Use of Adjuvants to Enhance Performance of Forest Herbicides

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Adjuvants: Materials added to spray mixtures to enhance performance or improve application efficiency

- Surfactants (Wetter, Spreader, Sticker)
- Oils
- Emulsifiers
- Water Conditioners
- Drift Mitigation
- Foam Reducers
- **4000 products** in US
- *Largely not regulated*

Product formulations vary!!!

- Many products are “Ready to Use” or already have surfactants, emulsifiers, etc. in the product formulation

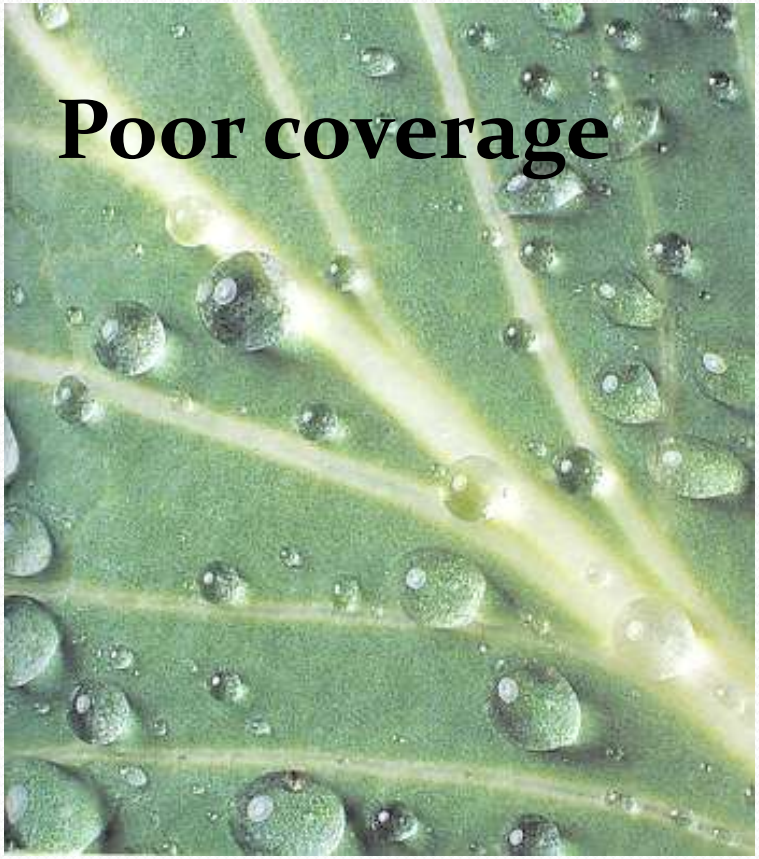
Arsenal® AC does not contain surfactant

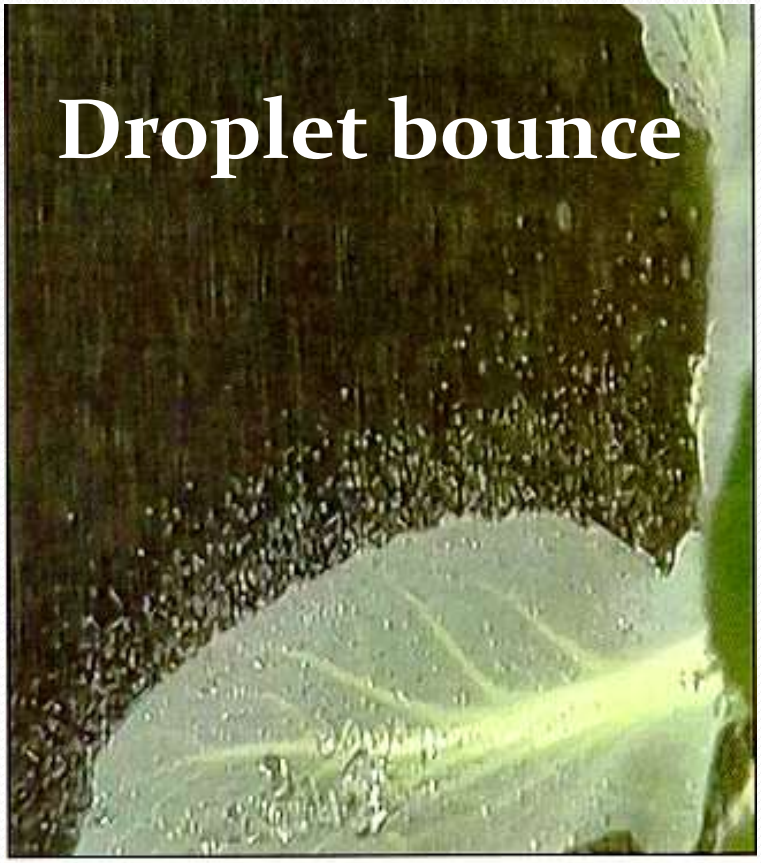
Common forestry products without surfactants

Common Name	Trade Names
glyphosate	Accord® Concentrate Foresters'®
imazapyr	Arsenal® AC Polaris®
metsulfuron methyl	Escort® XP® Patriot®
sulfometuron methyl	Oust® XP® Spyder®

Surfactants and Oils

- Increase **spread on leaf** improving absorption
- Increase **deposition efficiency** on leaf surface





It **dissolves in water** *(water-loving,* ***hydrophylic****)*
or it **dissolves in oil** (*lipid or oil loving,* ***lipophylic***)


WATER
OIL

Oil and oil emulsion carriers

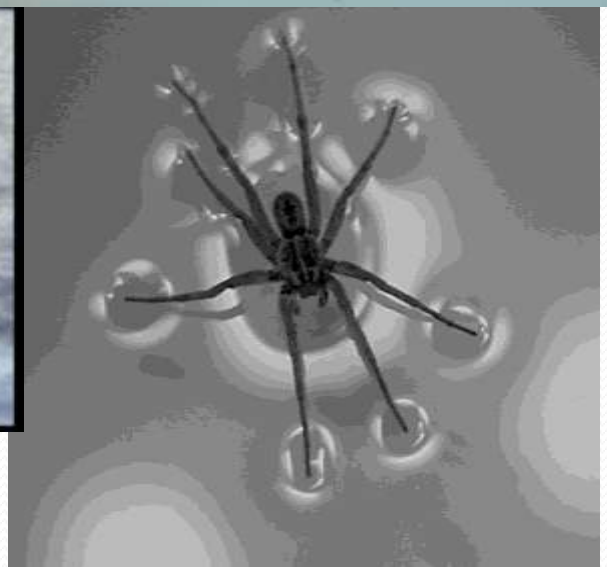
Advantages

- Excellent droplet spread
- Reduced evaporation, greater absorption
- Good deposition, little "bounce"
- Solvent to the cuticle, the wax covering the leaf, more herbicide gets inside the plant

Disadvantages

- Costs more than water
- Potential worker exposure/toxicity
- Potential volatility, drift
- Spray preparation may not be as stable
- More difficult to clean equipment

The power of surface tension holds water together



The force of hydrogen bonding

Wetting agents *reduce surface tension* increasing droplet spread and uptake

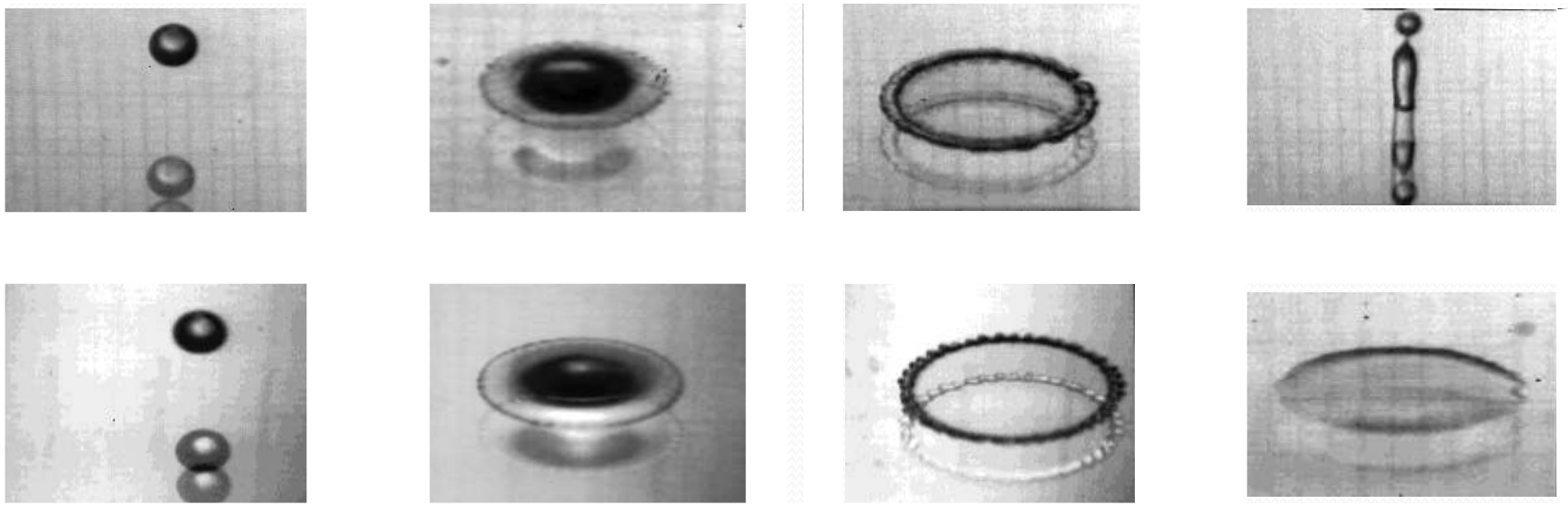
Herbicide in water

Herbicide in water
plus surfactant

Polymers reduce droplet bounce

No Sticker

Impact | Expansion | Retraction | **BOUNCE**

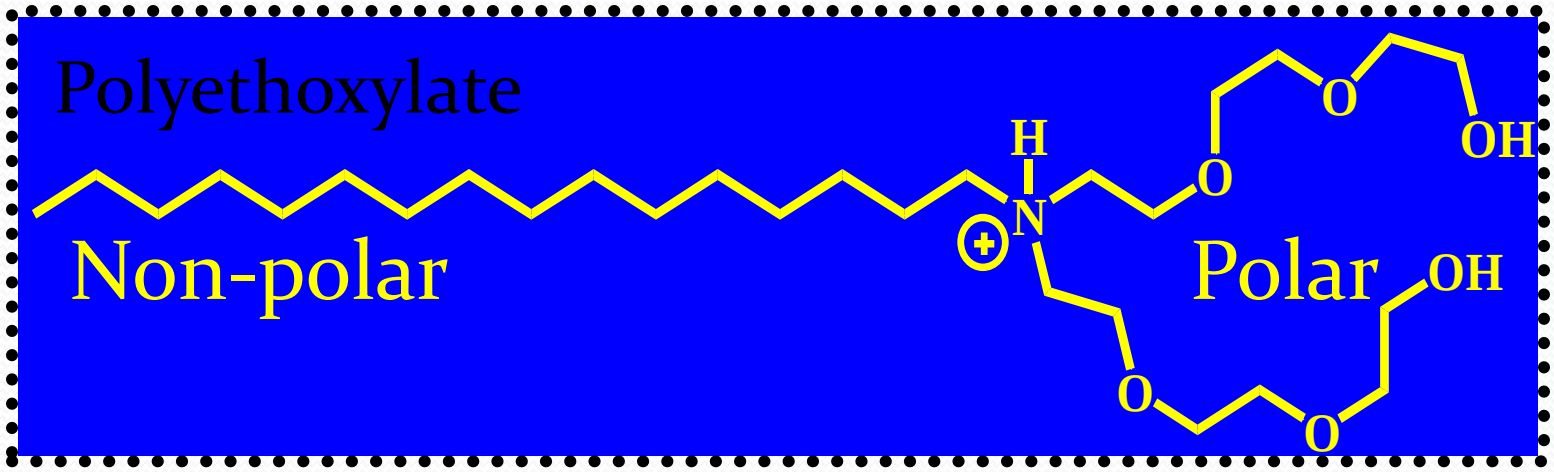


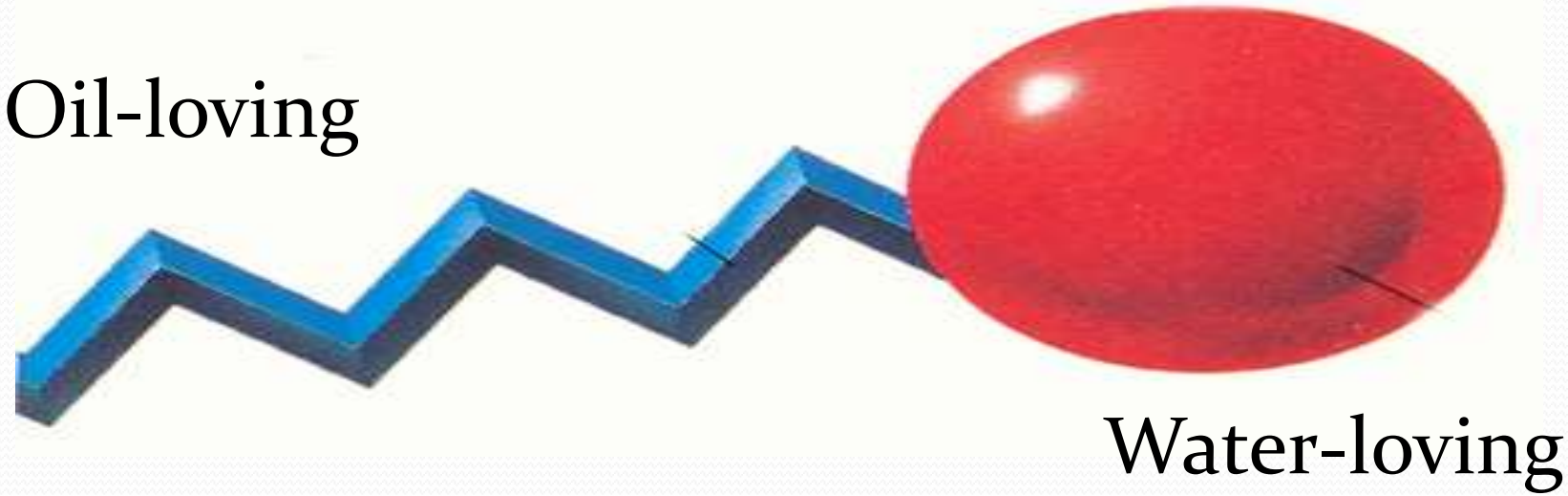
Sticker (Polymer)

NO BOUNCE

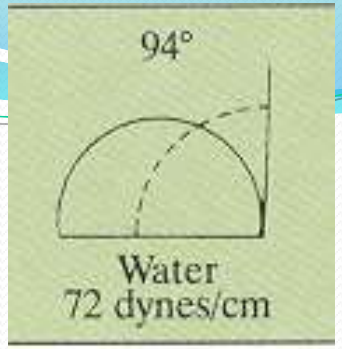
Reference: Bergeron, V., Martin, J-Y., and Vovelle, L. 2003. Use of polymers as sticking agents. U. S. Patent 6,534,563.
Bergeron, V., Bonn, D., Martin, J-Y., and Vovelle, L. Controlling droplet deposition with polymer additives. Nature 2000: 405:772-775.

How do surfactants work?

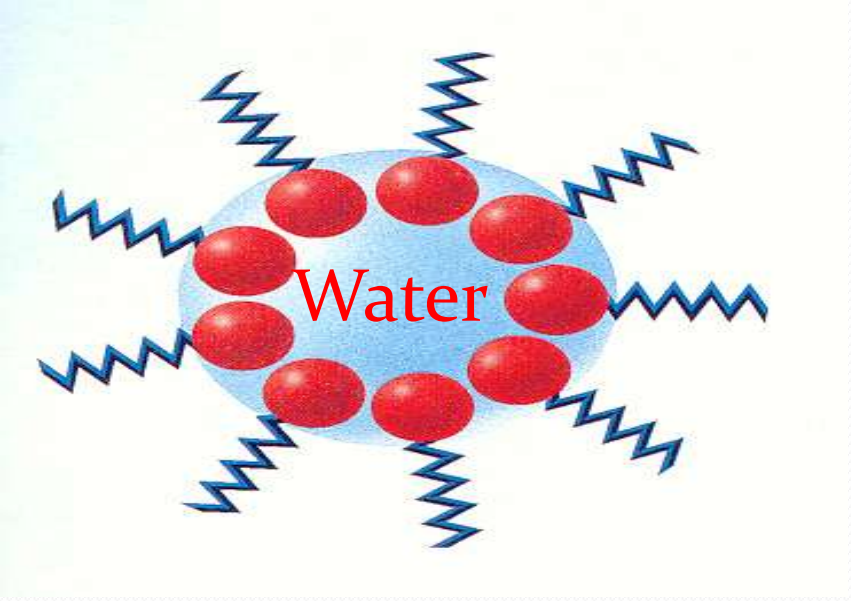




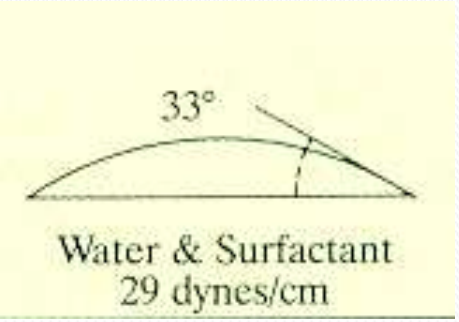
Water



Surfactants reduce the energy holding the water droplet together resulting in better coverage



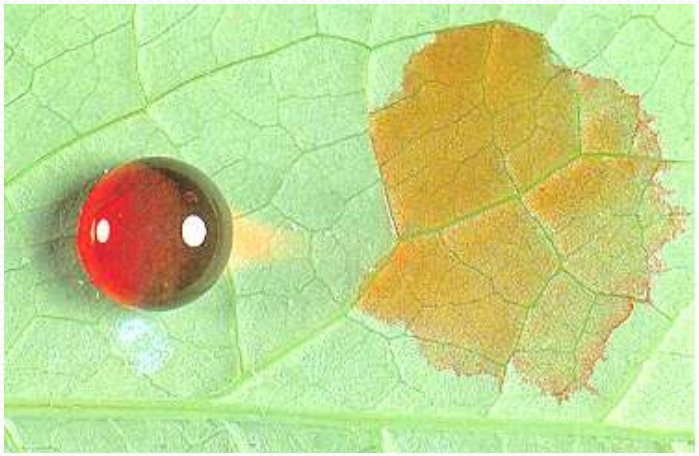
Water plus *Surfactant*



"Contact angle" is reduced

Silicone surfactants

- **Super spreaders**
- Used at very low rates, **½-1 pints per 100** gallons spray
- Form emulsions in water
- Eye irritant
- May cause foaming



Common products

Surfactants

- **Non-ionic surfactant** such as polyethoxylates, 1-3 quarts per 100 gal spray (0.25-0.75% solution)
- **Silicone**, containing silicone

Oils

- **Crop oils**, paraffin derived from mineral oil
- **Basal oils**, mixed mineral oils containing paraffin, aromatic and napthelene
- Methylated seed oil (**MSO**), esterified free fatty acids from plant glycerol (bio-deisel)
- **Tallow amine**, free fatty acids from animal fat

Common oil-based forestry herbicides

Emulsifiers in formulation

Common Name	Trade Names
tricopyr ester	Garlon® 4 Tahoe® 4E
2,4-D ester	Weedar® Many others
2,4-DP ester	Weedone® Many others

Phenoxies and pyridinecarboxylic acids

Emulsifiers mix oil and water

- Emulsions enhance herbicide uptake
- Reduce evaporation, provide drift mitigation
- Emulsifiers promote the suspension of one liquid in another
- Emulsions are milky-white, micelles dispersed in water

Emulsifiers are amphoteric molecules with polar heads and non-polar tails.

Two kinds of emulsions:

Oil in Water

- Most common
- Emulsifiable Concentrate (EC) products make these

Water in Oil

- Require careful mixing, injector systems
- Provide **drift mitigation**
- Reduce volatile losses
- KEEP WATER OUT after mixing!

Water Quality Problems?

Water conditioners:

Reduce interaction of herbicide and water

Water Problems:

- ✓ Hard Water
- ✓ Iron
- ✓ Carbonates
- ✓ pH
- ✓ Clay
- ✓ Algae

Water conditioners,

many products for specific uses

- Polyacrylates (Quest®)
- Ammonium Sulfate
- Phosphate ester surfactants (Buffer® PS)
- Chelates (EDTA)
- pH Buffers (TSPP)
- Acids

Glyphosate (Accord®, Roundup®, etc) is sensitive to water quality issues!

- Water hardness (Ca^{++}, Mg^{++}, Fe^{++}) **precipitates glyphosate**
- Limestone regions: High pH, hardness, bicarbonates
- **Add water conditioner** if hardness greater than **120 ppm**
- **Ammonium Sulfate**, NH_4SO_4, precipitates calcium, add **7-18 lb** per 100 gallons, **BEFORE HERBICIDE**!

Larger droplets are less prone to drift! Droplet size determined by:

- Size and Type of Nozzle
  - Larger nozzle orifice size means a larger droplet
- Pressure at the Nozzle
  - Lower pressures produce less fines
- Application Height
  - Potential for movement increases with height
  - Spray droplets evaporate as they fall, making them smaller
- **Droplet Shear**
- **Evaporative Losses While Airborne**

Drift mitigation agents:

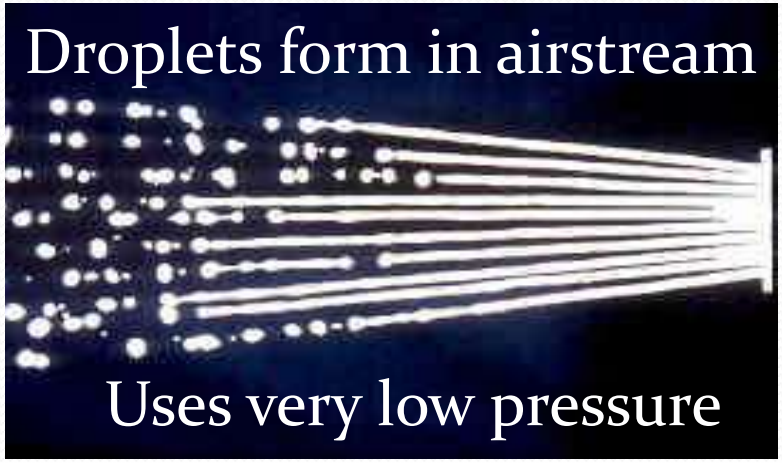
Larger droplets are less prone to drift!

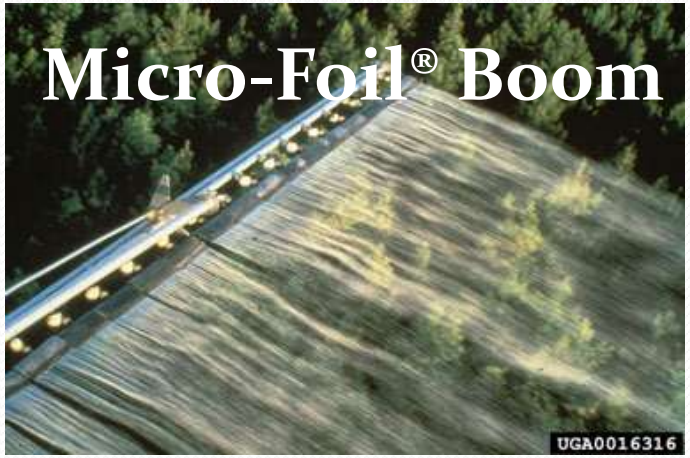
- ***Polymers*** (polyacrylamide, polyvinyl) increase viscosity, make droplets larger, less prone to drift. ***Used for water-based spray***. (Nalcotrol)
- ***Oil Emulsions*** reduce droplet shear at nozzle, evaporation of droplets
- ***Organic Gums*** (guar gum) increase viscosity, increase droplet mean diameter (DMD)

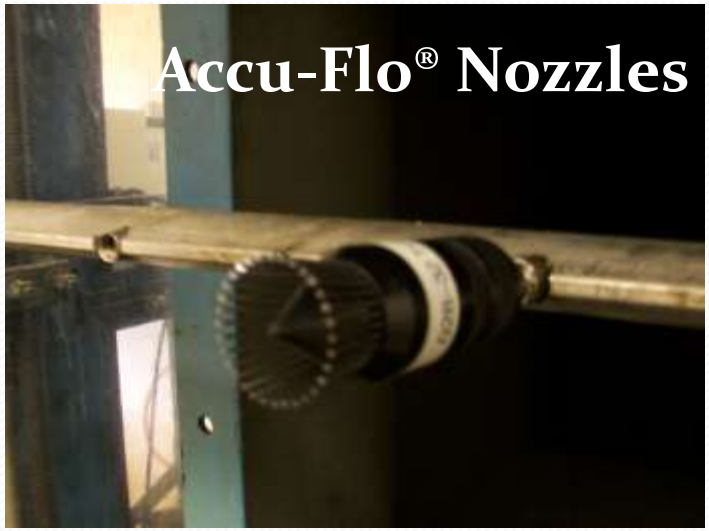
Excessive amounts of surfactant increase drift potential!

Advances in aerial application technology

Controlled droplet size application systems:







Foam reducing agents

- Keep a foam-buster on hand, a little bit goes a long way
- Foaming is a **common problem** due to:
  - **Excessive surfactant concentrations**
  - Lower spray application volumes, higher herbicide product concentrations
  - Greater use of dry formulations
  - Less use of emulsifiable concentrates
- Add foam control agents **prior to pesticides**
  - **Anti-foaming** agents prevent foaming
  - **De-foaming** agents correct the problem
  - The best products do both
  - Common problem with glyphosate products

Mixing order:

Least to most soluble, in general

- Fill tank **half-full**, start agitation
- Consider screening, 20-35 mesh at opening

➢ 1) Wetable powder (**WP**), first slurry in water

➢ 2) Dry flowable (**DF**), pre-mix in water

➢ 3) Emulsifiable Concentrate (**EC**), pre-mix 1:2 in water

➢ 4) Drift Control

➢ 5) Water soluble liquid (**SL**)

➢ 6) Surfactant, **ADD LAST**!

✓ **CONTINUE AGITATION** (except when filling)

Sources of additional information

- **Southern Regional Extension Forestry: http://www.sref.info/**

- **Integrated Forest Vegetation Management Website http://ifvm.ufl.edu/**

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