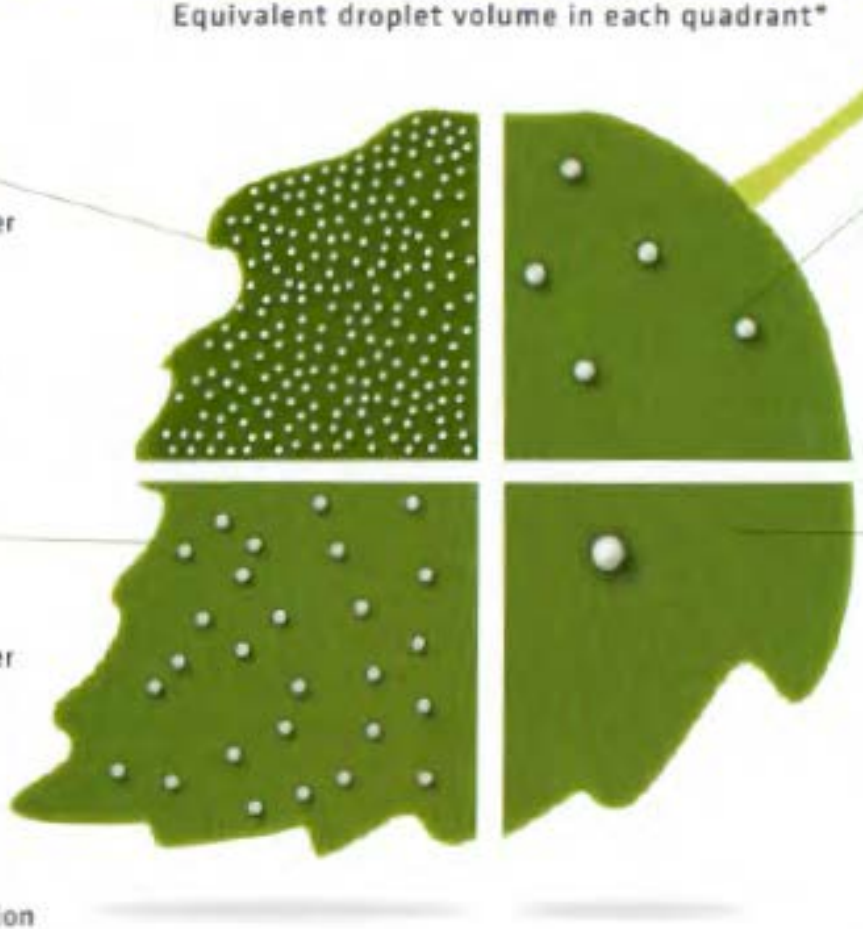
200 MICRON

ADVANTAGES

+ Very good coverage
+ Low droplet bounce/shatter
+ Good efficacy for contact pesticides

DISADVANTAGES

- Fast evaporation
- Fast drying time on leaf
- High drift potential
- Moderate canopy penetration



350 MICRON

ADVANTAGES

+ Good coverage
+ Moderate evaporation
+ Low drift potential
+ Good canopy penetration
+ Favorable drying time on leaf
+ Good efficacy for many pesticides

DISADVANTAGES

- Some droplet bounce/shatter

600 MICRON

ADVANTAGES

+ Long evaporation
+ Very low drift potential
+ Good canopy penetration
+ Long drying time on leaf

DISADVANTAGES

- Low coverage
- High droplet bounce/shatter
- Reduced efficacy for many pesticides

Regardless of which droplet size you need, using the right nozzle and adding InterLock® adjuvant to the tank will increase the number of right-sized droplets you are seeking.

*Relative comparisons. Results vary depending on environment, products included, adjuvants, canopy characteristics and other factors.

WINFIELD® Adjuvants

ANSI/ASAE S572.1 MAR2009
Spray Nozzle Classification by Droplet Spectra

2009

American Society of
Agricultural and Biological Engineers

STANDARD

ASABE S-572.1 Droplet Size Standard

ASABE is a professional and technical organization dedicated to advancement of engineering applicable to agriculture. ASABE Standards are consensus documents developed and adopted by the American Society of Agricultural and Biological Engineers to meet standardization needs within the scope of ASABE. Agricultural equipment, farmstead equipment, structures, soil and water resources equipment, forest engineering, food and process engineering, natural resources and environment, and waste management.

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ASABE, 2950 Niles Road, St. Joseph, MI 49085-9659, USA ph. 269-429-0300, fax 269-429-3852, hq@asabe.org

Spray Measurement

Reference Sprays

- Establish Reference Nozzles/Sprays

VF/F **F/M** **M/C** **C/VC** **VC/XC**

ANSI/ASAE S572.1 MAR2009
Approved March 2009 as an American National Standard

Spray Nozzle Classification by Droplet Spectra

Developed by the ASAE Pest Control and Fertilizer Application Committee; approved by the Power and Machinery Division Standards Committee; adopted by ASAE August 1999; reaffirmed February 2004; revised March 2009; approved as an American National Standard March 2009.

Keywords: Chemicals, Drop size, Droplet, Fertilizer, Nozzle, Spray

1 Purpose and scope

1.1 This Standard defines droplet spectrum categories for the classification of spray nozzles, relative to specified reference fan nozzles discharging spray into static air or so that no stream of air enhances atomization. The purpose of classification is to provide the nozzle user with droplet size information primarily to indicate off-site spray drift potential and secondarily for application efficacy.

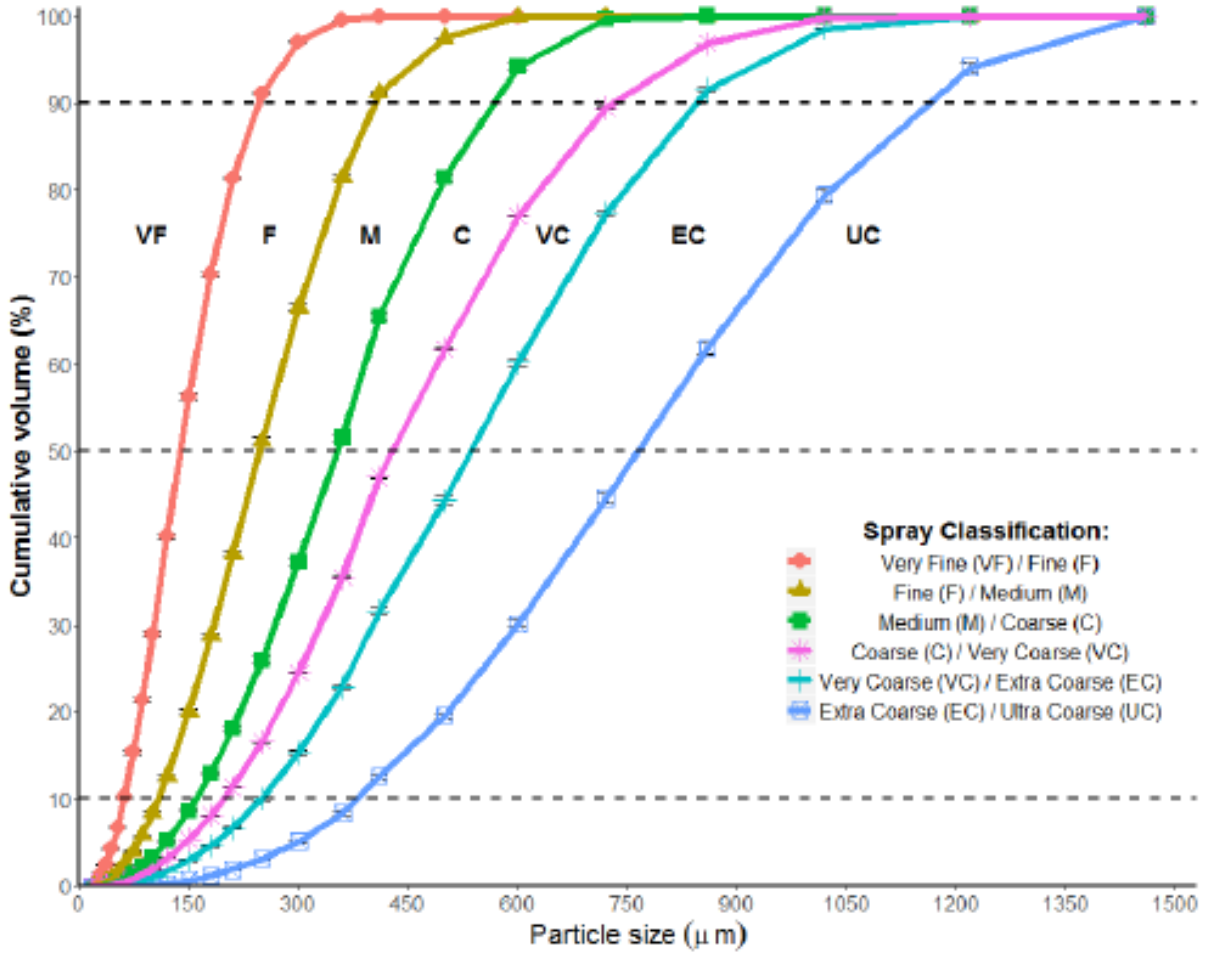
1.2 This Standard defines a means for *relative nozzle comparisons only*

3.3 Classification categories, symbols, and corresponding color codes are the following:

Classification category	Symbol	Color code
Extremely fine	XF	Purple
Very fine	VF	Red
Fine	F	Orange
Medium	M	Yellow
Coarse	C	Blue
Very coarse	VC	Green
Extremely coarse	XC	White
Ultra Coarse	UC	Black

University of Nebraska – North Platte

Reference Spray Classifications



ASABE Standard S-572.1
Spray Droplet Spectrum Classification

Category and code	Color code
Extremely Fine (XF)	
Very Fine (VF)	
Fine (F)	
Medium (M)	
Coarse (C)	
Very Coarse (VC)	
Extremely Coarse (XC)	
Ultra Coarse (UC)	

VMD Source: University of Nebraska-Lincoln

One Nozzle Doesn't Fit All Applications

Spray Quality Categories	
ASABE Standard S-572.1	
Category (symbol)	**Color Code**
Extra Fine (XF)	Purple
Very Fine (VF)	Red
Fine (F)	Orange
Medium (M)	Yellow
Coarse (C)	Blue
Very Coarse (VC)	Green
Extra Coarse (XC)	White
Ultra Coarse (UC)	Black

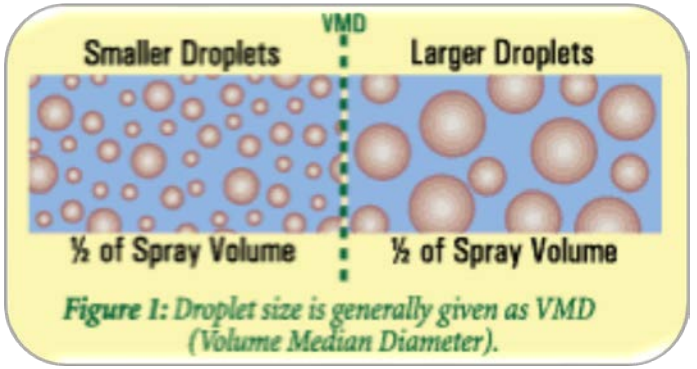


Figure 1: Droplet size is generally given as VMD (Volume Median Diameter).

Fungicides/Insecticides

Herbicides - Contact

Herbicides - Systemic

How far will particles go?

Droplet	Diameter in microns	Time to fall 10 feet	Travel distance in feet in an 8 MPH wind
Fog	5	66 minutes	15,840 feet
Very Fine	20	4.2 minutes	1,100 feet
Fine	100	10 seconds	44 feet
Medium	240	6 seconds	28 feet
Coarse	400	2 seconds	8.5 feet
Fine Rain	1,000	1 second	4.6 feet
Source: Herbicide Spray Drift, NDSU Extension			

Why Interest in Drift?

- Spotty pest control
- Wasted chemicals
- Off-target damage
- More high value specialty crops
- Urban sprawl and.....
- Less tolerant neighbors
- Litigious Society
- More wind?? (Timing)
- Environmental impact
  - Water and Air Quality
- Public more aware of pesticide concerns! (Negative) (Perceptions)
- Result-higher costs-$$$

Factors Affecting Drift:

Spray Characteristics

- chemical
- formulation
- drop size
- evaporation

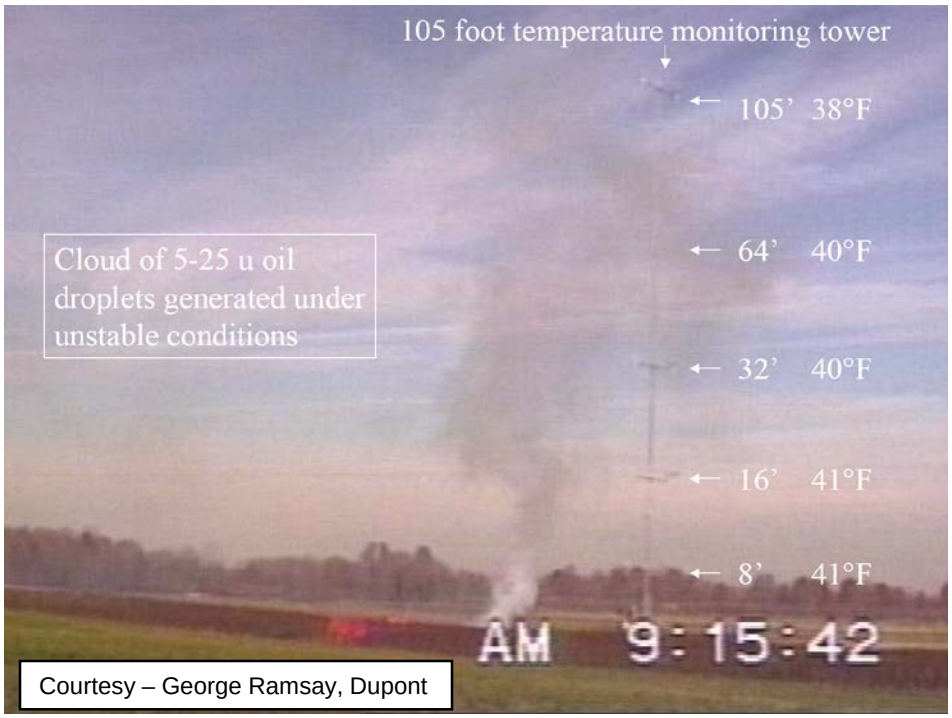
Equipment & Application

- nozzle type
- nozzle size
- nozzle pressure
- height of release

Weather and Environmental Conditions

Weather factors of concern:

- air movement (direction and velocity)
  - Topography, etc.
- temperature and humidity
- air stability/inversions



What are NOT good sources of the weather data required?

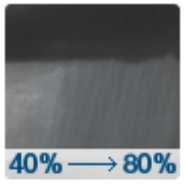
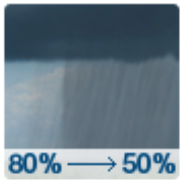
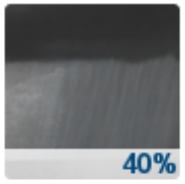
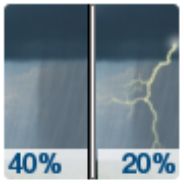
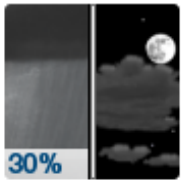
Current conditions at
La Junta Municipal Airport (KLHX)
Lat: 38.05°N Lon: 103.51°W Elev: 4193ft.

Overcast
58°F
14°C

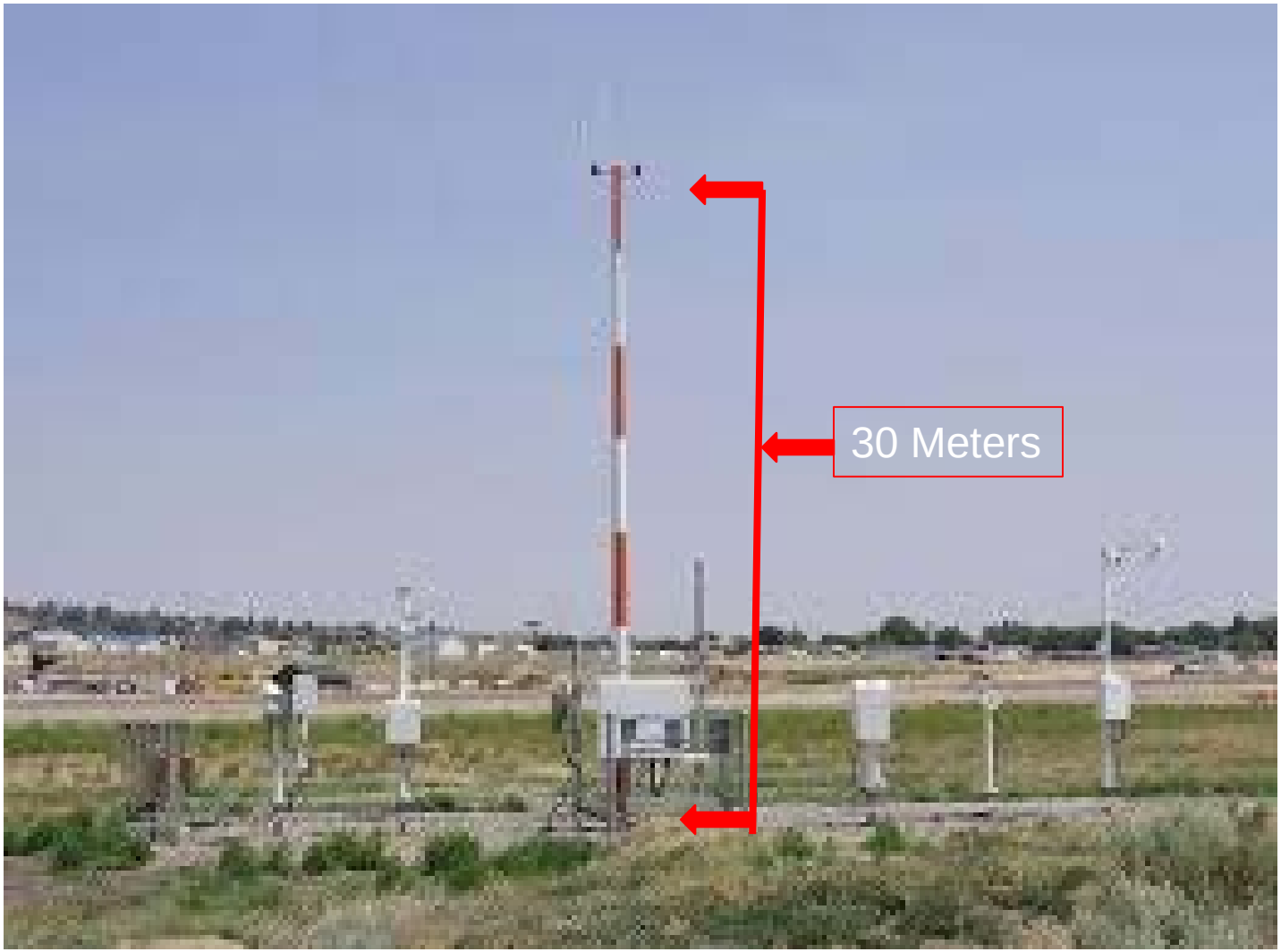
Humidity	81%
Wind Speed	E 5 mph
Barometer	30.30 in (1022.7 mb)
Dewpoint	52°F (11°C)
Visibility	10.00 mi
Last update	27 Sep 8:53 pm MDT

More Information:
Local Forecast Office
More Local Wx
3 Day History
Mobile Weather
Hourly Weather Forecast

Extended Forecast for
La Junta CO

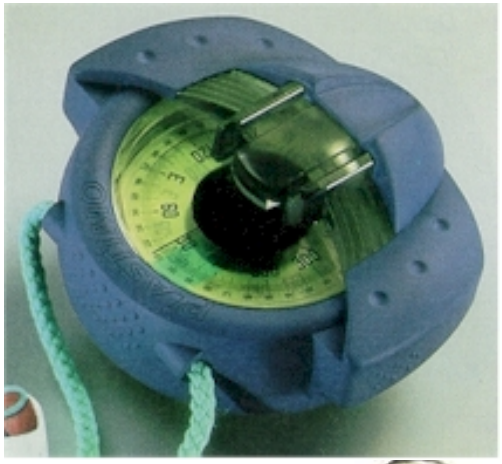
Tonight	Thursday	Thursday Night	Friday	Friday Night	Saturday	Saturday Night
						
Chance Showers then Showers	Showers then Chance Showers	Chance Showers	Chance Showers then Slight Chance T-storms	Chance Showers then Partly Cloudy	Mostly Sunny	Mostly Clear
Low: 48 °F	High: 54 °F	Low: 47 °F	High: 61 °F	Low: 50 °F	High: 75 °F	Low: 53 °F

Met Stations



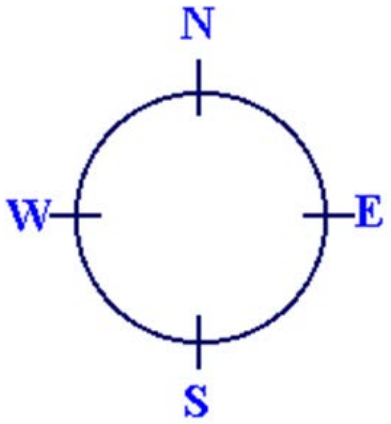
Wind direction:

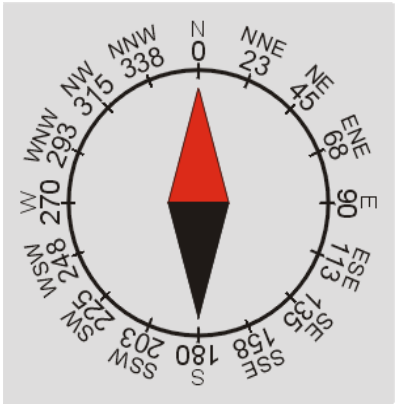
- Wind **direction** is very important
  - Know the location of sensitive areas - consider safe buffer zones.
  - Do not spray at any wind speed if it is blowing towards sensitive areas - all nozzles can drift.
  - Spray when breeze is gentle, steady, and blowing **away** from sensitive areas.
  - "Dead calm" conditions are **never** recommended.

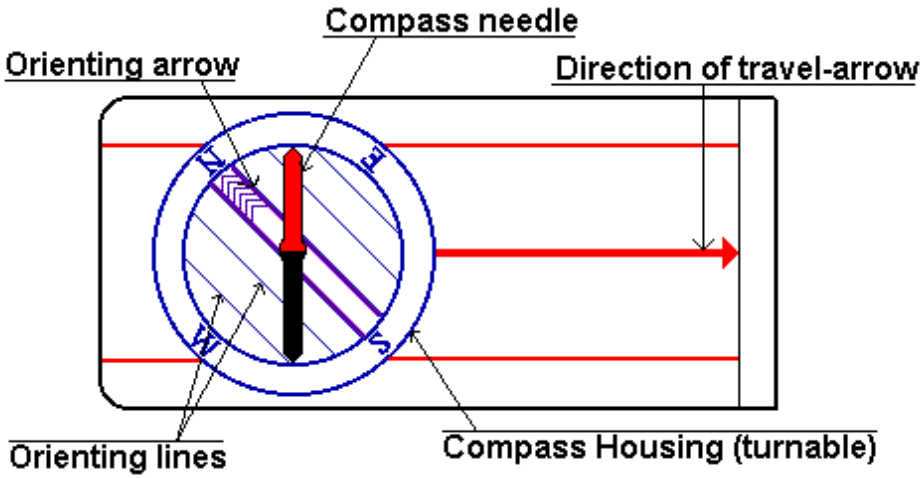


Determining wind direction:

- Compass
  - Provide magnetic description
  - Direction blowing from
  - Into your face!







Wind Speed

- Follow the label guidelines
- How do you determine wind speed?

Drift Potential: High at Low Wind Speeds?

- Because:
  - Light winds (0-3 mph) tend to be unpredictable and variable in direction.
  - Calm and low wind conditions may indicate presence of a temperature inversion.
- Drift potential is lowest at wind speeds between 3 and 10 mph (gentle but steady breeze) blowing in a safe direction.

KestrelMeters.com

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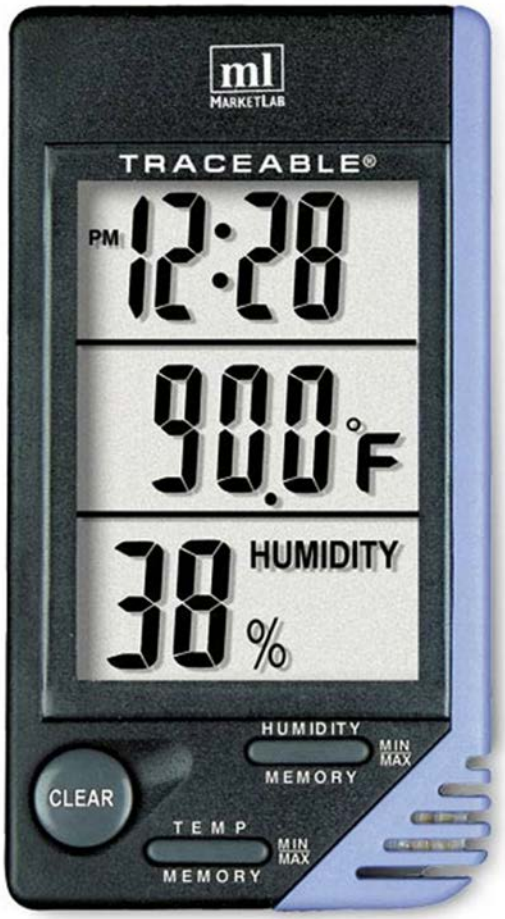
WatchDog Sprayer Station

Three display/logging options:
Sprayer Station Console, Raven Viper Pro, Viper 4,
and Envisio Pro, or Windows Mobile PDA or Windows Laptop

AIMMS-20

Aircraft-Integrated Meteorological Measurement System

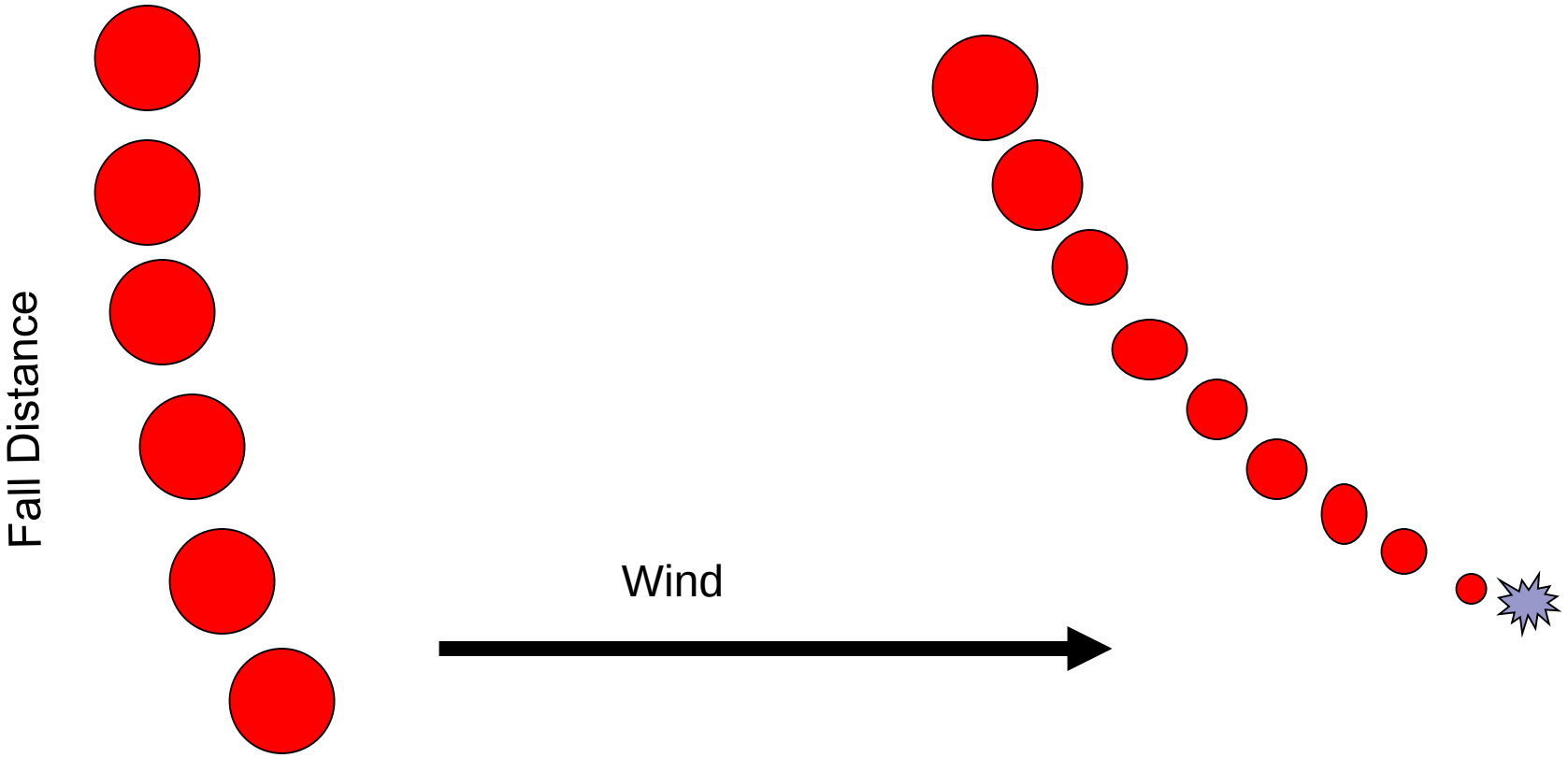
Temperature & Humidity



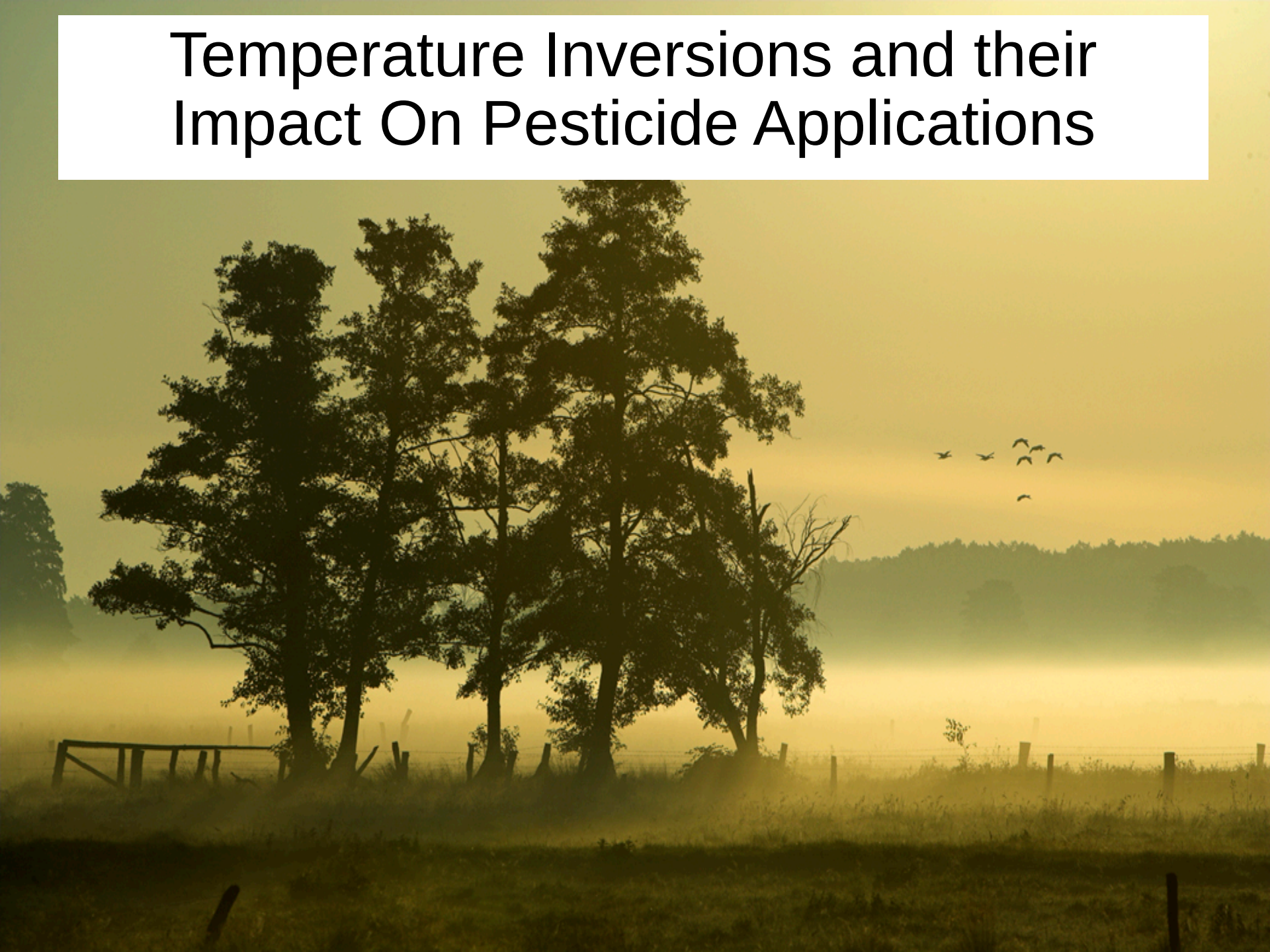
Evaporation of Droplets:

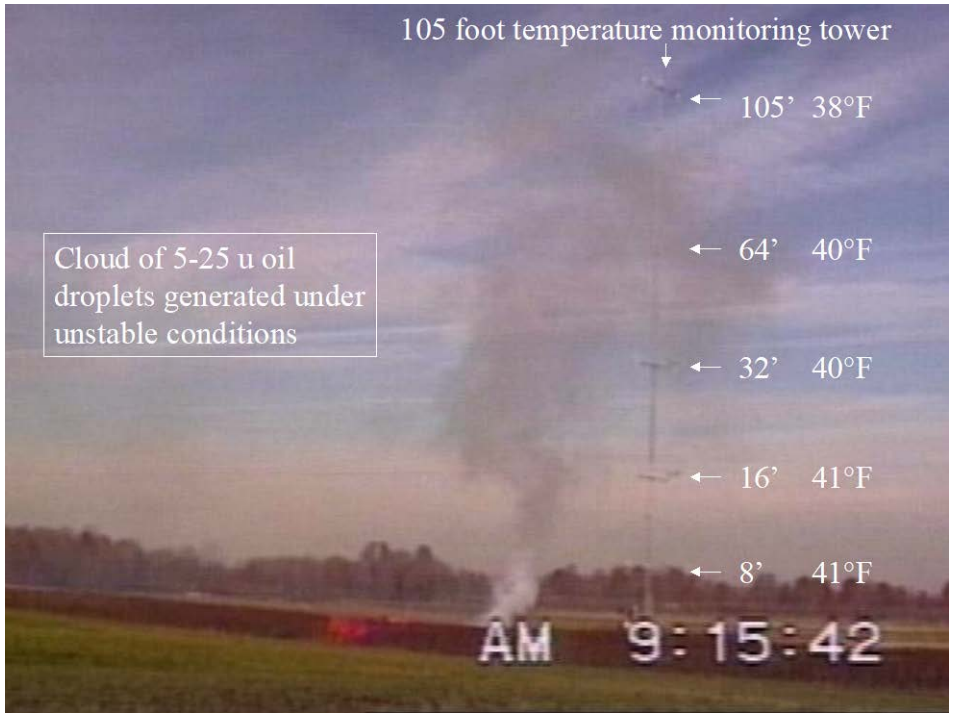
High Relative Humidity
Low Temperature

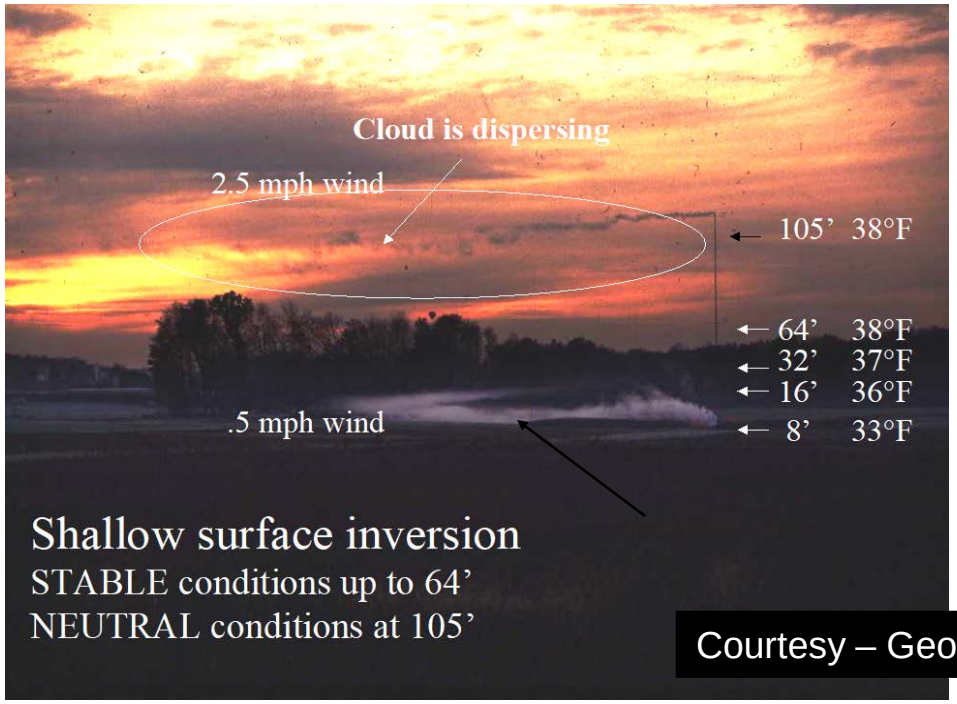
Low Relative Humidity
High Temperature



Temperature Inversions and their Impact On Pesticide Applications







Courtesy – George Ramsay, Dupont

Recognizing Inversions

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

Fine spray drops hang in the air


Dust from vehicles or farm machinery will hang in the air

If the light and fog reflect just so, one can actually see the inversion.

All the conditions we've talked about assumes very little wind.

Sufficient wind will mix the air, thus preventing or destroying the inversion.

There is low heavy cloud cover
The wind speed is greater than 5-6 mph at ground level
5 degree temp rise after sun-up

Air Temperature Inversions

Causes, Characteristics and Potential Effects on Pesticide Spray Drift

John W. Enz
Professor Emeritus
Department of Soil Science

Vernon Hofman
Professor Emeritus
Department of Agricultural and Biosystems Engineering

Andrew Thostenson
Extension Pesticide Program Specialist

Pesticide spray drift always has been a costly and frustrating problem for applicators.

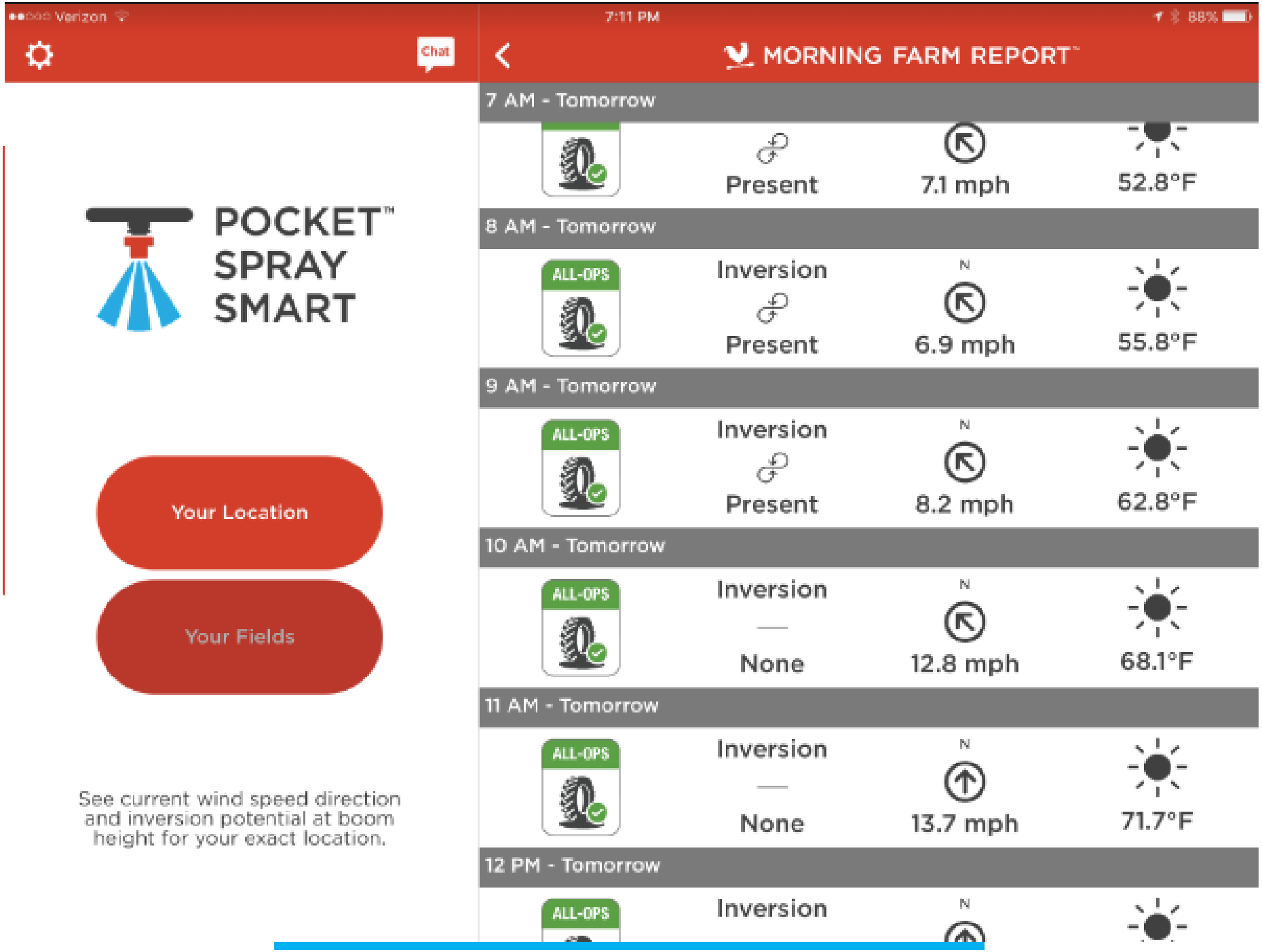
It's particularly frustrating because some of the seemingly best weather conditions for pesticide application are often the worst. That is because those conditions are caused by air temperature inversions. Air temperature inversions provide near-perfect conditions for tiny, aerosol-size droplets to drift away from their targets.

Understanding inversions is essential to following state and federal regulations that prohibit pesticide application during inversions, observing pesticide manufacturers' warnings about inversion conditions on product labels and preventing unintended pesticide contact with nontarget areas. An understanding of air temperature inversions – why they occur, their characteristics and their dissipation – requires a basic understanding of energy transfer at the Earth's surface and in the lower layers of the atmosphere.

NDSU EXTENSION SERVICE
November 2017

https://www.ag.ndsu.edu/publications

AE1705 (revised)


Verizon
7:11 PM
88%
Chat
MORNING FARM REPORT™
POCKET™
SPRAY
SMART
Your Location
Your Fields
See current wind speed direction and inversion potential at boom height for your exact location.
7 AM - Tomorrow
Present
7.1 mph
52.8°F
8 AM - Tomorrow
ALL-OPS
Inversion
Present
N
6.9 mph
55.8°F
9 AM - Tomorrow
ALL-OPS
Inversion
Present
N
8.2 mph
62.8°F
10 AM - Tomorrow
ALL-OPS
Inversion
—
None
N
12.8 mph
68.1°F
11 AM - Tomorrow
ALL-OPS
Inversion
—
None
N
13.7 mph
71.7°F
12 PM - Tomorrow
ALL-OPS
Inversion
N

Application Recordkeeping

Documenting the Weather

Application Recordkeeping:
Focus on Environmental Conditions

Bob Wolf: Professor Emeritus, Kansas State University, Wolf Consulting and Research LLC.
Dennis Gardisser: Professor Emeritus, University of Arkansas, WRK of Arkansas LLC.

When applying crop protection products, a good steward is one who can identify and record the environmental factors that may negatively impact making an application; particularly, the possibility of spray drift. New label language states: *"Avoiding spray drift at the application site is the responsibility of the applicator."* A wise sprayer operator must possess the ability to assess the environmental conditions at the field location to determine how best to spray the field, or maybe decide it would be best not to spray that field, or part of that field, at that time. Instruments that assess environmental conditions are available to assist applicators in making good decisions. Making the correct measurement is the critical first step. Record the information measured to document the application conditions. Quality records help mitigate against any misapplication allegations, such as a drift complaint. Many of the items listed below are based on past legal experiences with applications involving spray drift litigation.

The following guidelines should help you measure and accurately record environmental conditions at the application site.

1. Document any instrument used by recording the manufacturer and model number. Accurate portable weather instruments are recommended. Portable weather instruments are available that log and store data, and aid in auditing and recordkeeping. Some will have Bluetooth/wireless capabilities.
2. Environmental measurements include wind speed and direction, temperature, and relative humidity.
3. At a minimum, record data at the start and finish of the job. Consider more often as conditions change or for a job that lasts over a longer period. For example, make observations when tank refilling for larger fields. Time stamp all observations with a.m., p.m., or military time.

2017 AAPSE Annual Meeting Fargo, North Dakota, USA
Application Technology
July 25, 2017

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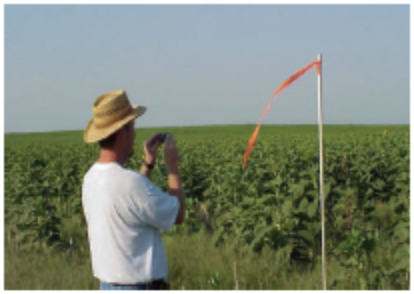
Web: http://ndsupesticide.org
https://twitter.com/Thostenson

4. Take meteorological readings as close to the application site as possible. Be advised that the weather data received via a smart phone or local weather station may not be accurate for the location being sprayed.
5. Note the specific location where the measurement was made, such as GPS coordinates, field entry point, field location, etc. Check the label to see if it requires a specific observation location in relation to the treatment area.
6. Make all measurements as close as possible to the nozzle release height (boom height) and in an area not protected from the wind by the spray machine or your body. For aerial applications, six feet is suggested when using a hand held instrument.
7. Record wind speed averaged over a 1 to 2 minute time span. Note the time the observation was recorded. Most instruments give an average over a period of time. Make sure the instrument's anemometer is facing directly into the wind.
8. Do not record winds as variable or with a range i.e. 4 to 8 mph – an average gives a better indication of the transport energy. Light and variable winds, where directions may change several times over a short period, can be more problematic than higher speed winds in a sustained direction. Observe any label restrictions on wind speed.
9. Wind direction requires a similar averaged measurement. Record direction in degrees magnetic from a compass (0-360°). The use of alphabetic characters, i.e., N, S, NW, to indicate wind direction is discouraged. The key for determining direction is to have an accurate assessment method: trees moving, dust, smoke, a ribbon on a short stake, etc. Face directly into the wind and record the direction from which the wind is coming. A ribbon on a stake with the ribbon blowing directly at your body is a simple fail safe approach. Movement of smoke, particularly from moving aircraft, or dust may help determine direction.



10. Record temperature and humidity since they can be helpful in determining temperature inversion potential. It may be advisable to record both temperature and humidity well before and after the application for this purpose. In fact, recording a morning low and an afternoon high would be useful regarding determining the potential for an inversion. Take temperature measurements with the instrument out of direct sunlight. Shade the instrument with your body or spray equipment. This is especially critical if you are trying to assess temperature differentials for determining if an inversion is in place.
11. Be alert to field level temperature inversion conditions which typically occur from late afternoon, can be sustained through the night, and into the next morning. Beware, inversions can start mid-afternoon. Observe conditions such as the presence of ground fog, smoke layers hanging parallel to the ground, dust hanging over the field/gravel road, heavy dew, frost, or intense odors (i.e., smells from manure or stagnant water from ponds are held close to the surface when inversion conditions exist). Inversions commonly occur with low (less than 3 mph) to no wind speeds. Spraying in calm air is not advised. If a mechanical smoker is used, note wind direction and smoke dissipation with a time stamp.
12. Note any variances due to terrain or vegetation differences, tree lines, buildings, etc.
13. Initial or sign all recordings to indicate who made the observation(s).

Suggested Weather Documenting:

- Document the instrument used.
- Measurements include:
  - Wind speed and direction
  - Temperature and humidity
- Minimum recordings – start and finish.
- Time stamp and sign the record.
- Record data taken on site.
- Record specific locations -GPS Coordinates

Suggested Weather Documenting:

- Record data nozzle release height. 6-foot or higher for aerial.
- Average wind speed and direction over a 1-2 minutes. Not a range, but average.
- Record direction in degrees.
- Measure temperature and humidity before and after – good inversion indicator.
- Note any terrain conditions.

Application Recordkeeping
What is required? What is essential?

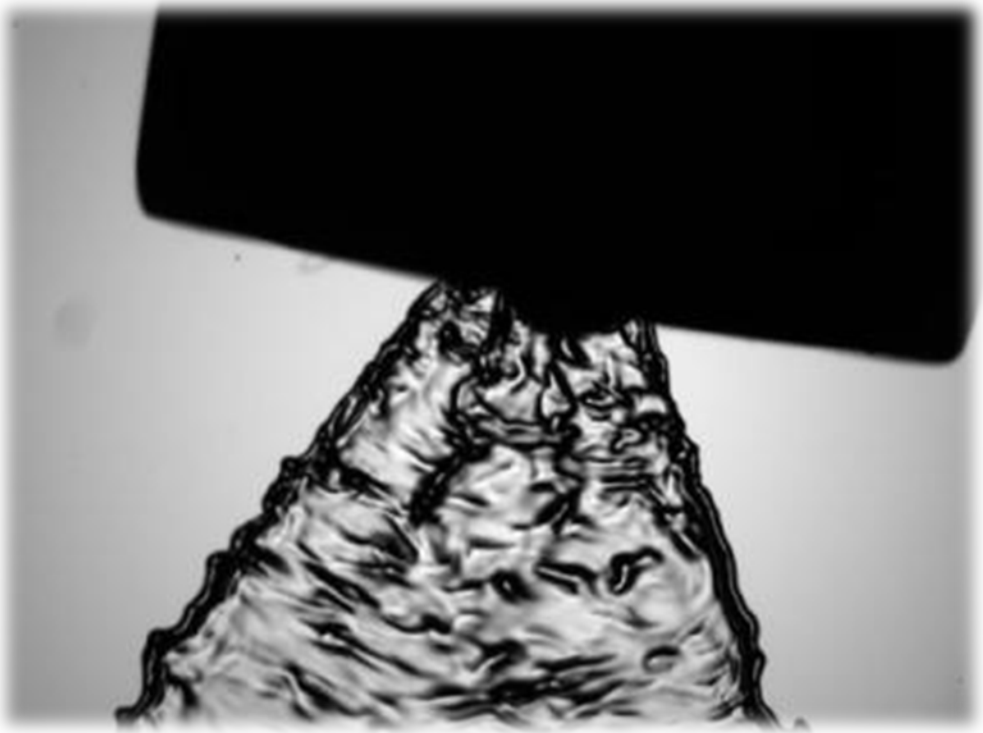
- Field location (target pest, crop)
- Equipment details (aircraft, boom)
- Nozzles (type, size, deflection)
- Application parameters (PSI, GPA, MPH)
- Solution – tank mix products (adjuvants)
- Environmental factors

Develop a protocol….
Standard of Practice…..

CYA

Solution Factor:

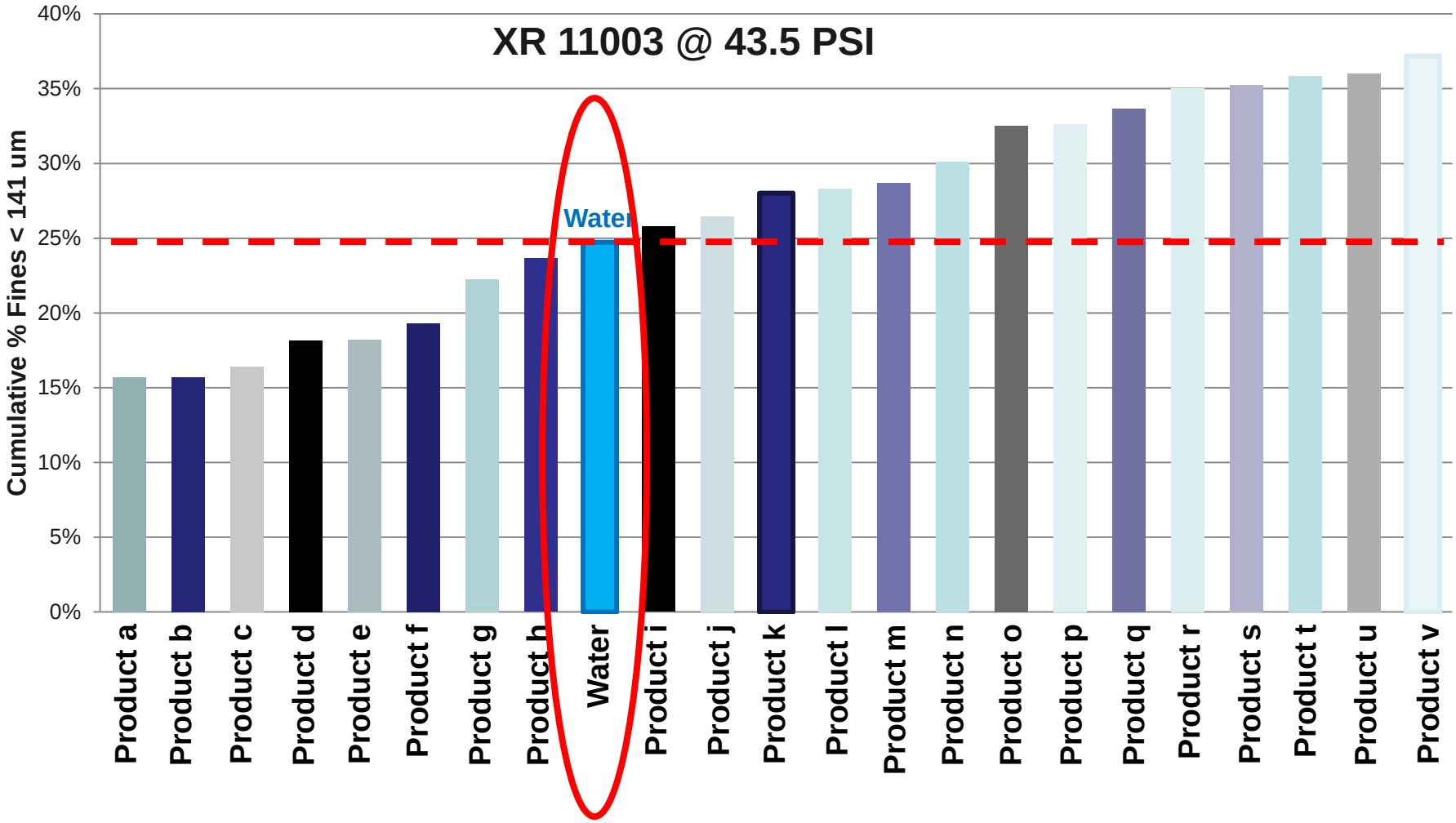
- Does it change the flow rate ????
- Changes the droplet spectra !!!!



No deposition aid

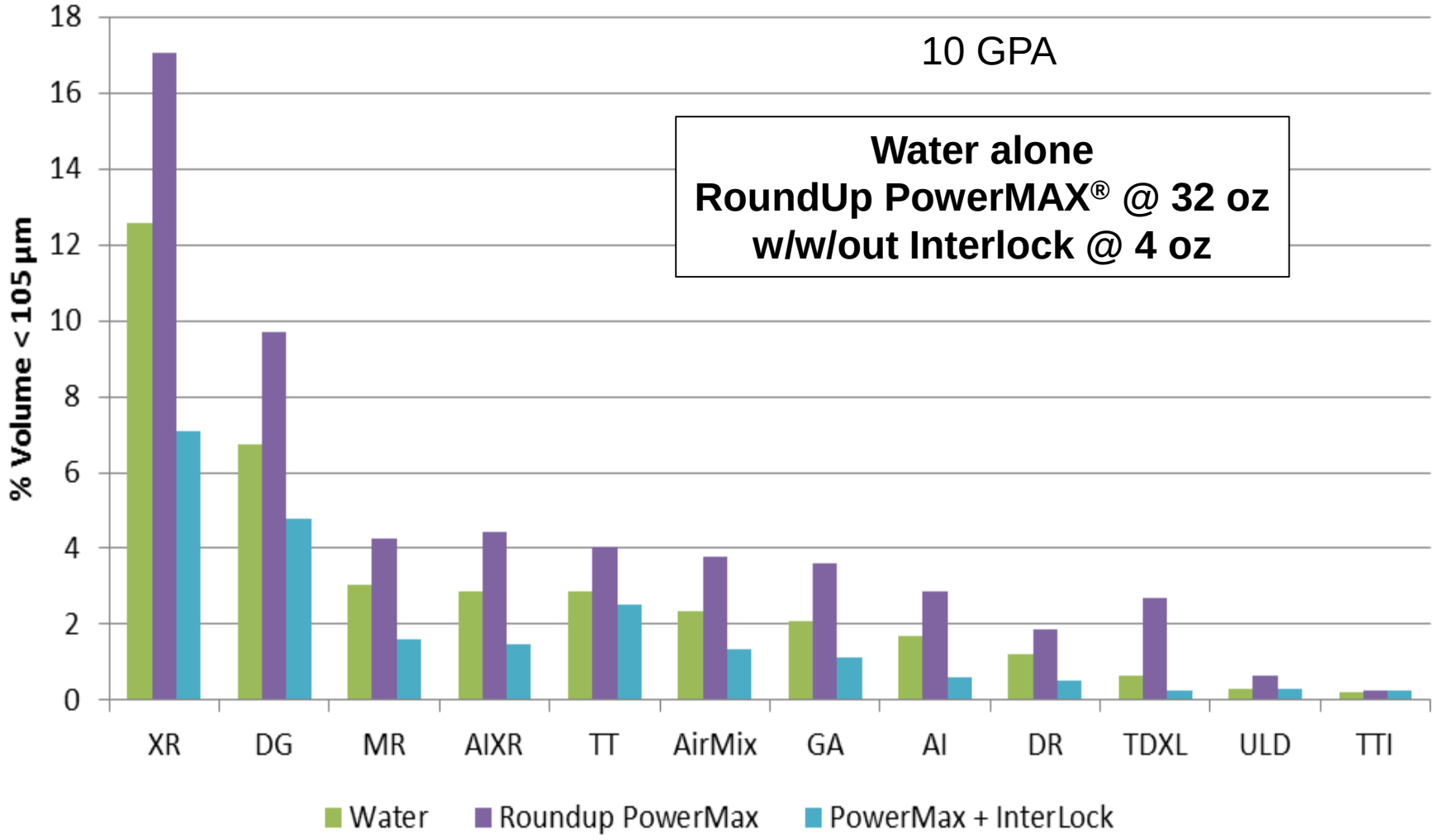
With deposition aid

Influencing Droplet size – Tank-mixes

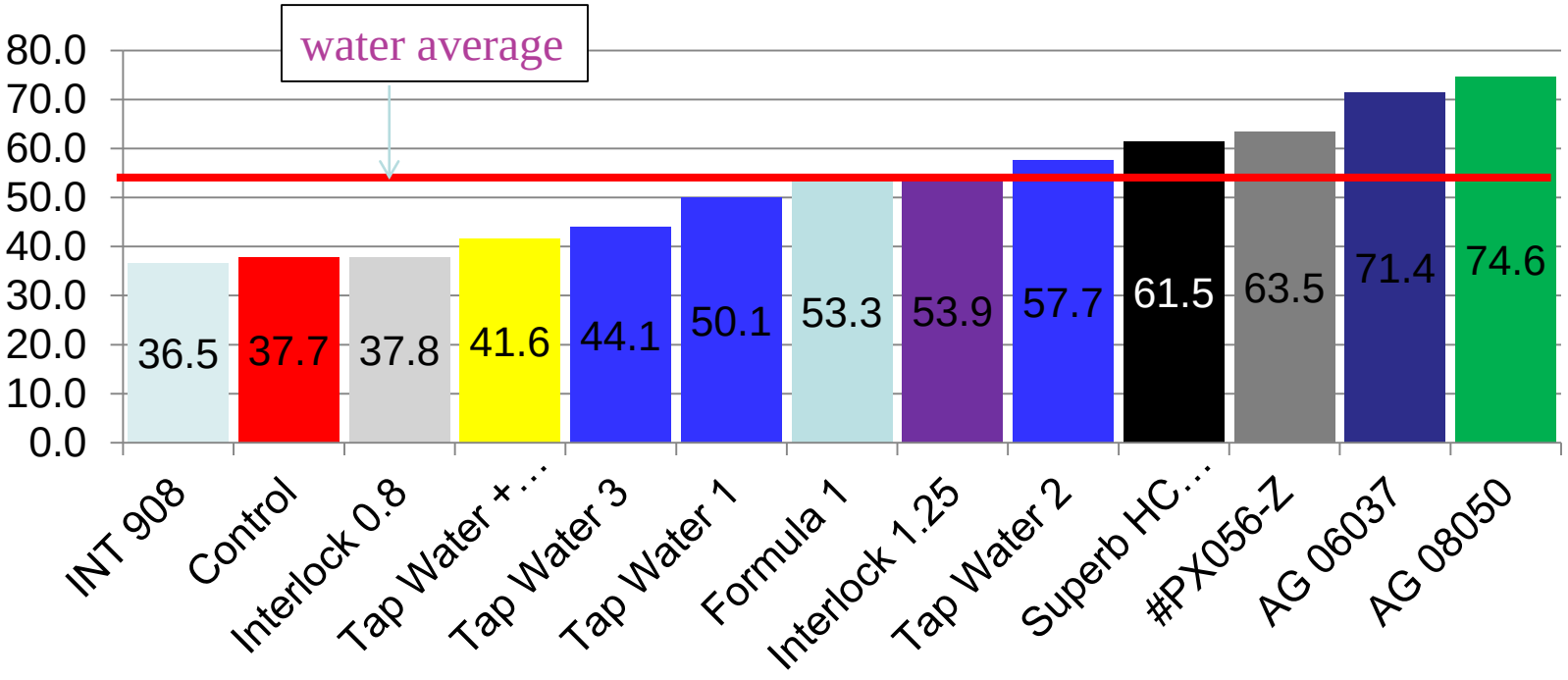


Without drift reducing adjuvants--other adjuvants indicated by ‘mix’

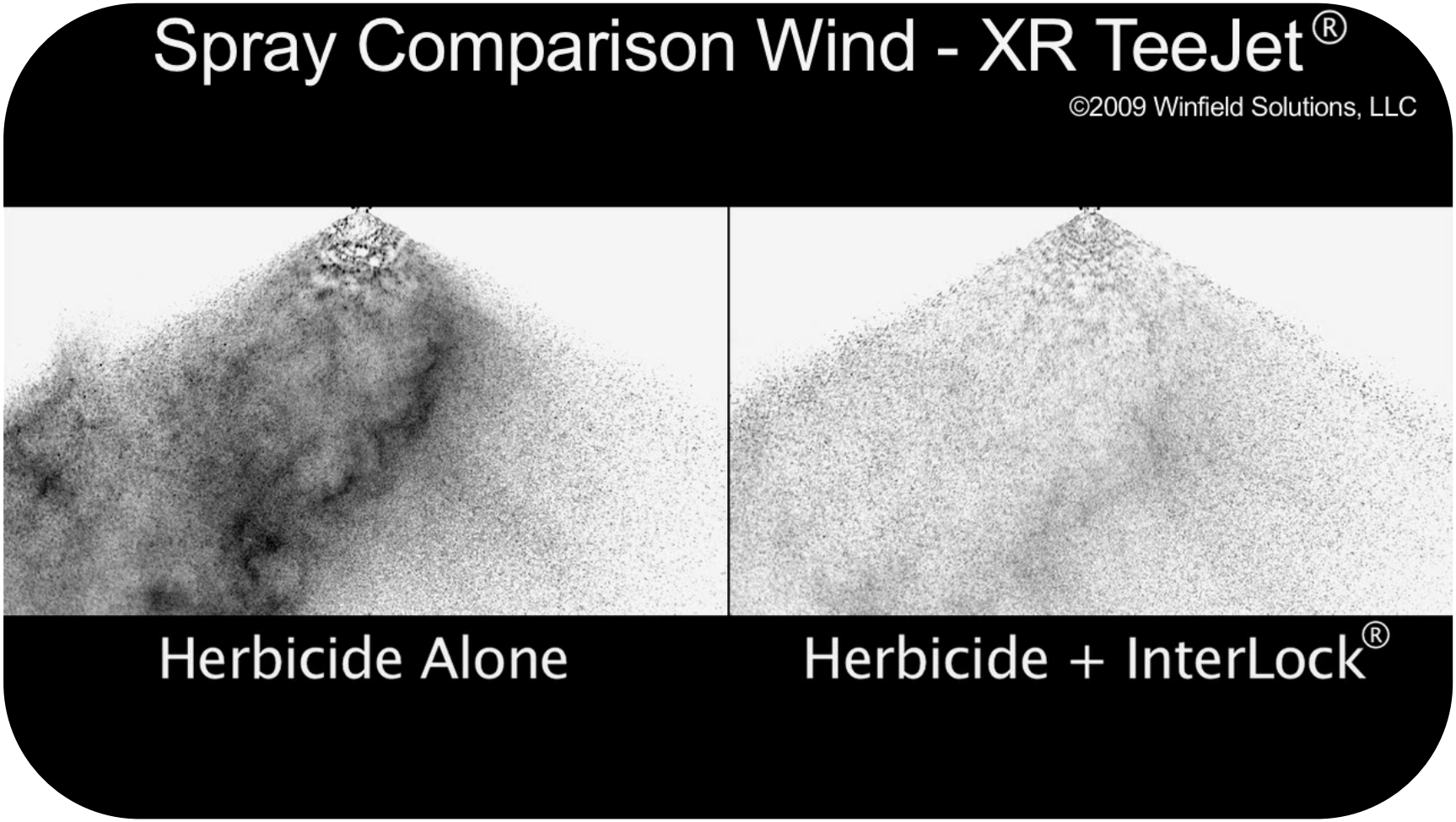
Volume % Driftable Fines
110°/120° - 04 Nozzles @ 40 psi



Total Drift Ranked:



Influencing droplet size - Adjuvants



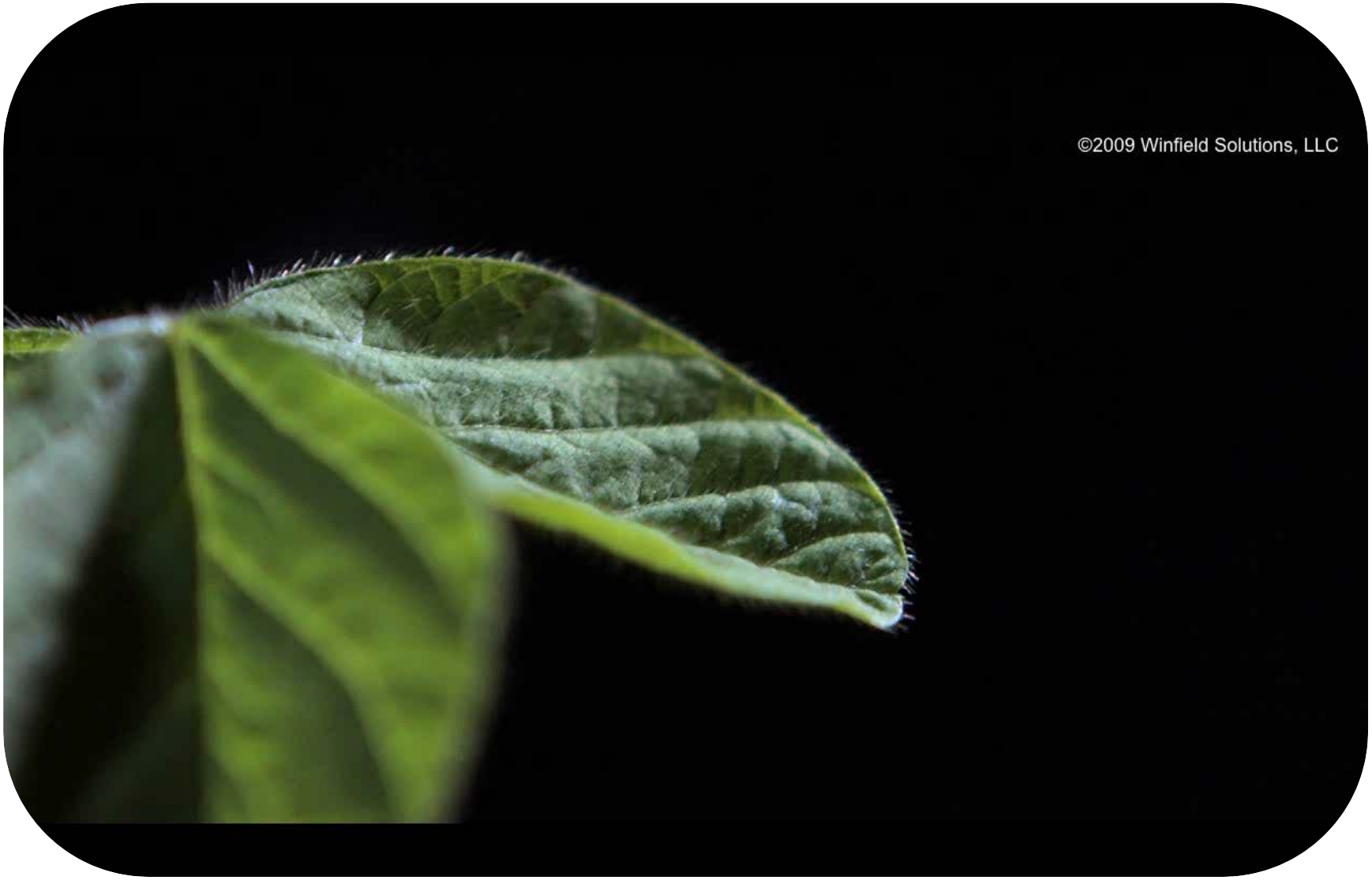
WINFIELD UNITED

An Evaluation of Nozzle Performance with AG16098

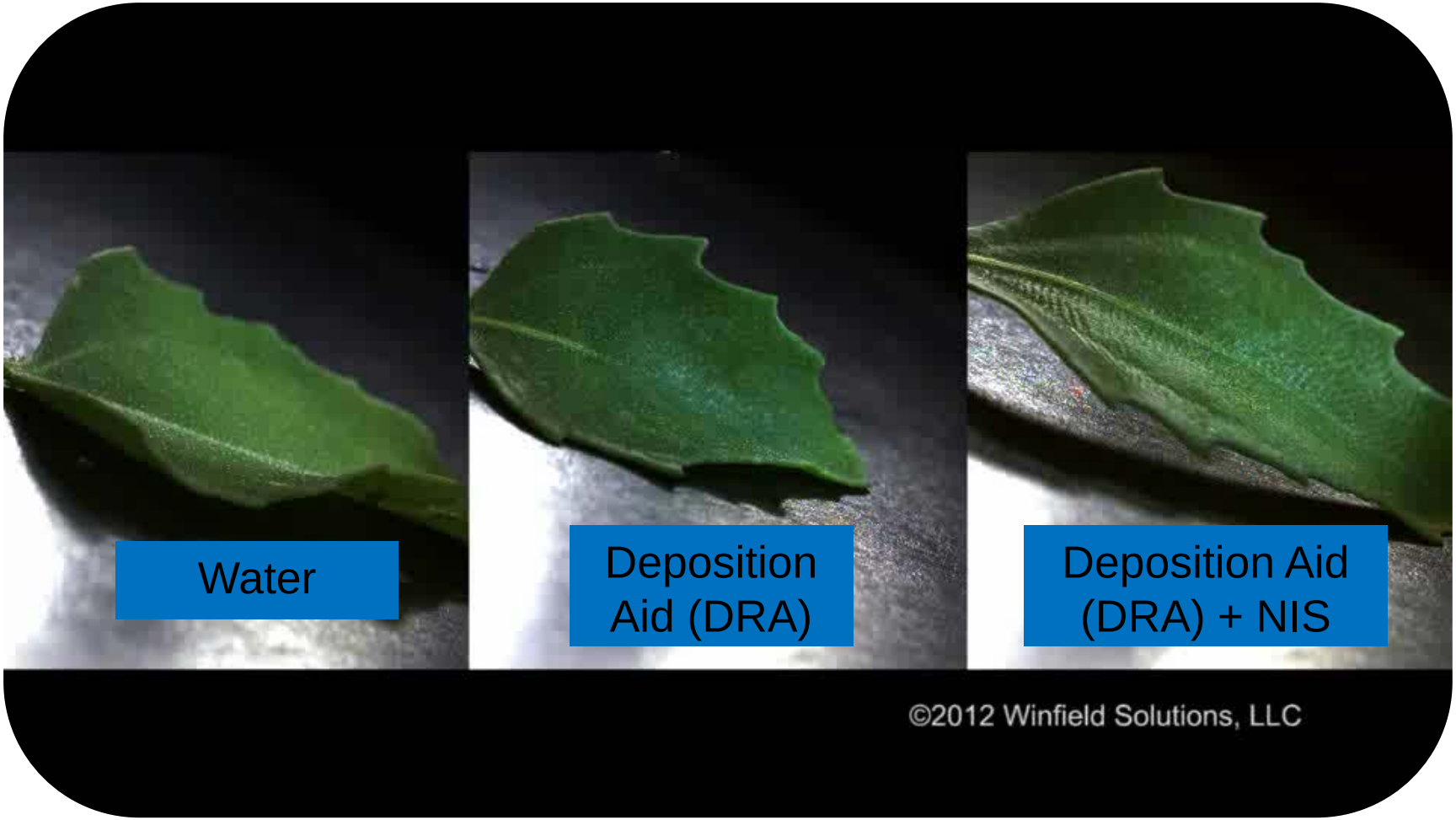
Example of an unacceptable spray pattern

Example of an acceptable spray pattern

Droplet Fate - Bounce



Drift Mitigating – Deposition



WCR PPP-115 WS-54

COMPENDIUM OF HERBICIDE ADJUVANTS

2016 • 13th Edition

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PURDUE EXTENSION

SIU Southern Illinois University CARBONDALE

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Thanks!