

# Using Photography to Aid in Analyzing Airplane Spray Patterns at Operation SAFE Workshops

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American Society of  
Agricultural and Biological Engineers



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# Operation S.A.F.E.



# Operation S.A.F.E.

- **Self-Regulating Application and Flight Efficiency**
  - Comprehensive program of education,
  - Professional analysis of application, and
  - Commitment to the principles outlined by the NAAA Board of Directors which includes:
    - Demonstration of responsibility to minimize the potential for adverse health and environmental effects from applying crop protection chemicals.
- **Professional Applicator Analysis Clinic**
  - S.A.F.E. Flyin Workshop
    - Swath/Pattern and droplet analysis – open to all licensed operators or agricultural aviators
    - Receive S.A.F.E. Emblem – current NAAA member
  - Emblem given when aircraft, pilot, and the operator meet S.A.F.E. guidelines



# Third source of information: Digital Photographs



# Fluorometer + DropletScan



# Two sources of data – two reports

- Spray pattern analysis
  - Fluorescent dye applied to string
  - Relative concentration measured using fluorometer
  - Used to measure spray pattern uniformity and determine appropriate swath width
- Droplet size analysis
  - Spray droplets stain water sensitive paper cards
  - Stains measured using computer scanner
  - Used to measure droplet size and determine risk of drift and effects on efficacy



# Five Passes



## Aircraft Data

Reg. Nbr:  Make/Mod:

Nozzle I: 40 FF40SmallOrif / # 8 Orif @ 0 °

Nozzle II:

Pressure: 38 PSI Rate: 2.0 GPA Swath: 66.0 Ft.

## Program Options

Print Passes

Print Average

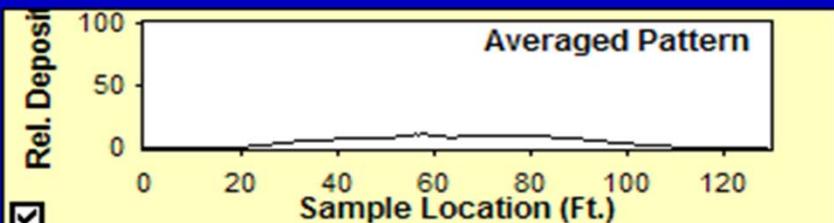
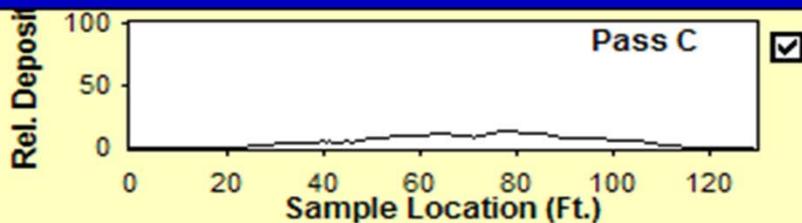
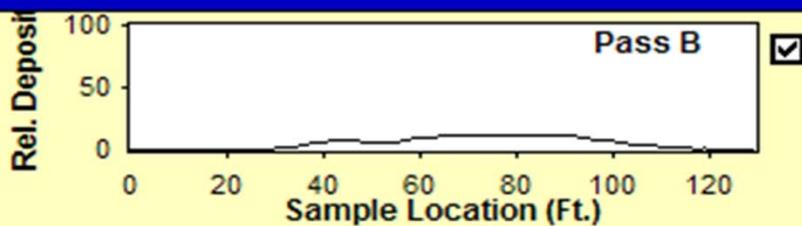
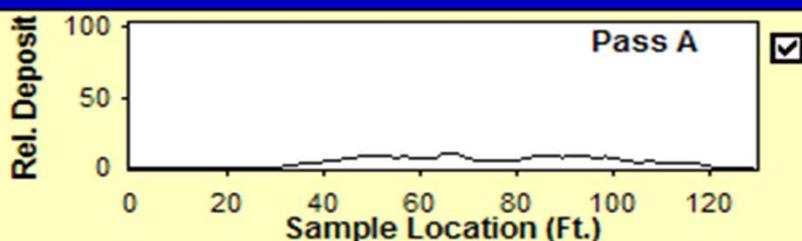
Print Both

### Flight-Line Data

|               | A    | B    | C    | D   | E   | Avg  |
|---------------|------|------|------|-----|-----|------|
| Speed: MPH    | 120  | 119  | 119  | 0   | 0   | 119  |
| Height: Ft.   | 11.0 | 10.0 | 12.0 | 0.0 | 0.0 | 11.0 |
| Wind Vel: MPH | 9.0  | 8.0  | 9.0  | 0.0 | 0.0 | 8.7  |
| X-wind: MPH   | 1.9  | 1.0  | 0.6  | 0.0 | 0.0 | 1.2  |
| Temp: F       | 0    | 0    | 0    | 0   | 0   | 00   |
| Humidity: %   | 0    | 0    | 0    | 0   | 0   | 00   |

VMD = 348 <100 μm = 3.69 % < 200 μm = 10.86 %

From models by Dr. I.W. Kirk, USDA/ARS (\* = Data outside modelled range)



# Swath Analysis

Slide to select a swath interval.



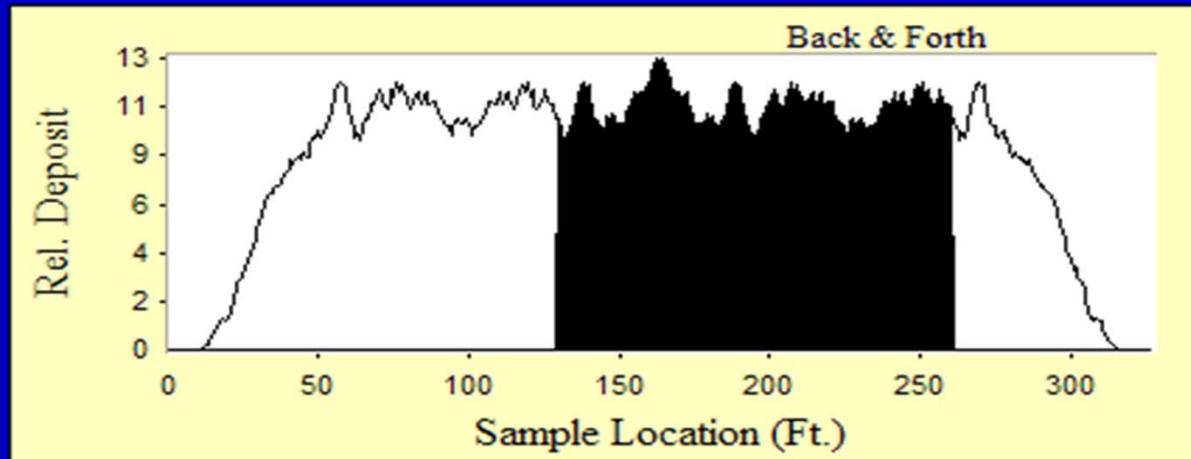
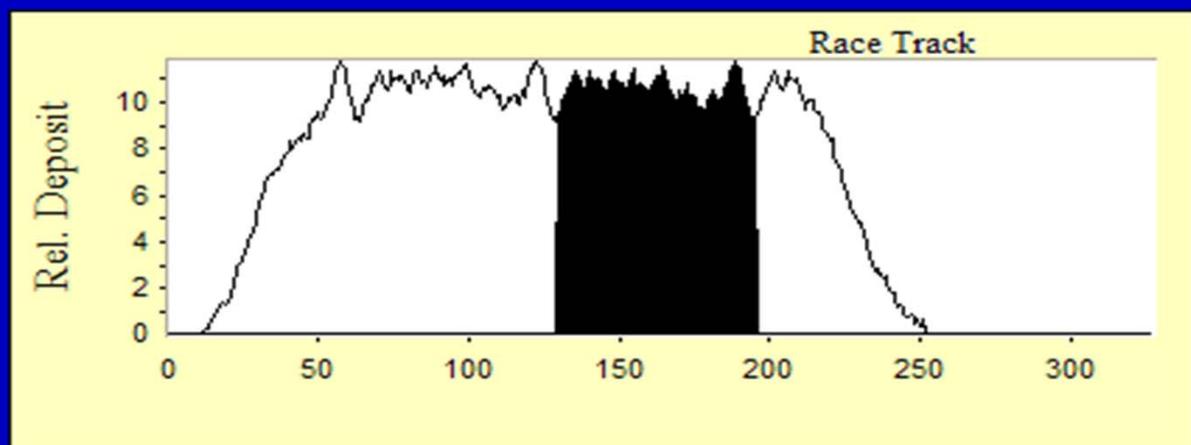
Selected

66 Ft.

Program Options

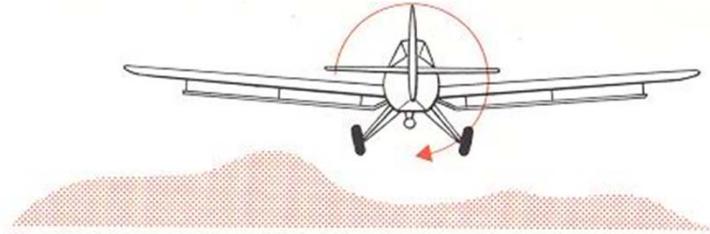
Print

| Est. Rate | R T CV | B & F CV |
|-----------|--------|----------|
| 1.86 GPA  | 5 %    | 7 %      |

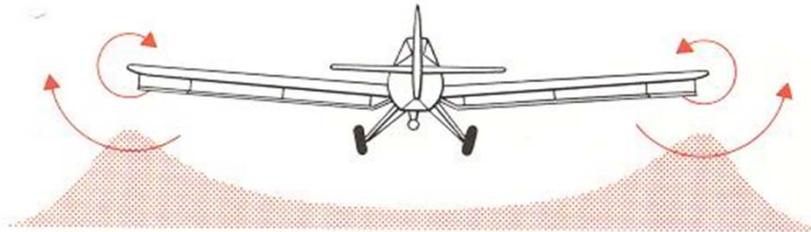


| Swath Ft. | Est. Rate GPA | R T CV | B F CV |
|-----------|---------------|--------|--------|
| 56        | 2.19          | 11 %   | 11 %   |
| 57        | 2.15          | 11 %   | 10 %   |
| 58        | 2.12          | 11 %   | 10 %   |
| 59        | 2.08          | 10 %   | 10 %   |
| 60        | 2.05          | 9 %    | 9 %    |
| 61        | 2.01          | 8 %    | 9 %    |
| 62        | 1.98          | 8 %    | 8 %    |
| 63        | 1.95          | 7 %    | 8 %    |
| 64        | 1.92          | 7 %    | 8 %    |
| 65        | 1.89          | 6 %    | 8 %    |
| 66        | 1.86          | 5 %    | 7 %    |
| 67        | 1.83          | 5 %    | 7 %    |
| 68        | 1.8           | 5 %    | 8 %    |
| 69        | 1.78          | 6 %    | 8 %    |
| 70        | 1.75          | 7 %    | 9 %    |
| 71        | 1.73          | 8 %    | 9 %    |
| 72        | 1.7           | 9 %    | 10 %   |
| 73        | 1.68          | 10 %   | 12 %   |
| 75        | 1.66          | 11 %   | 12 %   |
| 74        | 1.64          | 13 %   | 13 %   |
| 76        | 1.61          | 14 %   | 14 %   |
| 77        | 1.59          | 15 %   | 15 %   |

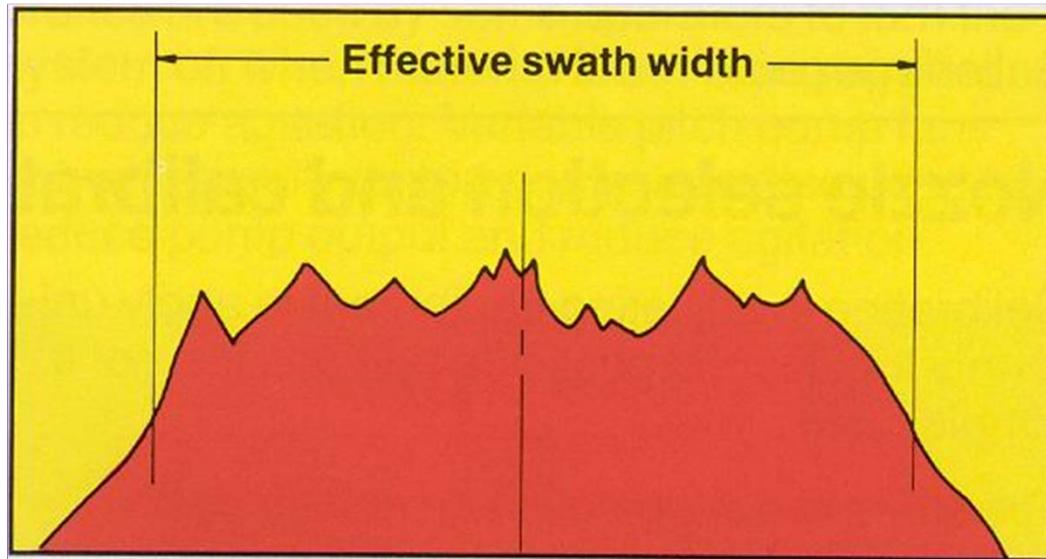
# Spray pattern analysis



The effect of propwash on spray recovery.



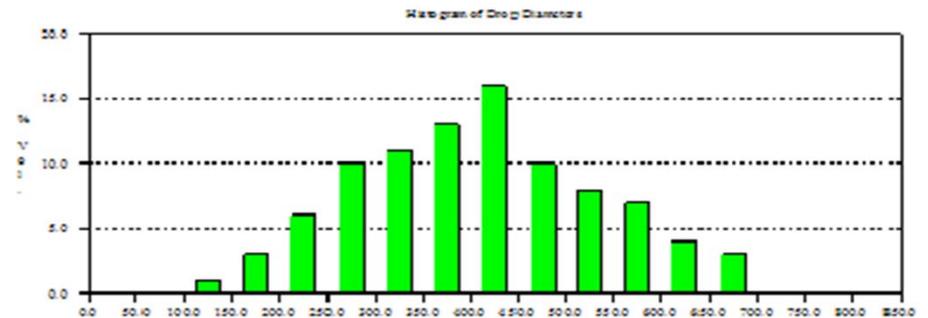
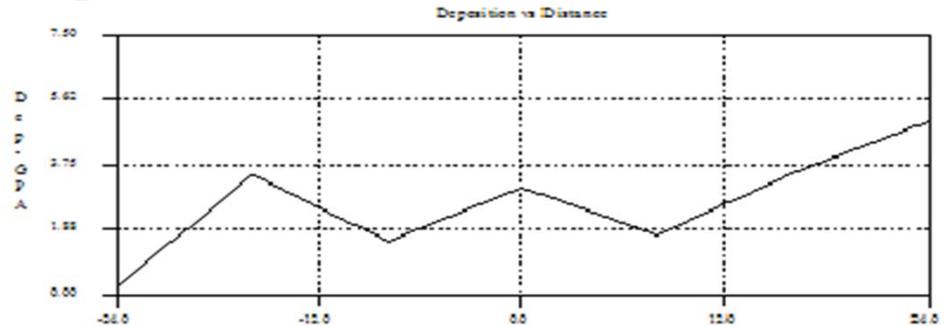
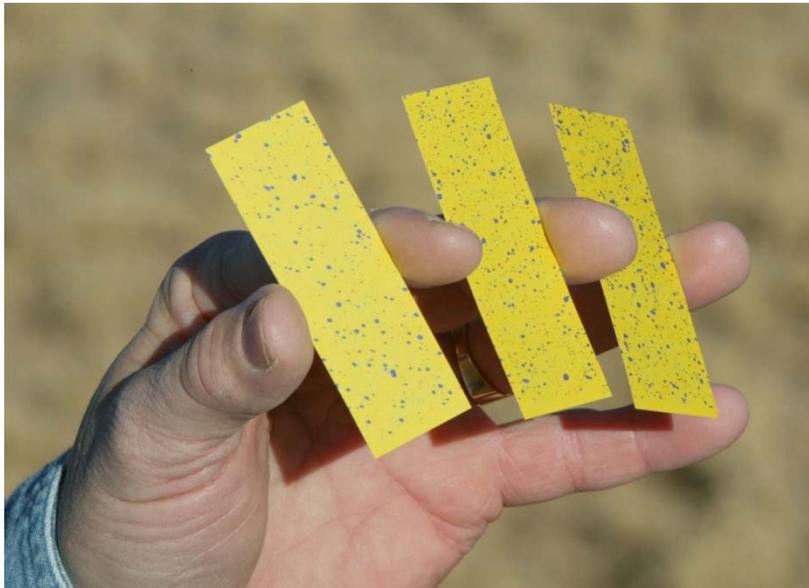
Wing tip vortices affecting spray pattern.



# DropletScan

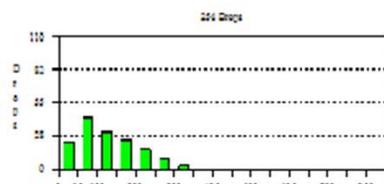
Report generated by DropletScan, a product of WRK and DSI.  
 File: C:\serial\Kansas Fly-in\Goodland-2003\Droplets\N61755-1.d\15:58:52 PM

|                                   |   |                             |
|-----------------------------------|---|-----------------------------|
| KSU-KAAA Fly-in S.A.F.E. Workshop |   | % Area Coverage = 6.4       |
| Goodland, KS                      |   | Run ID: 1                   |
| Sept 2003                         |   | Time: 4:45                  |
| Material: water-dye               | Number of Nozzles: 39                       | Target Rate (GPA): 2        |
| Nozzle Pres. (PSI): 31            | Flow Rate at 40 PSI (GPM): 0                | Target Swath (Ft): 66       |
| Nozzle Type: CP Flat Fan 10 SB    | Spread Factors Equation                     | Application Height (Ft): 12 |
|                                   | $SF = 1.8333 + 0.0009 * D + 0.0000 * D * D$ | Number of Passes: 1         |
| <b>Composite results</b>          |   | Ground Speed (MPH): 12.8    |
| VMD = 404                         |   | Wind Velocity (MPH): 16     |
| VD(0.1) = 237                     |   | Wind Direction (deg.): 180  |
| VD(0.9) = 592                     |   | Cross Wind (MPH): 0         |
| GPA = 2.650                       |   | Temperature (F): 83         |
|                                   |   | Humidity (%): 18            |

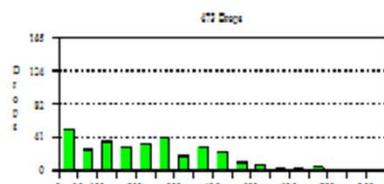
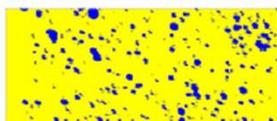


Report generated by DropletScan, a product of WRK and DSI  
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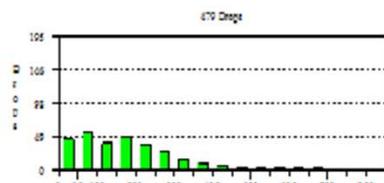
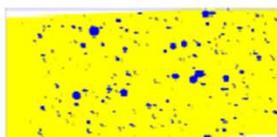
-24.0 with 0.63 % area & VMD = 224



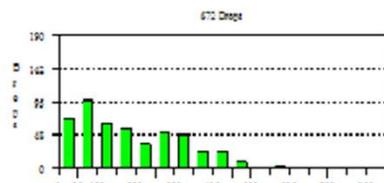
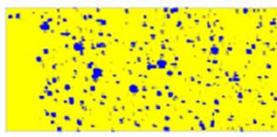
-16.0 with 3.33 % area & VMD = 425



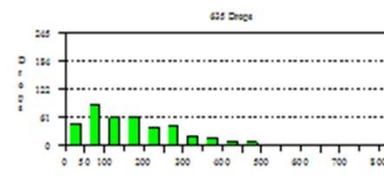
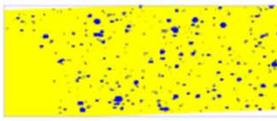
-8.0 with 3.62 % area & VMD = 377



0.0 with 7.31 % area & VMD = 365

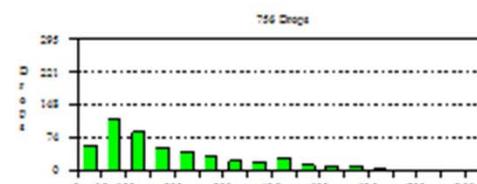
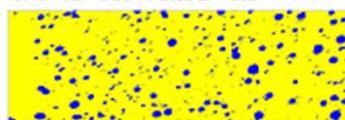


8.0 with 4.09 % area & VMD = 350

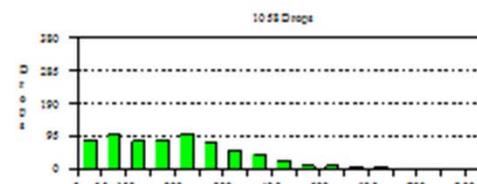
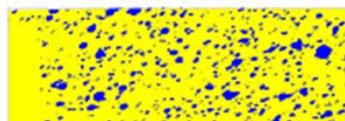


Report generated by DropletScan, a product of WRK and DSI  
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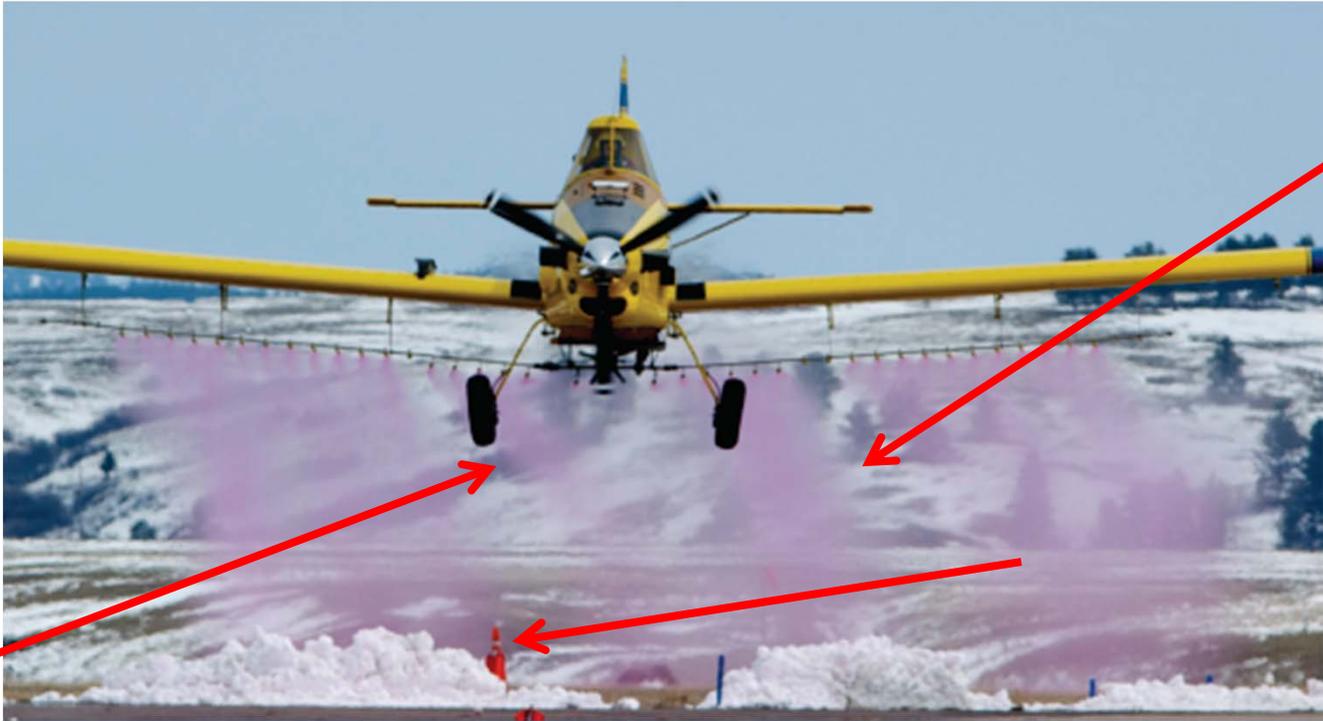
16.0 with 8.33 % area & VMD = 447



24.0 with 12.05 % area & VMD = 379





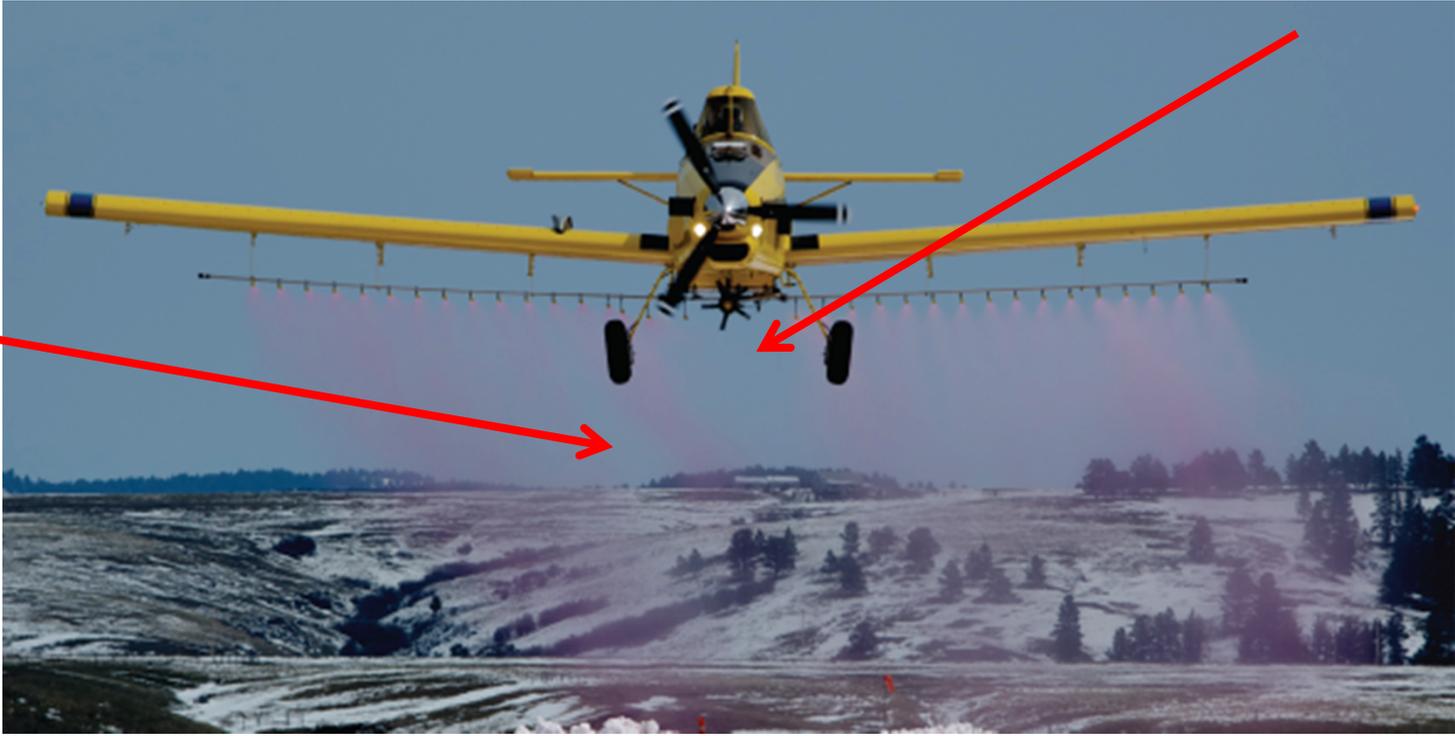


# Newby Equipment and Protocol:

- Nikon D70S with a Tamron 70-200mm 1:2.8 lens
  - Changing to a D90 for future events
- ISO of 200 produces exposures of 1/2000<sup>th</sup> of a second
- Best on solid tripod with remote shutter release
  - avoid any camera movement
- 200 yards and 200 mm focal length lens
- Flying down sun is most useful
- Fly toward the camera
  - normal passes over the string
- Flying away from camera toward string
  - shut off prior to string to avoid contamination
  - line crew winding for next pass













# Bretthauer Equipment:

- Digital SLR capable of using wireless remote
  - Now using a Canon EOS 30D
  - Lens focal length is 18-55mm
  - Depth of field - wide angle lens



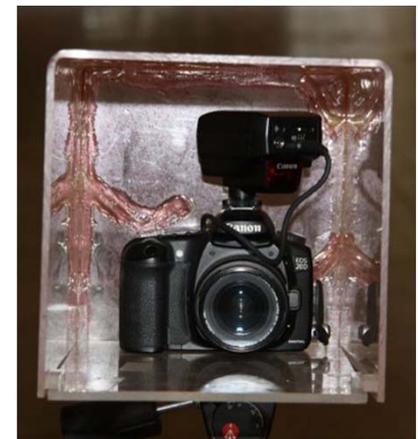
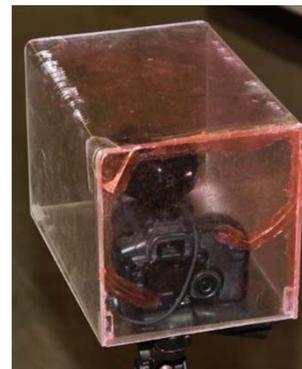
- Wireless controller with receiver & transmitter
  - Canon Wireless Controller LC-5 Transmitter/Receiver
  - Needs to be capable of burst mode - hold shutter and camera keeps firing
  - Requires autofocus mode
- Fully adjustable, sturdy tripod and head
  - Manfrotto 3221WM tripod with Manfrotto 3030 head



# Bretthauer Equipment cont.:



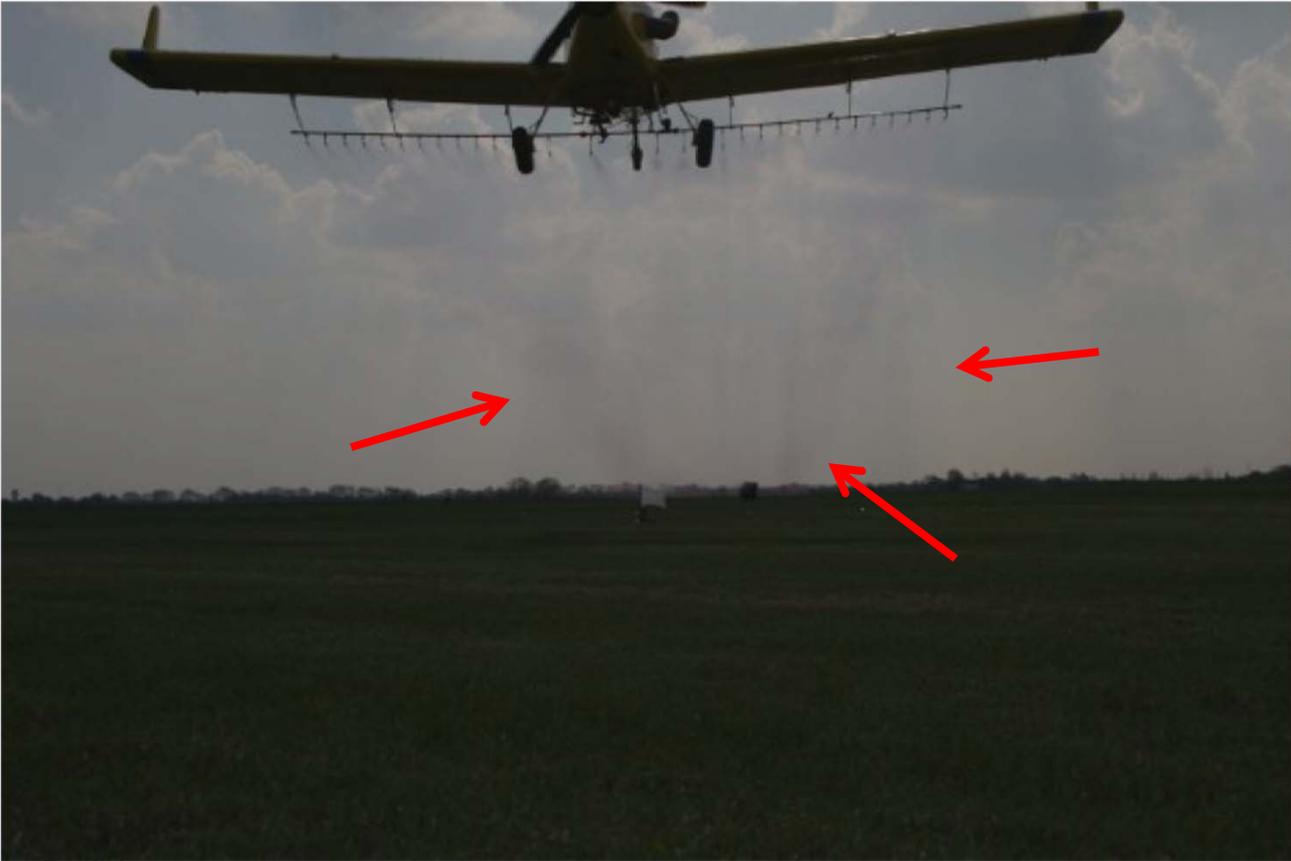
- Digital media cards compatible with camera
  - Use compact flash cards: 512 MB to 2 GB
  - Storage capacity – 100 images (dependant on camera megapixel rating)
  - Very high capacity cards not required
- Shield to protect camera – open on end lens faces
  - Custom built plexi-glass shield – see photos
- Batteries for both camera and receiver



# Bretthauer Protocol:

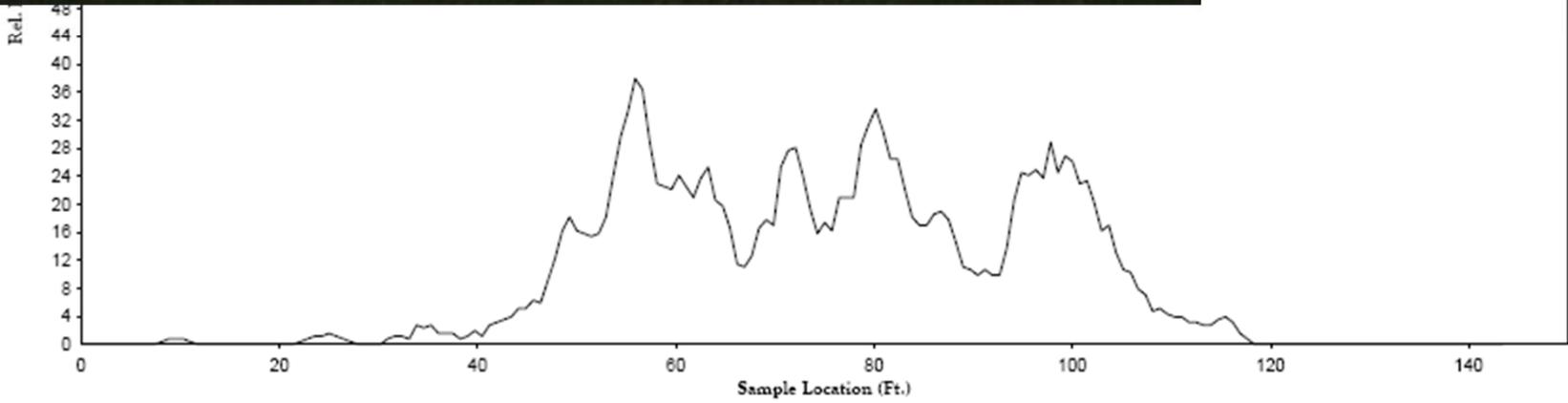
- Put camera in shutter priority mode
  - Tv on Canon EOS
- Select a fast shutter speed – 1/4000 or faster
- Put camera in burst mode
- Put camera in predictive autofocus mode
  - AI Servo on Canon
- Put the camera in partial metering mode (~10%)
- Select center autofocus point
  - should correspond to partial metering area
- Select a minimum ISO of 400
  - may need to use higher in dark conditions

#1



| Pass-C | Avg  |
|--------|------|
| 133    | 133  |
| 18.0   | 18.0 |
| 4.0    | 4.0  |
| 0.6    | 0.6  |
| 79     | 79   |
| 35     | 35   |

Flying into the page







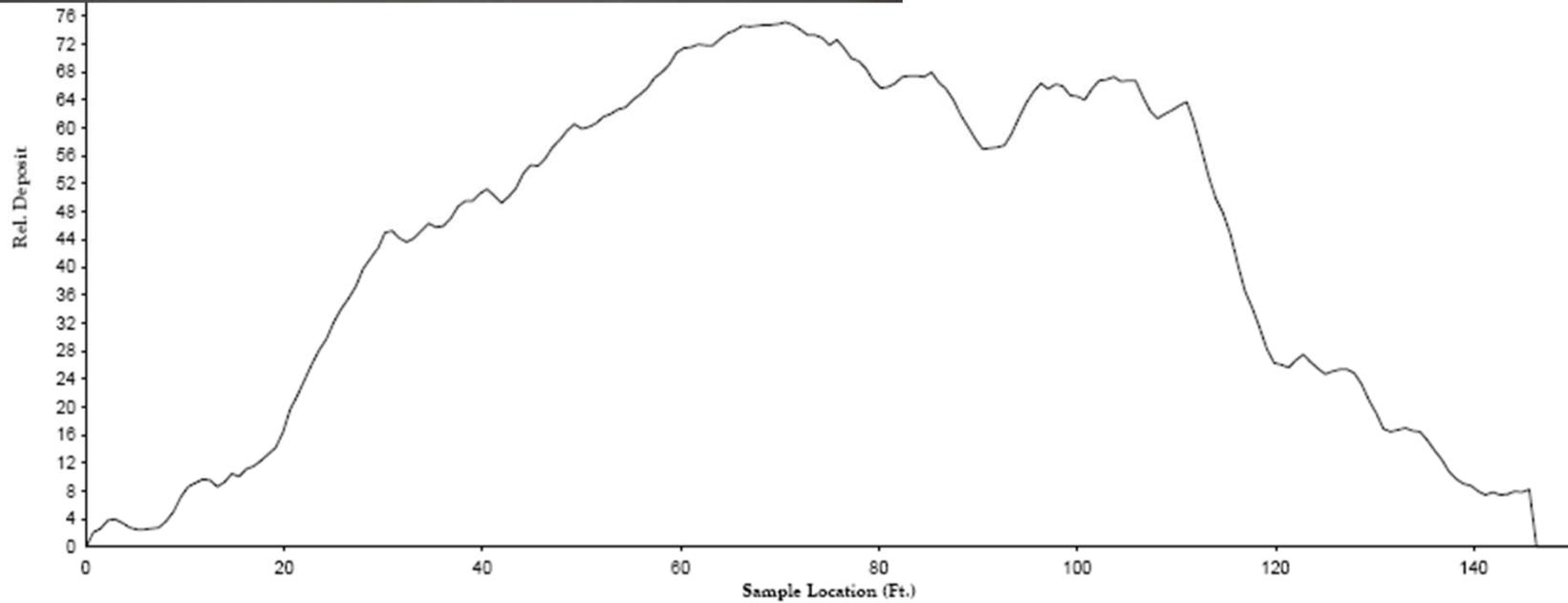
Clinic

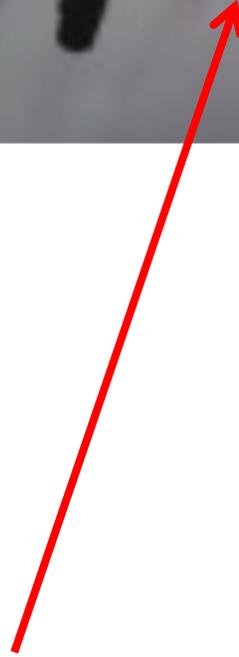
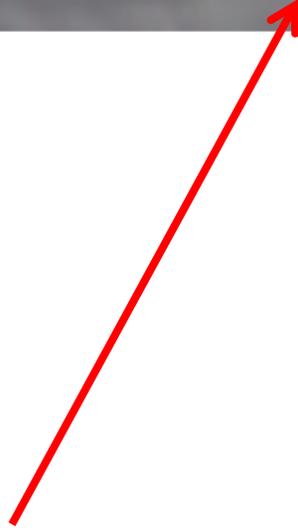
#2

*Flight-Line Data*

|                  | <i>Pass-A</i> | <i>Pass-B</i> | <i>Pass-C</i> | <i>Avg</i> |
|------------------|---------------|---------------|---------------|------------|
| ft Speed: (MPH)  | 129           | 122           | 119           | 123        |
| ft Height: (Ft.) | 21.0          | 15.0          | 18.0          | 18.0       |
| Velocity: (MPH)  | 7.0           | 8.0           | 9.0           | 8.0        |
| wind: (MPH)      | -1.8          | 0.0           | 1.6           | -0.1       |
| ent Temp: (F)    | 63            | 63            | 63            | 63         |
| ve Hum: (%)      | 73            | 73            | 73            | 73         |

aged Pattern

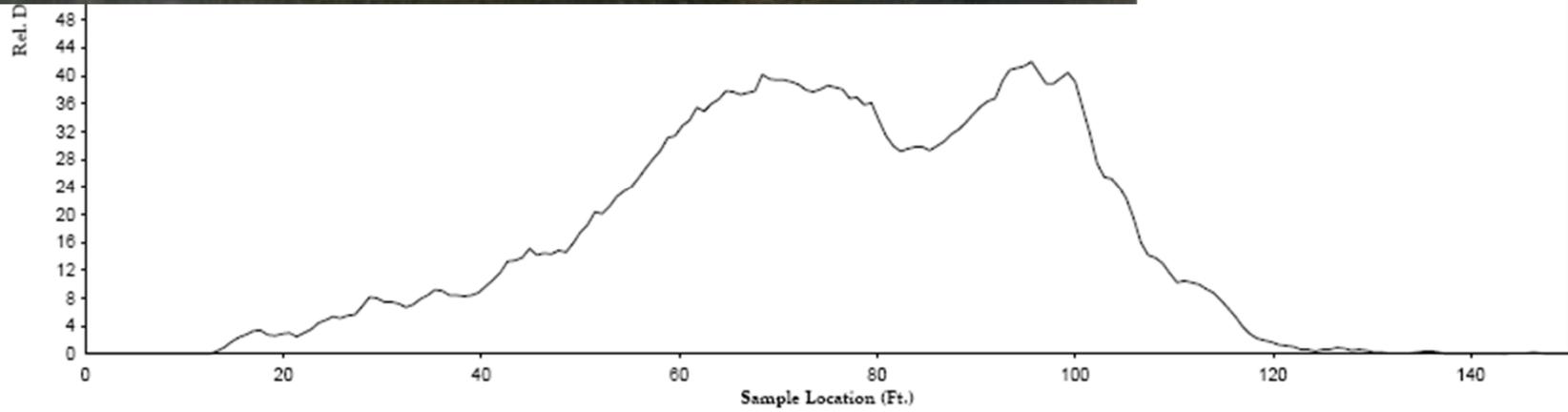




#3



| Pass-A | Pass-B | Pass-C | Avg  |
|--------|--------|--------|------|
| 120    | 117    |        | 120  |
| 12.0   | 10.0   |        | 10.7 |
| 13.0   | 13.0   |        | 13.0 |
| 1.1    | 1.1    |        | 1.1  |
| 70     | 70     |        | 70   |
| 64     | 64     |        | 64   |







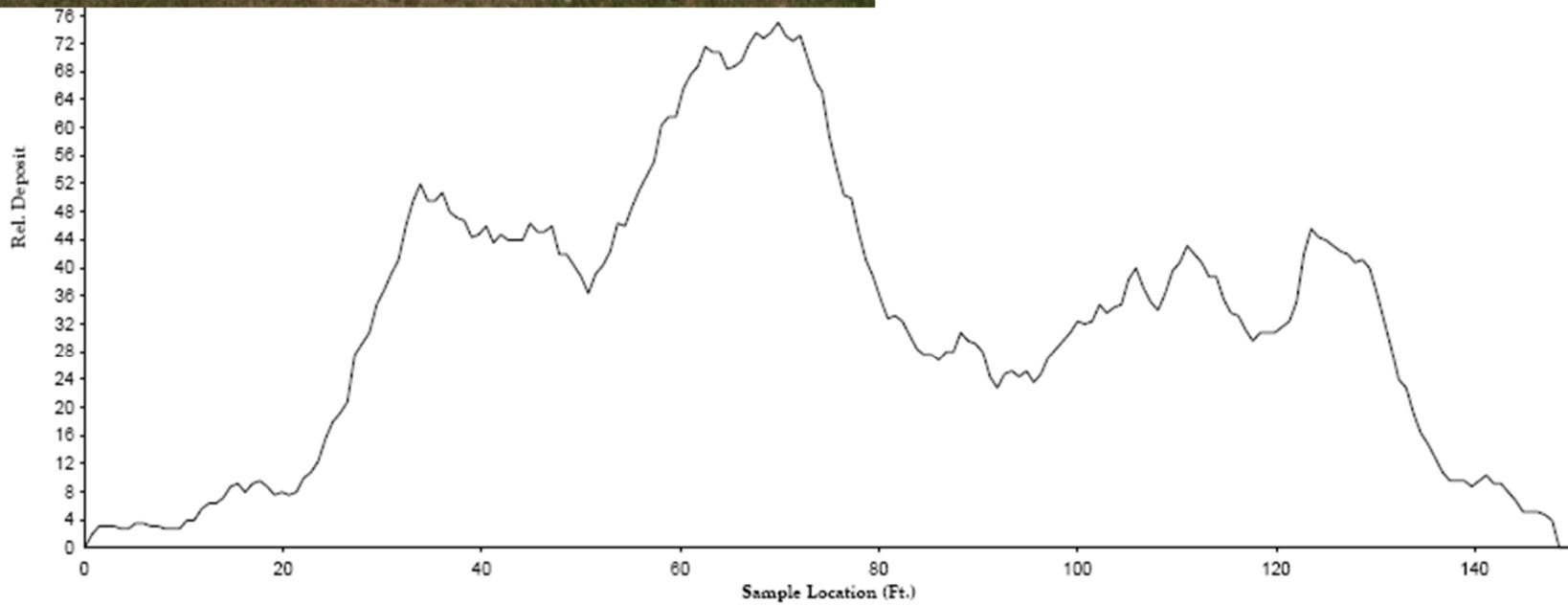
1  
09

#4

*Flight-Line Data*

|                         | <i>Pass-A</i> | <i>Avg</i> |
|-------------------------|---------------|------------|
| Aircraft Speed: ( MPH)  | 143           | 143        |
| Aircraft Height: ( Ft.) | 20.0          | 20.0       |
| Wind Velocity: ( MPH)   | 5.7           | 5.7        |
| Cross-wind: ( MPH)      | 1.9           | 1.9        |
| Ambient Temp: ( F)      | 79            | 79         |
| Relative Hum: (%)       | 55            | 55         |

*Averaged Pattern*

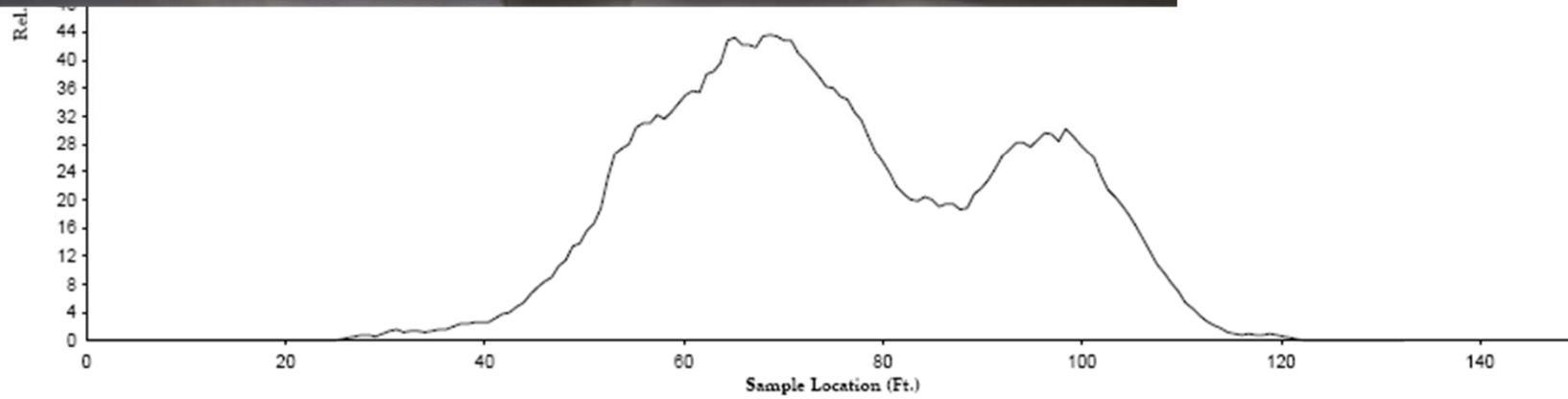


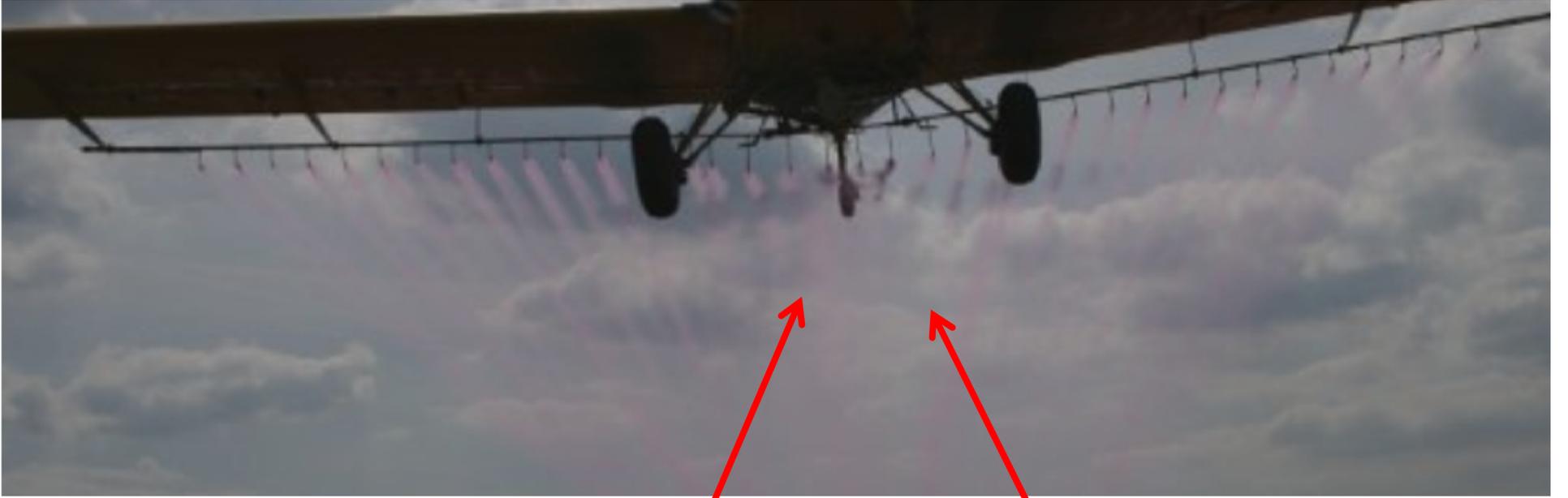


#5



| Pass-B | Avg  |
|--------|------|
| 122    | 122  |
| 14.0   | 14.5 |
| 8.0    | 5.5  |
| 7.5    | 5.2  |
| 82     | 82   |
| 45     | 45   |







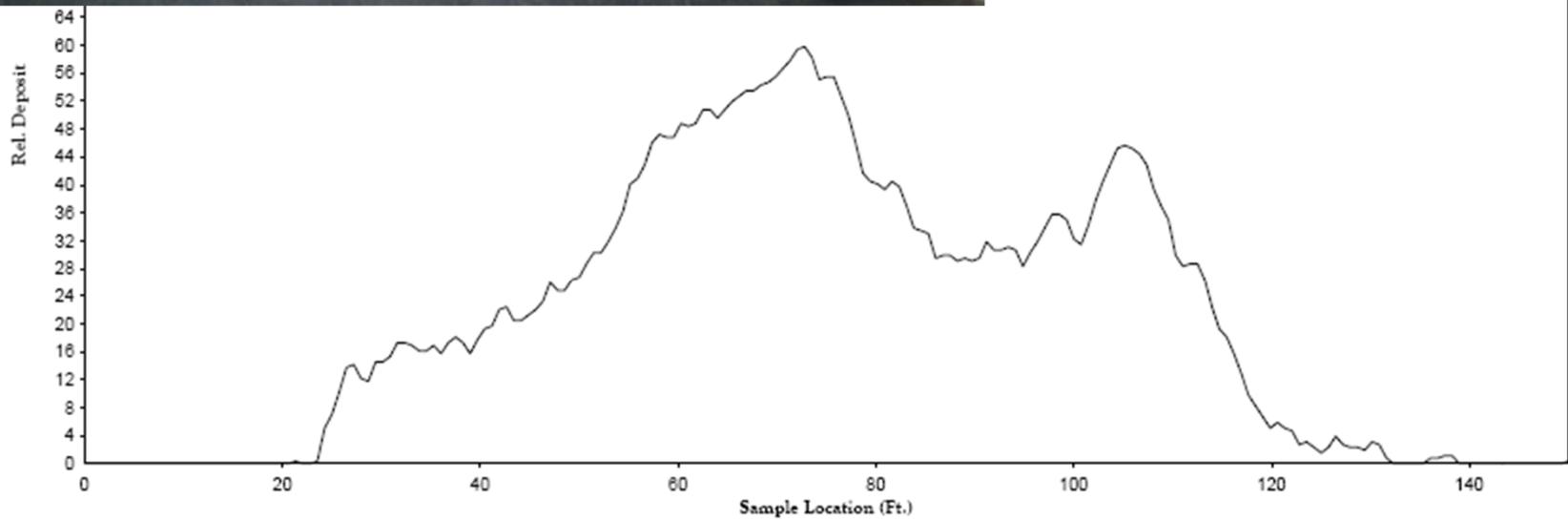
Development

#6

Flight-Line Data

|       | <i>Pass-B</i> | <i>Avg</i> |
|-------|---------------|------------|
| (MPH) | 156           | 156        |
| (Ft.) | 20.0          | 20.0       |
| (MPH) | 9.0           | 9.0        |
| (MPH) | 0.0           | 0.0        |
| (F)   | 64            | 64         |
| (%)   | 81            | 81         |

tern

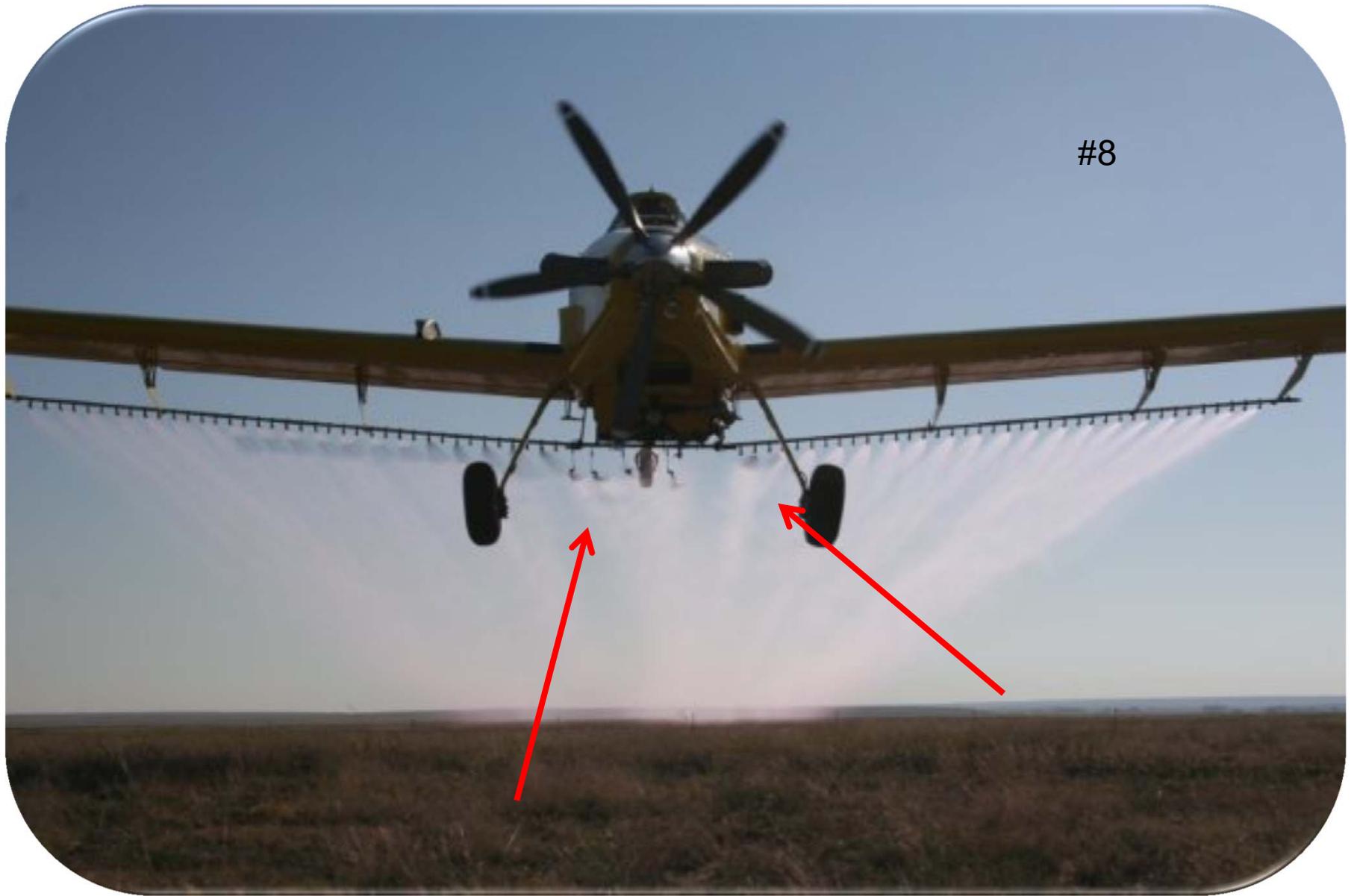




#7



#8



#9



# Summary/Conclusions

- Digital photography can be a great tool to help analyze an aircraft spray pattern
- High quality/professional equipment essential for best results
- Light conditions and position critical
- Not all things you see in a picture are necessarily correct, but certainly useful to help explain certain problems found in the printouts.

THANKS

