Considerations for Effective Spray Drone Applications

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New Method, Same Fundamentals

- Pest identification
- Effective pesticide
- Correct rate
- Optimum adjuvants
- Calibrated equipment
- Good environmental conditions before, during, and after application
- **Proper timing**

Photo credit: Jesse Haarmann

Photo credit: Darcy Telenko

Today's Presentation

- Factors influencing effective swath width
  - Platform/model
  - Application parameters
  - Nozzle type/droplet size
  - Spray adjuvants
- Research summary
  - Contact vs. systemic herbicides
  - Spray adjuvants
- Research implications
- Considerations for effective applications

Spray Distribution

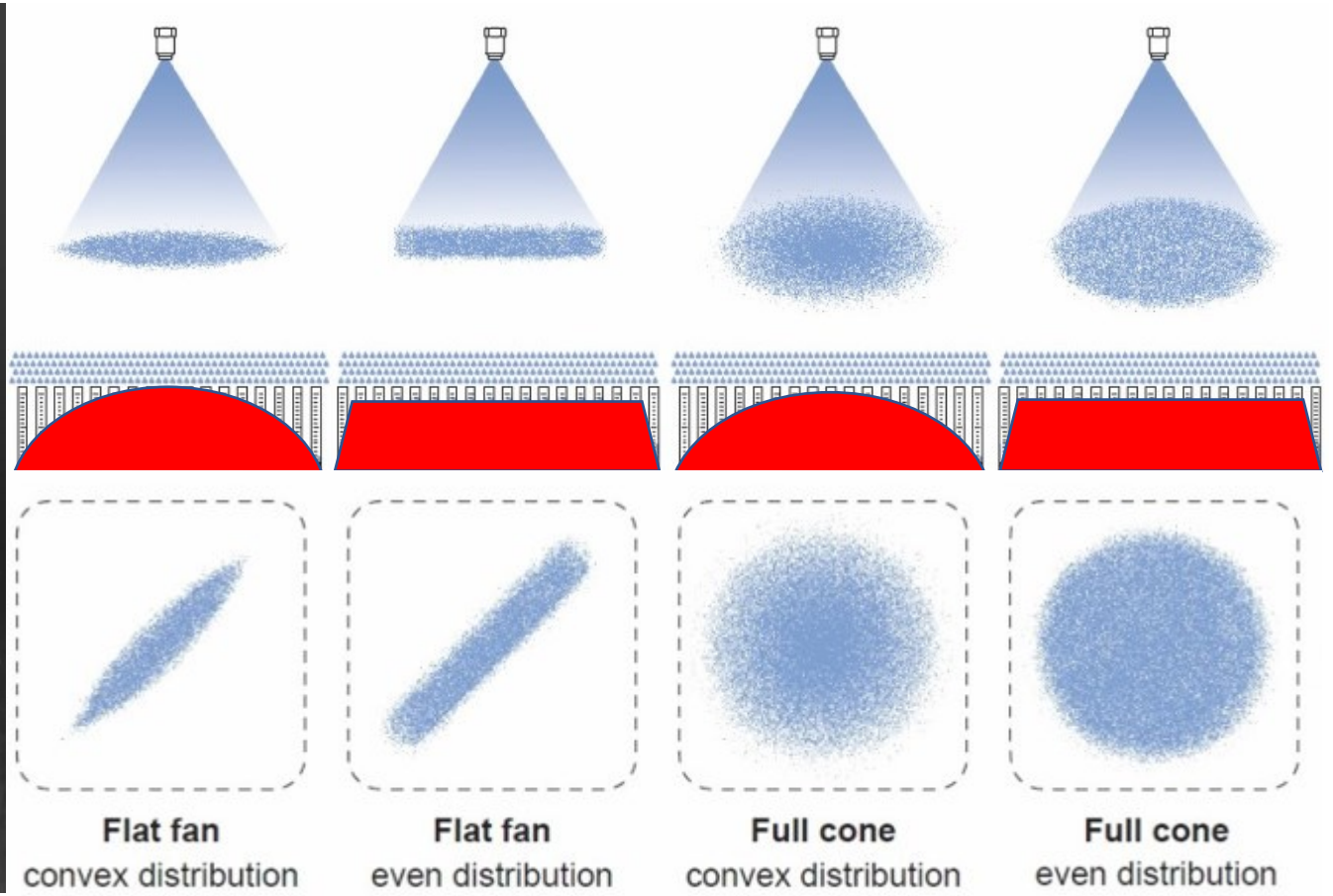
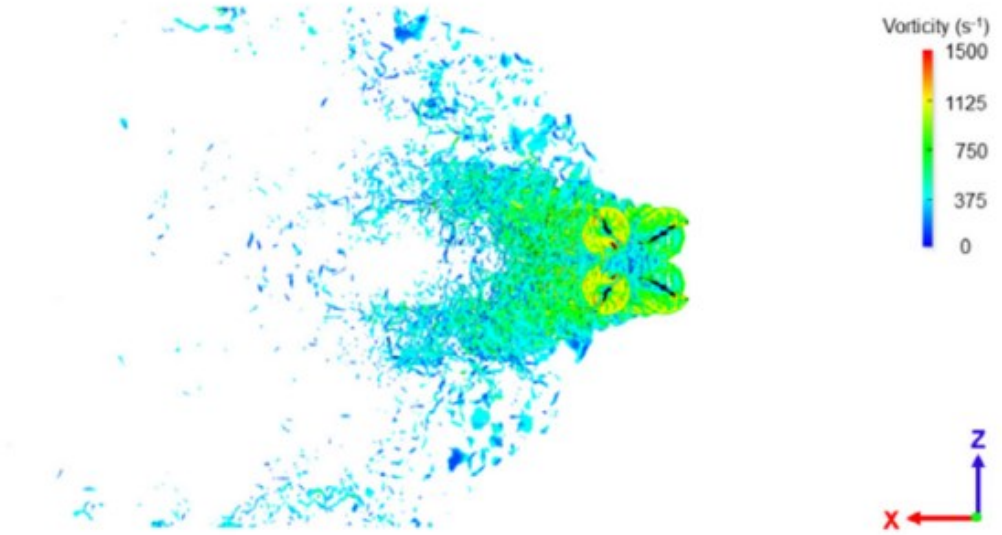
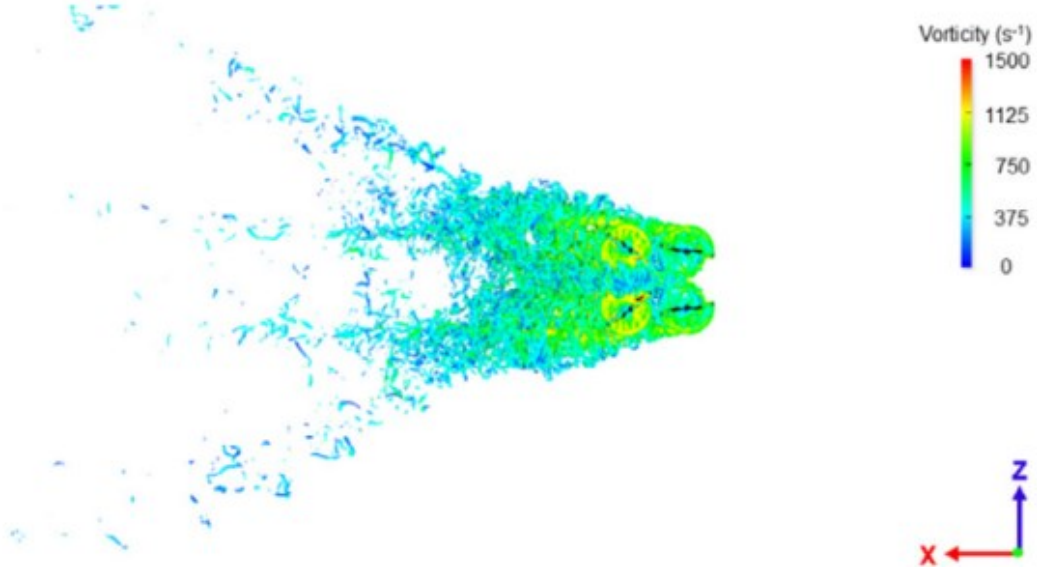


Photo credit: Techpro Australia

Rotor Wind Distribution



Lower speed



Higher speed

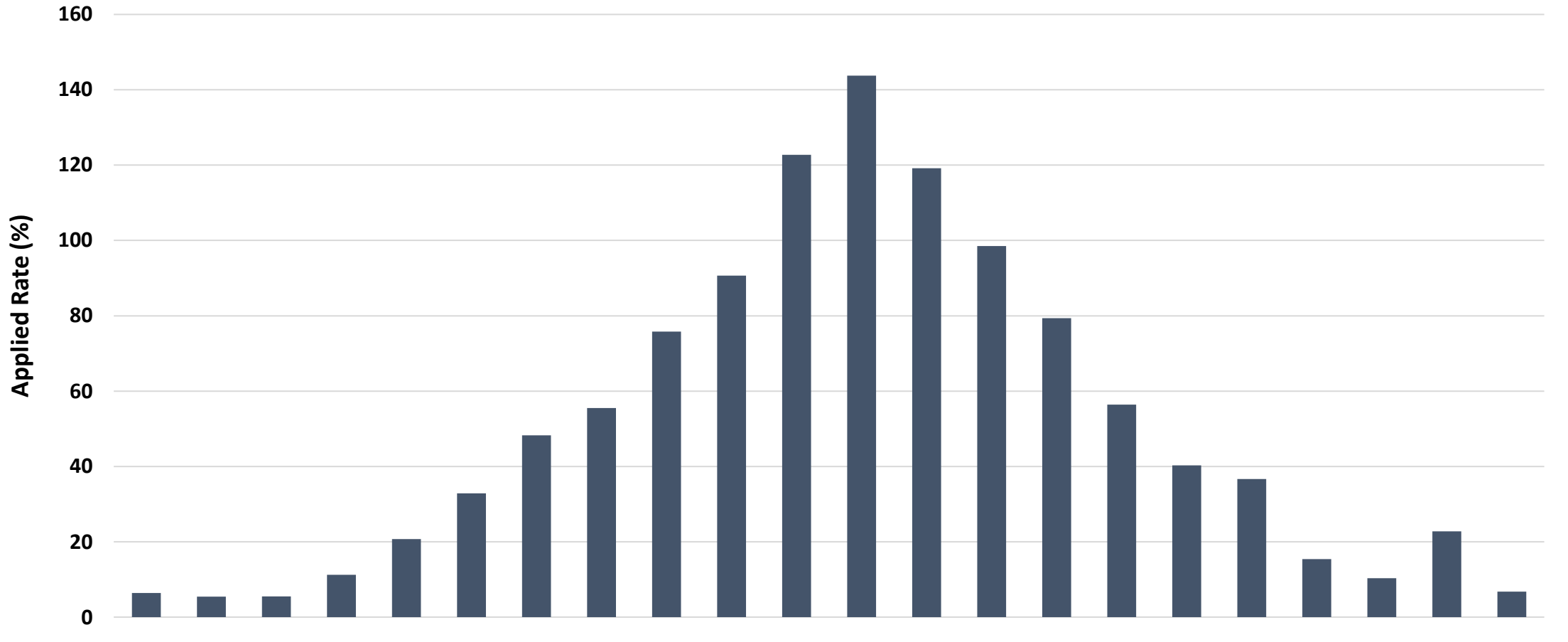
Adapted from: Wen S, Han J, Ning Z, Lan Y, Yin X, Zhang J, Ge Y (2019) Numerical analysis and validation of spray distributions by quad-rotor drone wake at different flight speeds. Comput Electron Agric 166:105036

Spray Distribution

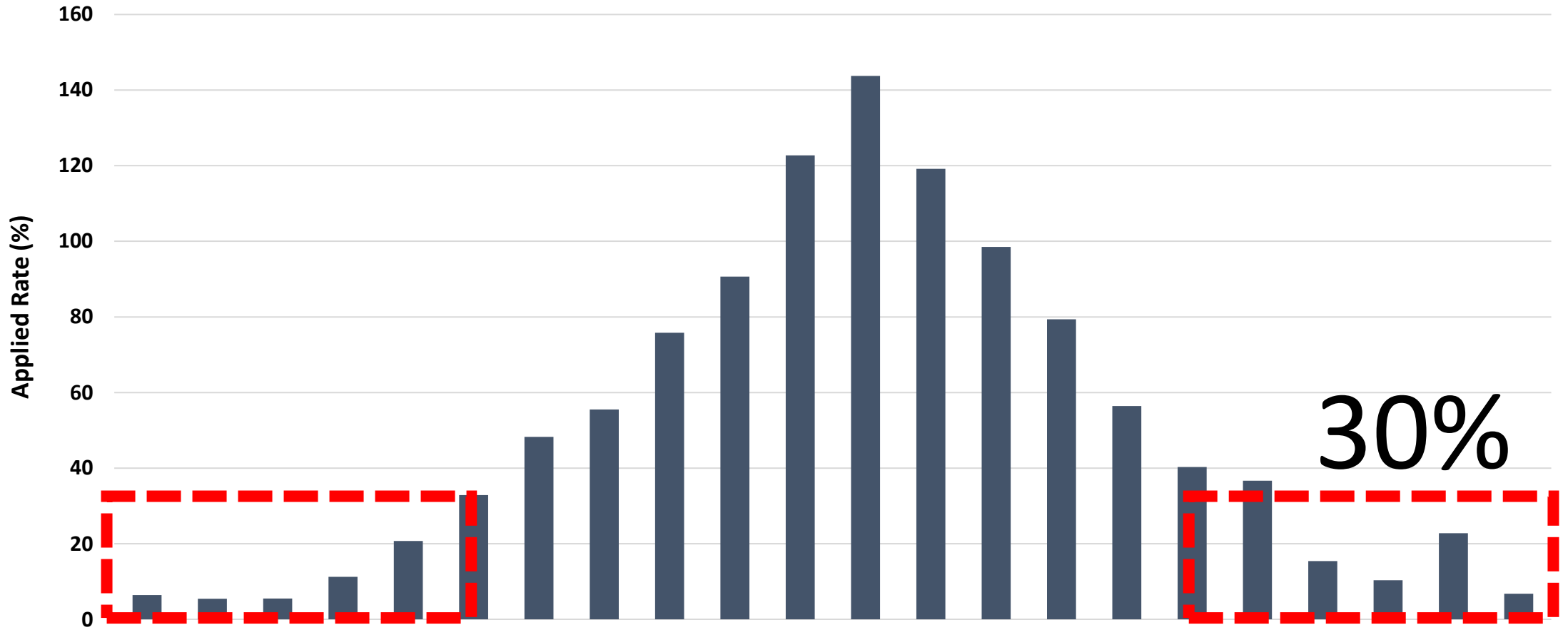
- Spray drones exhibit what we consider a “double pattern” or “double atomization” process
  - A liquid sheet is formed when solutions exit the nozzle or rotary atomizer and then another sheet is formed from the entire spray plume
  - Due to the force created by the rotors, the downwash will impact the breakup of the liquid sheet

- Droplet compositions will alter how and when the liquid sheet breakup occurs, which may not be consistent with our knowledge or recommendations using traditional application methods

Bell Curve Spray Pattern



What is Our Threshold for Proper Overlap?



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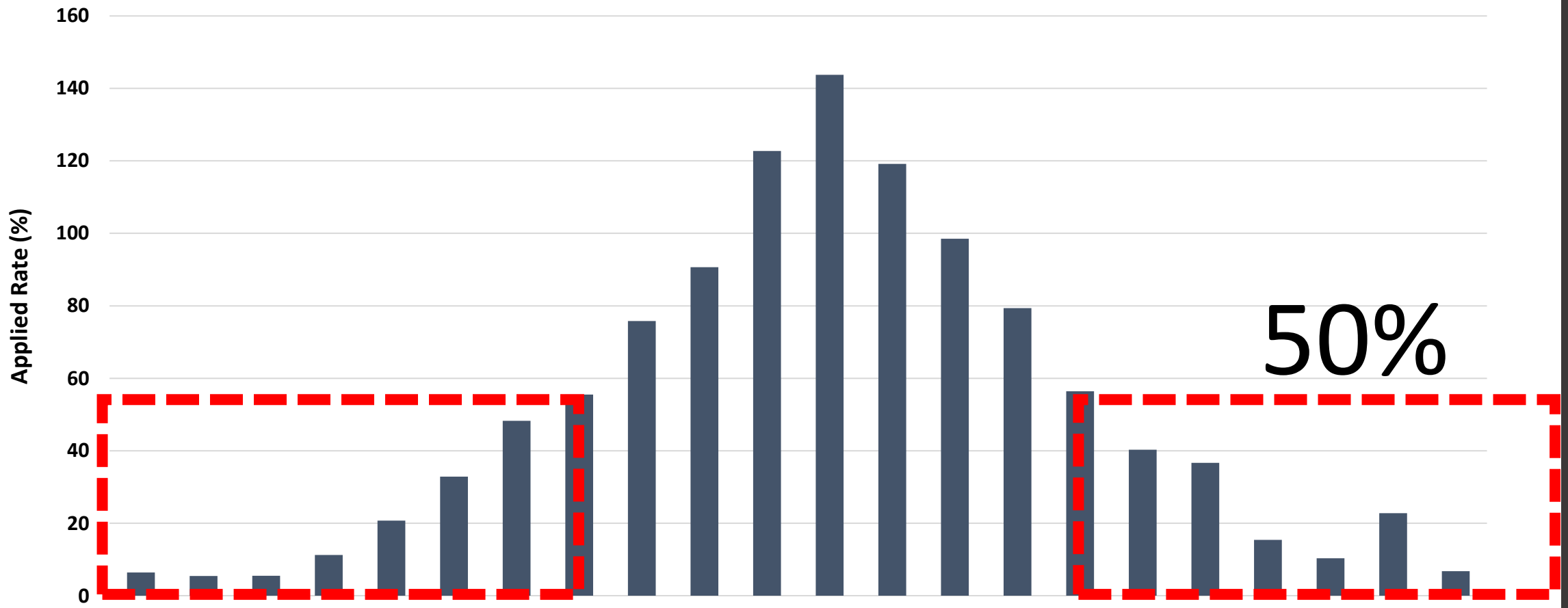

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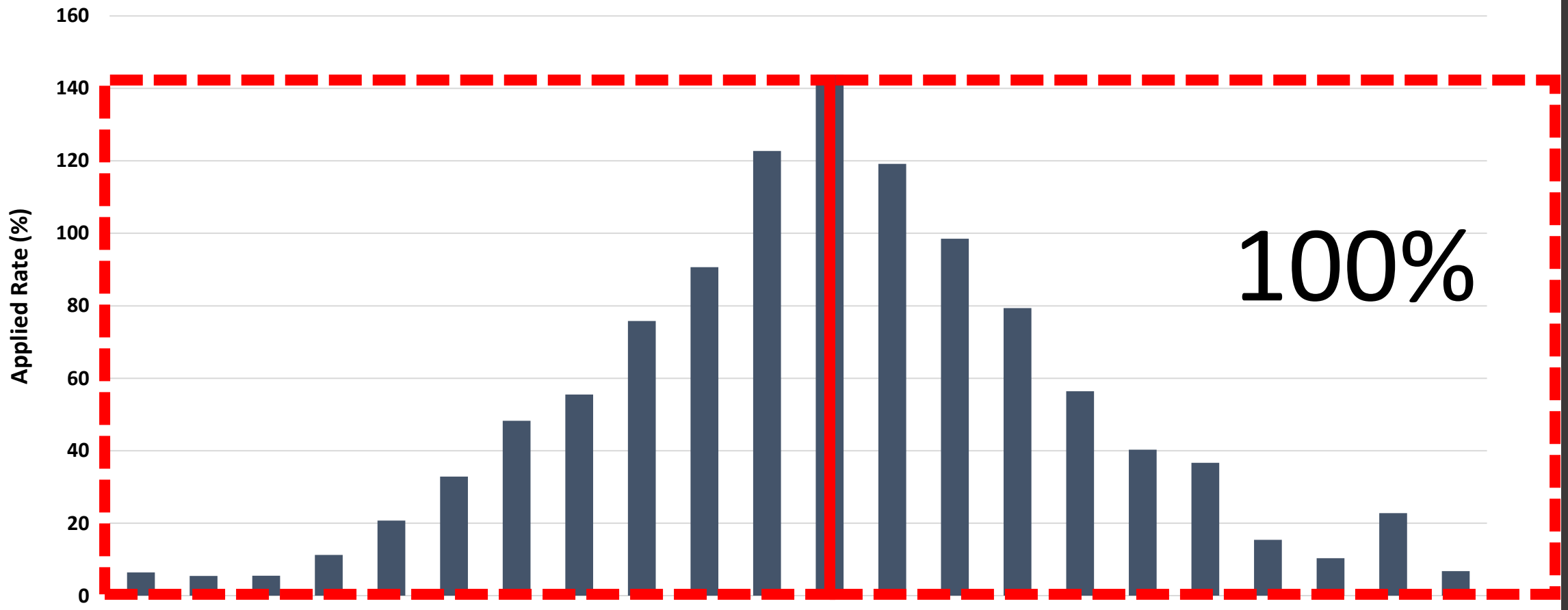


What is Effective Swath Width?

- ASABE standard definition: The swath spacing that will produce acceptable field deposition uniformity for intended application
- Effective overlap distance
- How do we measure uniformity?
  - Spray coverage or spray deposition
  - Coefficient of variation (CV): Percentage of standard deviation over the mean
    - Ground application: 10 to 15%
    - Aerial application: 20 to 25%
    - Drone Applications: 30%???

Effective Swath Width

- Platform/Model
- Application height
- Application speed
- Droplet size
  - Conventional nozzle type and orifice size
  - Rotary atomizer type and micron setting
- Carrier Volume
- Spray adjuvants
- Pesticide active ingredient and formulation
- Headwind/tailwind
- Crop canopy
- Environmental conditions

Platform/Model

XAG P100 Pro

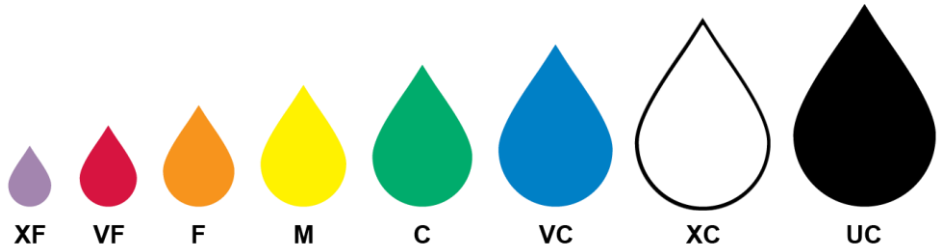
DJI Agras T40

DJI Agras T30

Hylio AG-272

- Rotor diameter and length
- Number of rotors
- Payload capacity
- Wingspan
- Take-off weight
- Application speed
- Application height

Nozzle Type/Droplet Size



- **Conventional Nozzles:**
  - Very Fine to Ultra Coarse
- **XAG P100 Pro: 60 to 400 µm**
  - Very Fine to Coarse
- **DJI Agras T40: 50 to 500 µm**
  - Extremely Fine to Very Coarse

Conventional Nozzles

Rotary Atomizers

Research Summary

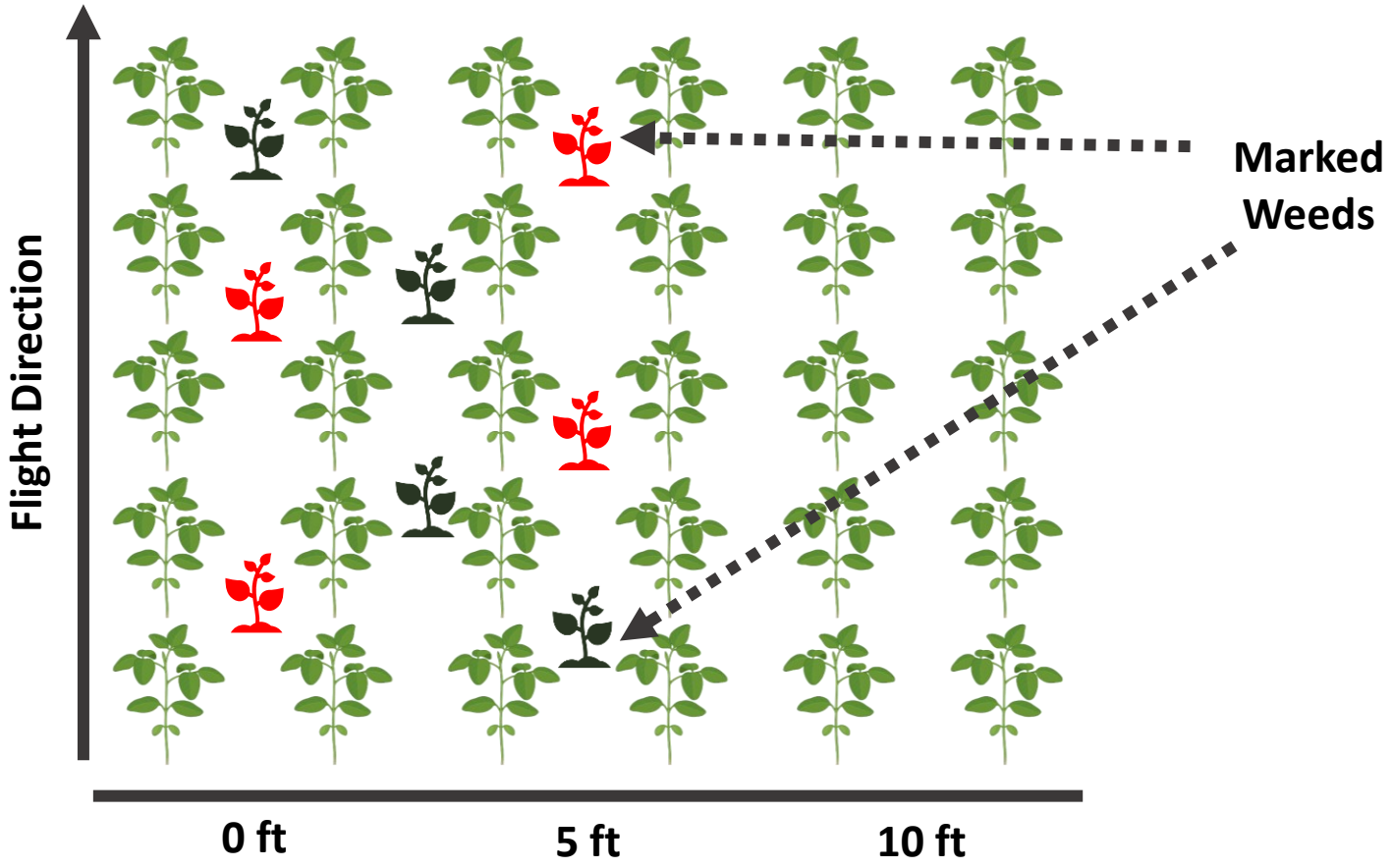
Study 1

Contact versus Systemic Herbicides Applied at Low Carrier Volumes

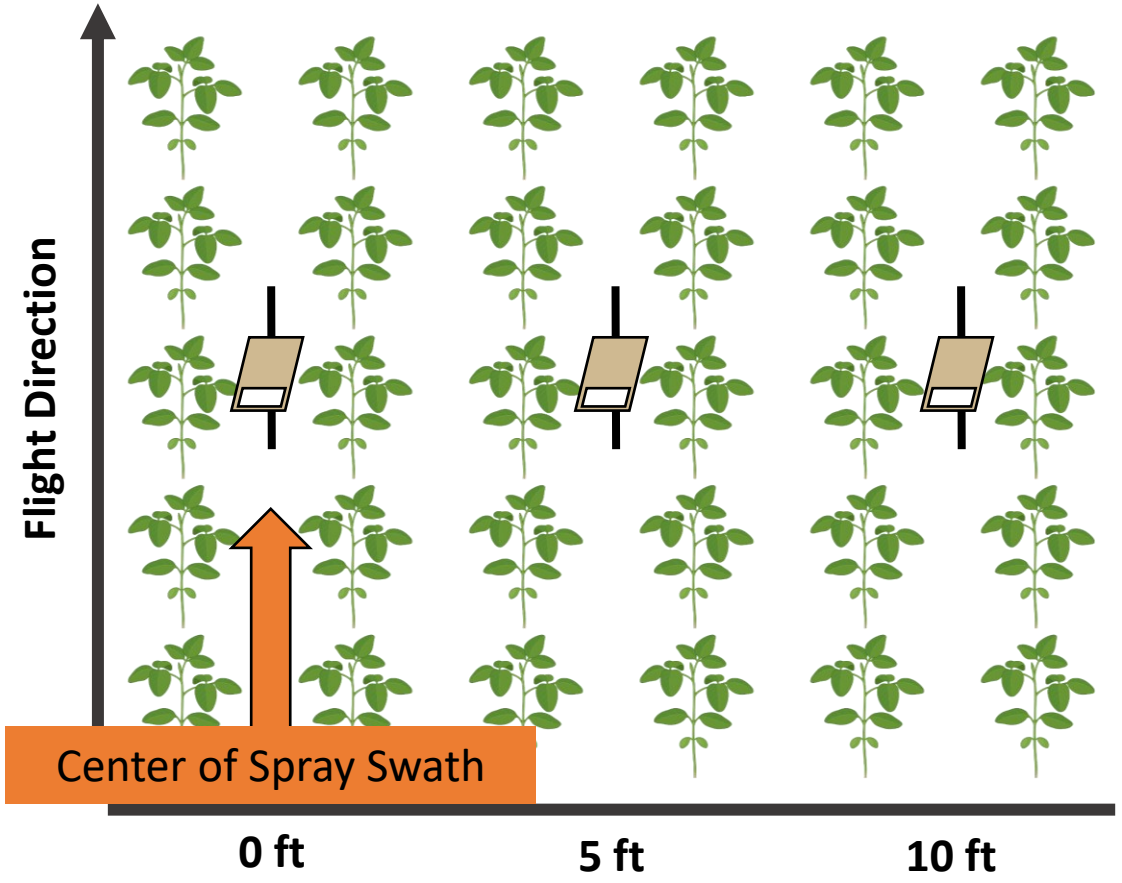
2023 Materials and Methods – Study 1

- Objectives:
  - Evaluate weed efficacy of glyphosate and glufosinate at several low carrier volumes
  - Quantify the spray coverage of glyphosate and glufosinate at three carrier volumes in spray drone applications
- Glyphosate- and glufosinate-resistant soybean planted at two Indiana locations (ACRE and DPAC)
- Treatments arranged in a RCBD with four replications
  - Herbicides:
    - Liberty® 280 SL (35 oz/A)
    - Roundup PowerMAX® 3 (22 oz/A)
  - Carrier Volumes:
    - 1, 2, 3 GPA (Drone)
    - 15 GPA (Hand boom)
  - Drone = DJI Agras T30
  - Application parameters:
    - TeeJet® XR11001
    - Swath: 30 ft
    - Height: 10 ft
    - Speed: 15 mph

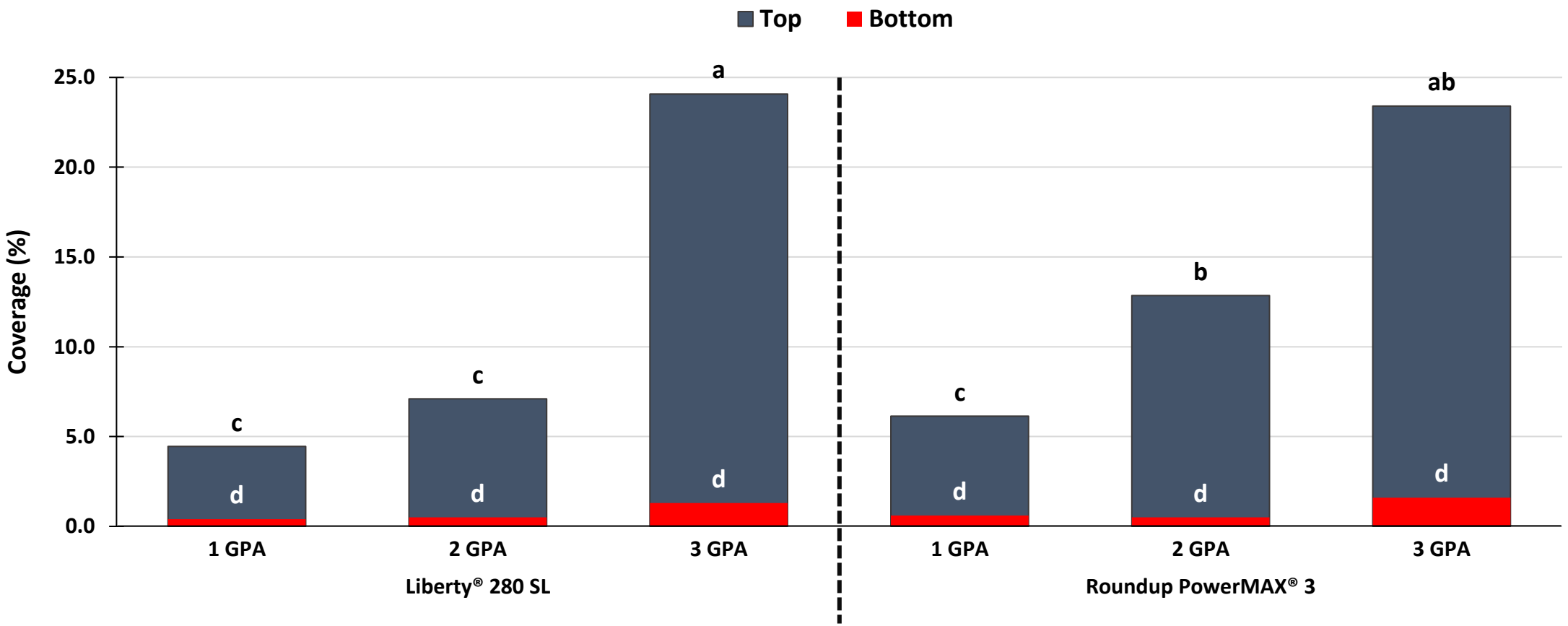
2023 Data Collection – Study 1



2023 Data Collection – Study 1

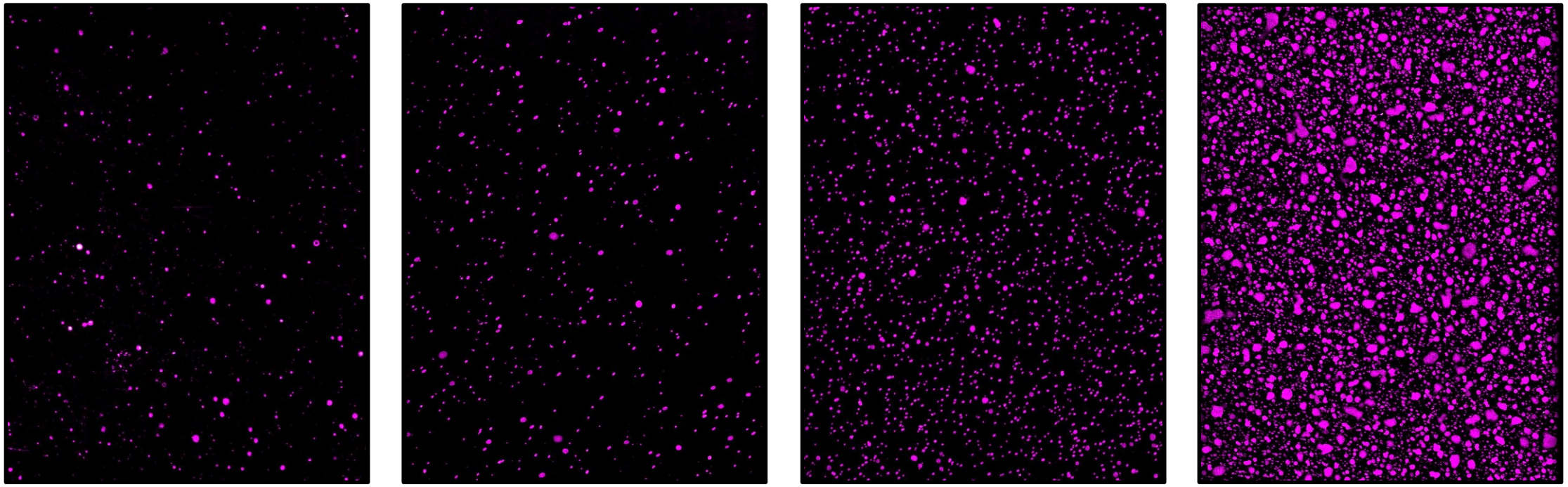


Pooled Coverage



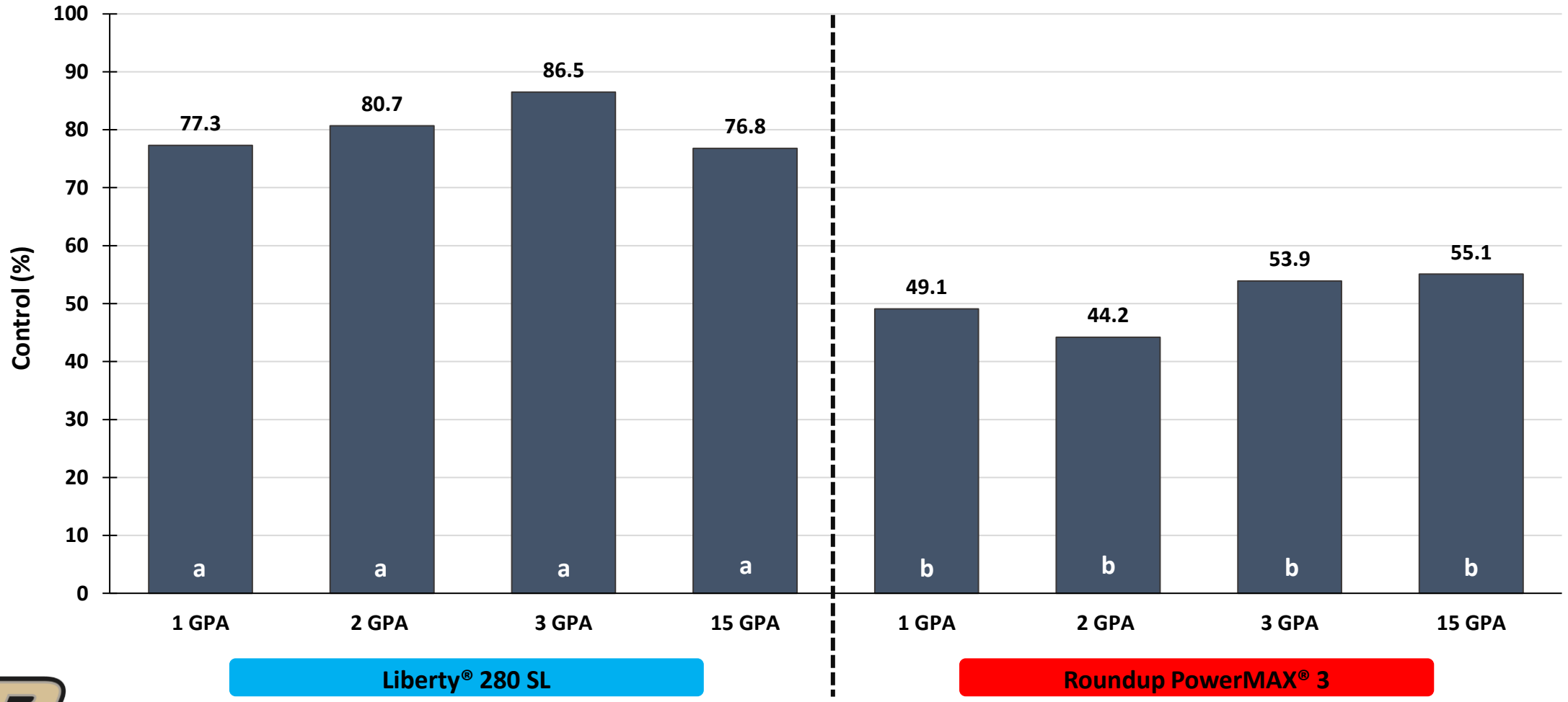
Pooled over card position and site

Top Card 0 ft Location – Liberty® 280 SL



1 GPA	2 GPA	3 GPA	15 GPA
7.2%	12.2%	47.1%	62.3%
	Drone		Hand Boom

Weed Control 14 DAA



Summary – Study 1

- Overall, spray coverage was greater at DPAC than at ACRE, which was likely associated with differences in temperature and humidity at the time of application
  - ACRE: 90°F, 45% relative humidity
  - DPAC: 77°F, 60% relative humidity
- Weed control was greater with the contact herbicide glufosinate across carrier volumes at each site compared to the systemic herbicide glyphosate, which was unexpected
- Increasing the carrier volume in drone applications may not always translate to greater weed control

Spray Modifier Adjuvants

- Deposition aid
  - A material that improves the ability of agrichemical sprays to deposit on targeted surfaces
  - Oil emulsions sourced from soybean, sunflower, and canola
- Drift reduction agent
  - A material used in liquid spray mixtures to reduce driftable fines
  - Polymer-based “spray thickeners”
    - Long chain synthetic polymers: polyacrylamides, polyethylene oxide, and polyvinyl polymer
  - Inverse emulsions
    - Vegetable oil- or lecithin-based

Study 2

Weed Control from Glufosinate Applied with Deposition Aids

2024 Materials and Methods – Study 2

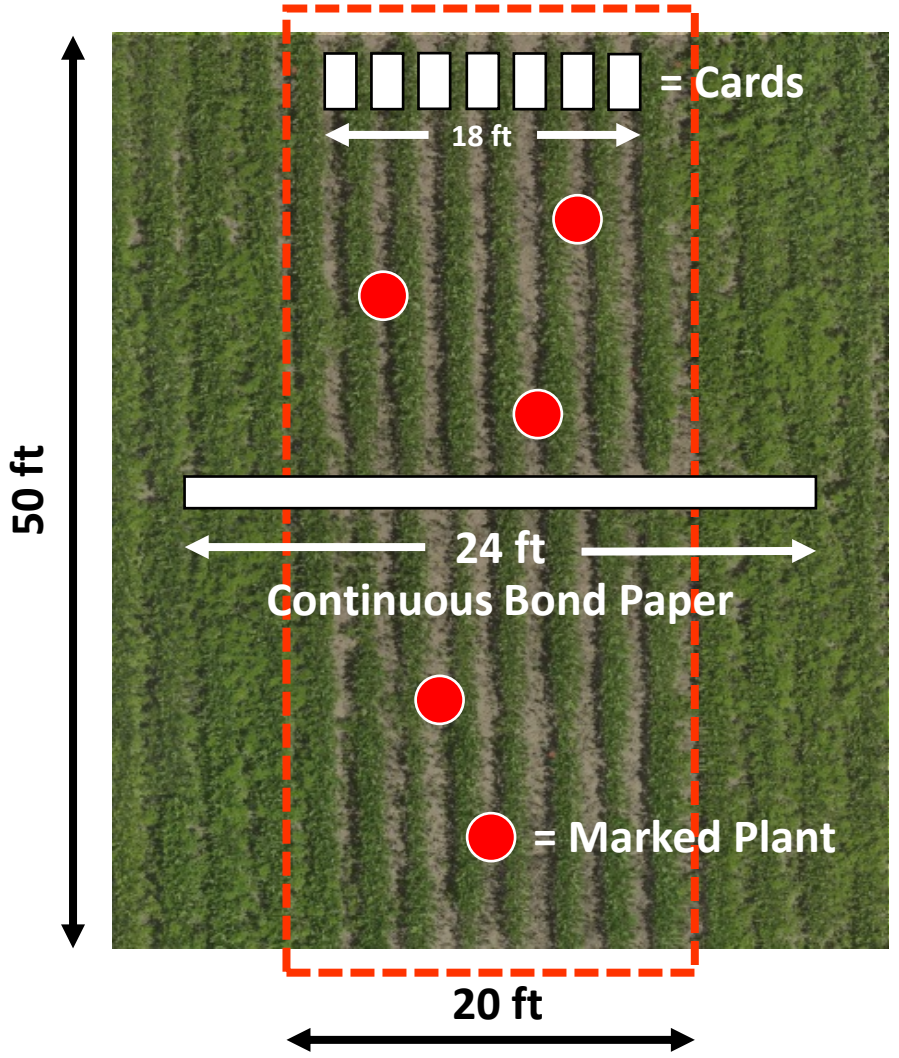
- **Objective**: Evaluate spray swath characteristics and weed control as influenced by deposition aids applied with glufosinate in a spray drone application

- **Herbicide, Adjuvants, and Rates:**
  1. Liberty® 280 SL @ 30 fl oz/A + AMS (1 lb/A)
  2. + Precisive™ (NIS-based) @ 0.5% v/v
  3. + Nexum™ NG (Oil-based) @ 4 fl oz/A
  4. + Salia™ (HSOC) @ 6 fl oz/A
  5. + Intact™ Pro (DRA) @ 0.25% v/v
  6. + Experimental @ 50% carrier

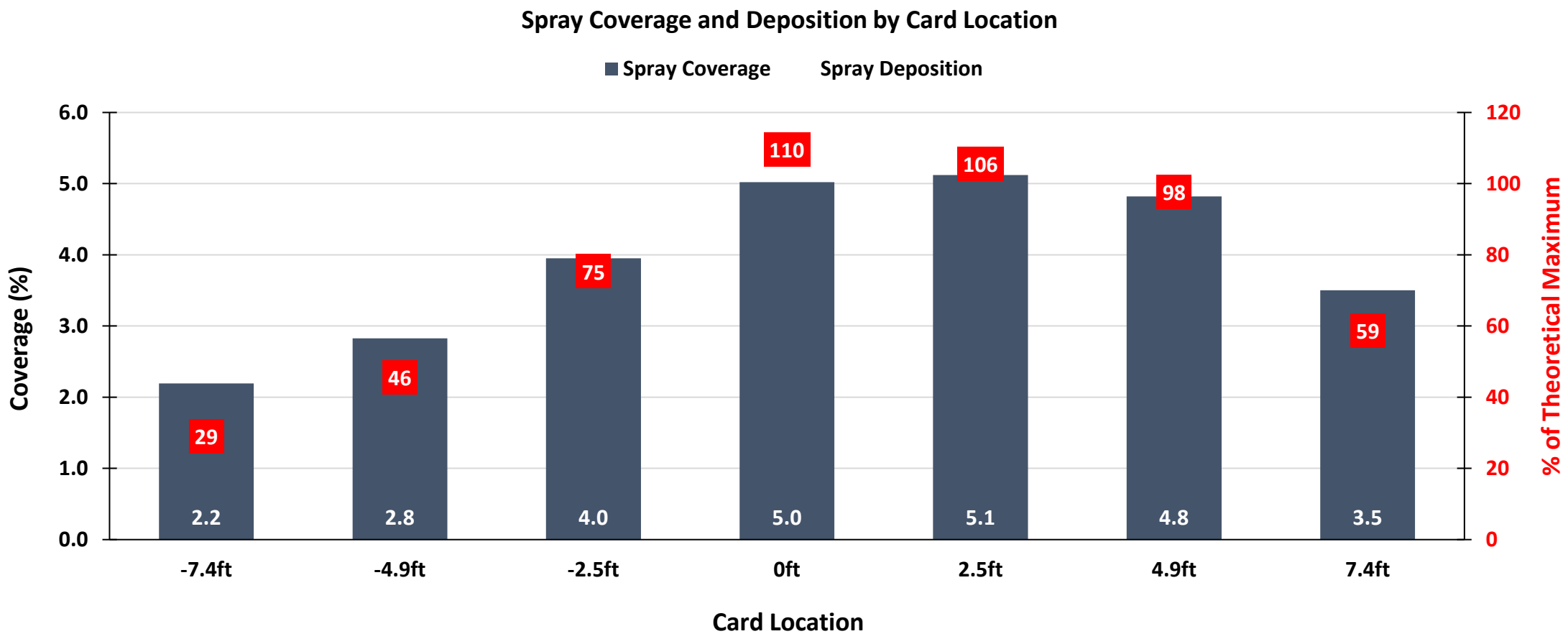
- *All treatments contained pink marker dye (0.375%) and fluorescent tracer dye (600 ppm)*

- Drone = DJI Agras T30
- Application parameters:
  - Swath width: 20 ft
  - Height: 10 ft
  - Speed: 15 mph
  - 2 GPA
- TeeJet® TT110015 nozzles

2024 Data Collection – Study 2

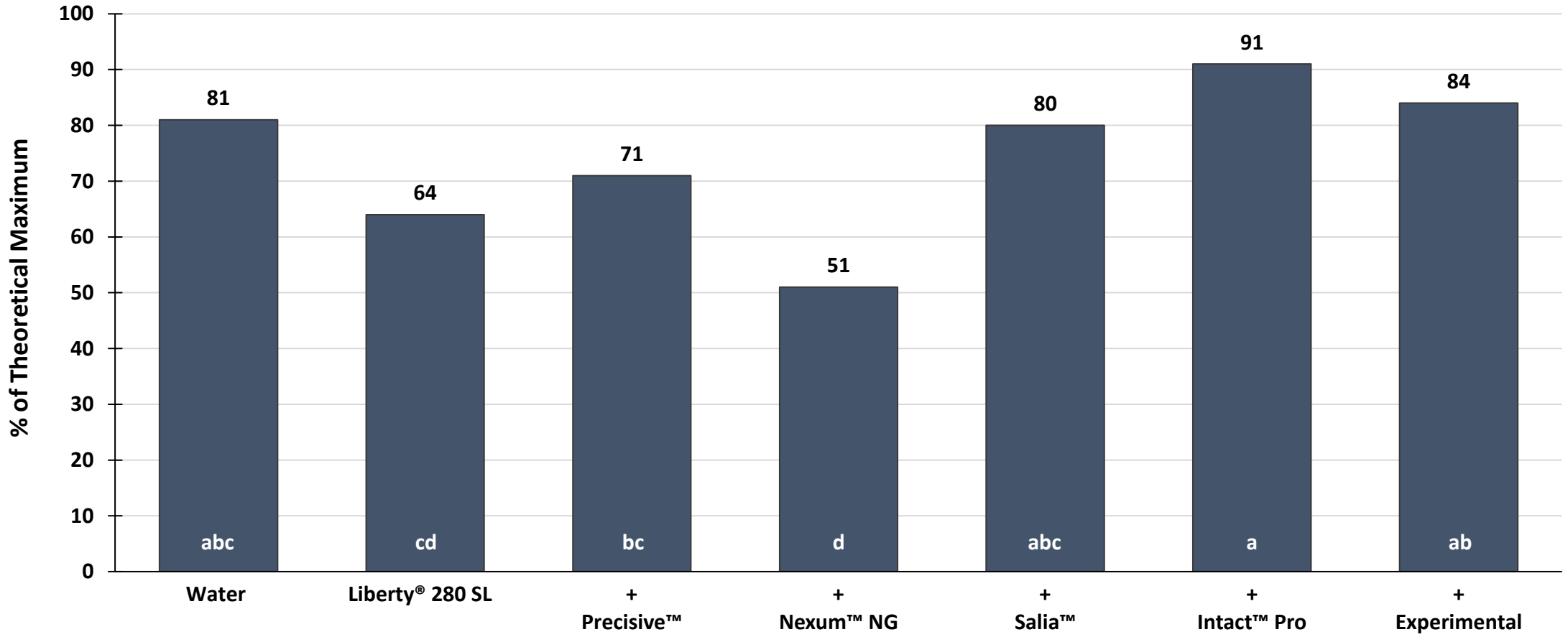


Spray Coverage and Deposition



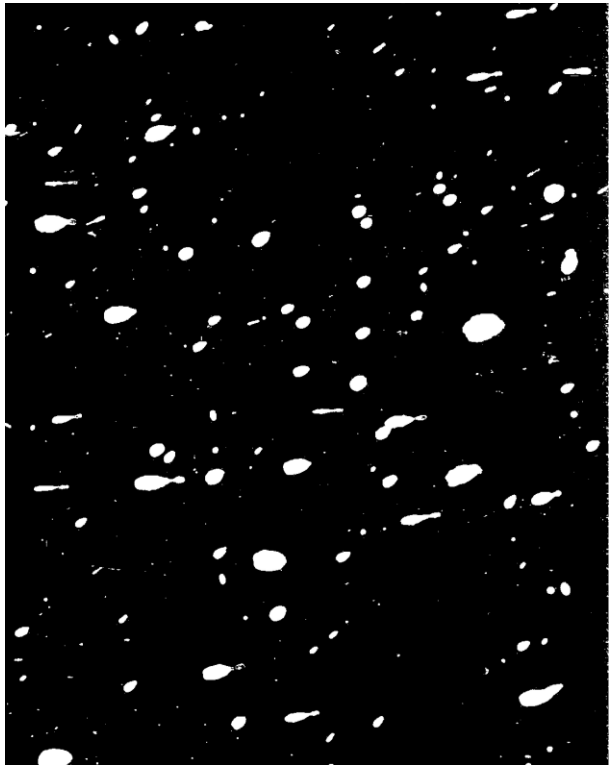
Averaged Across Treatment and Site

Spray Deposition

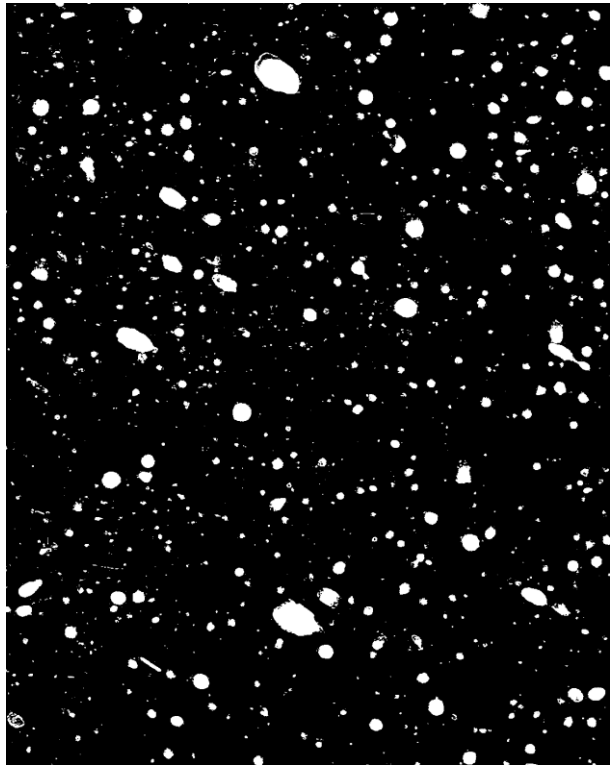


Averaged Across Card Location and Site

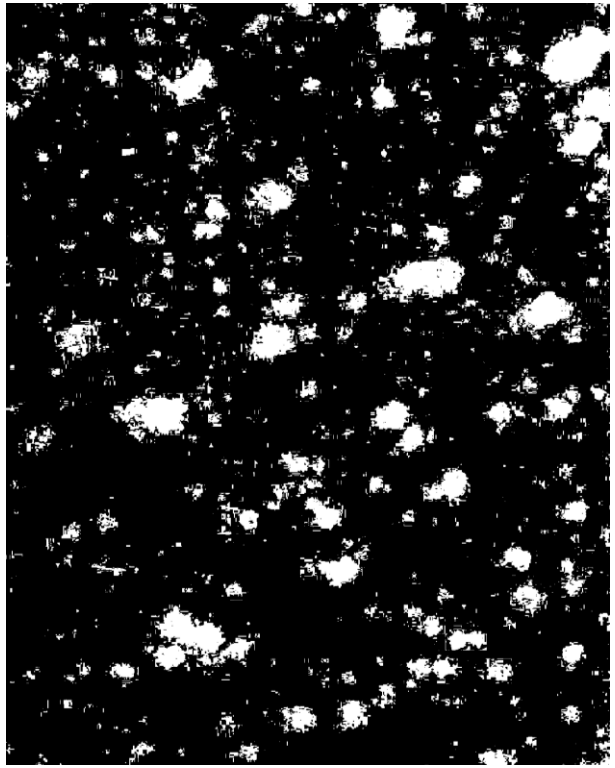
Center of Swath



Water

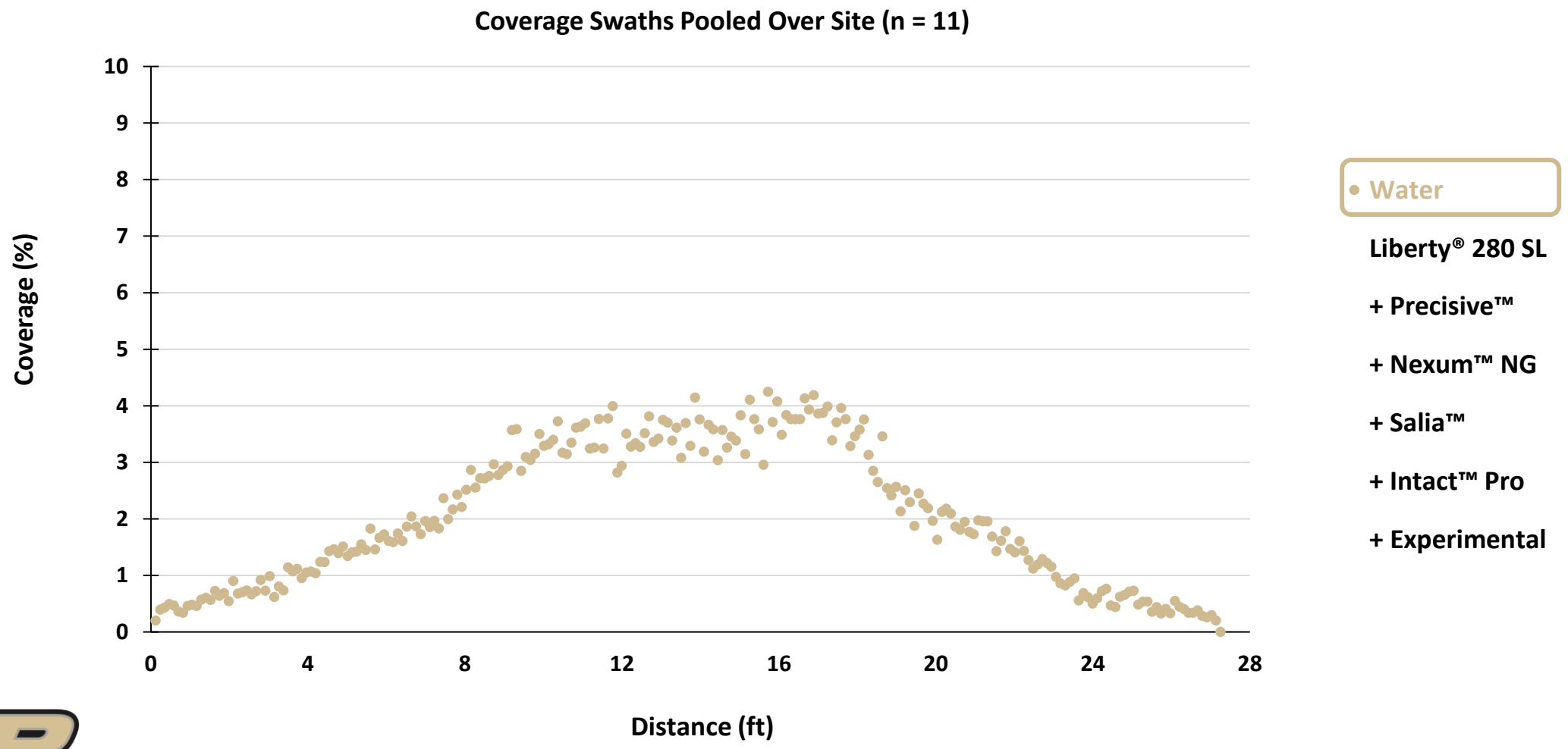


Liberty® 280 SL

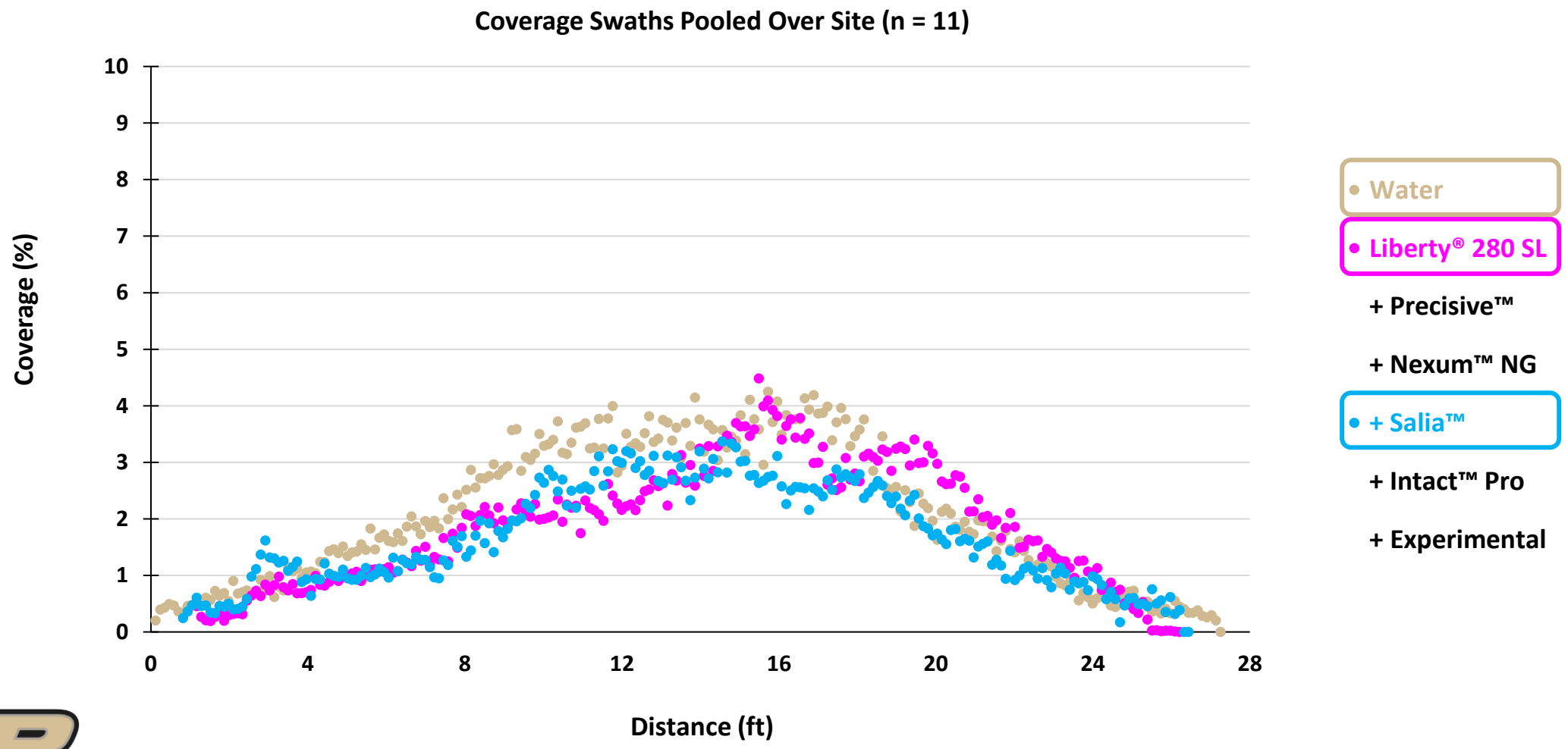


+ Experimental

Swath Distribution



Swath Distribution



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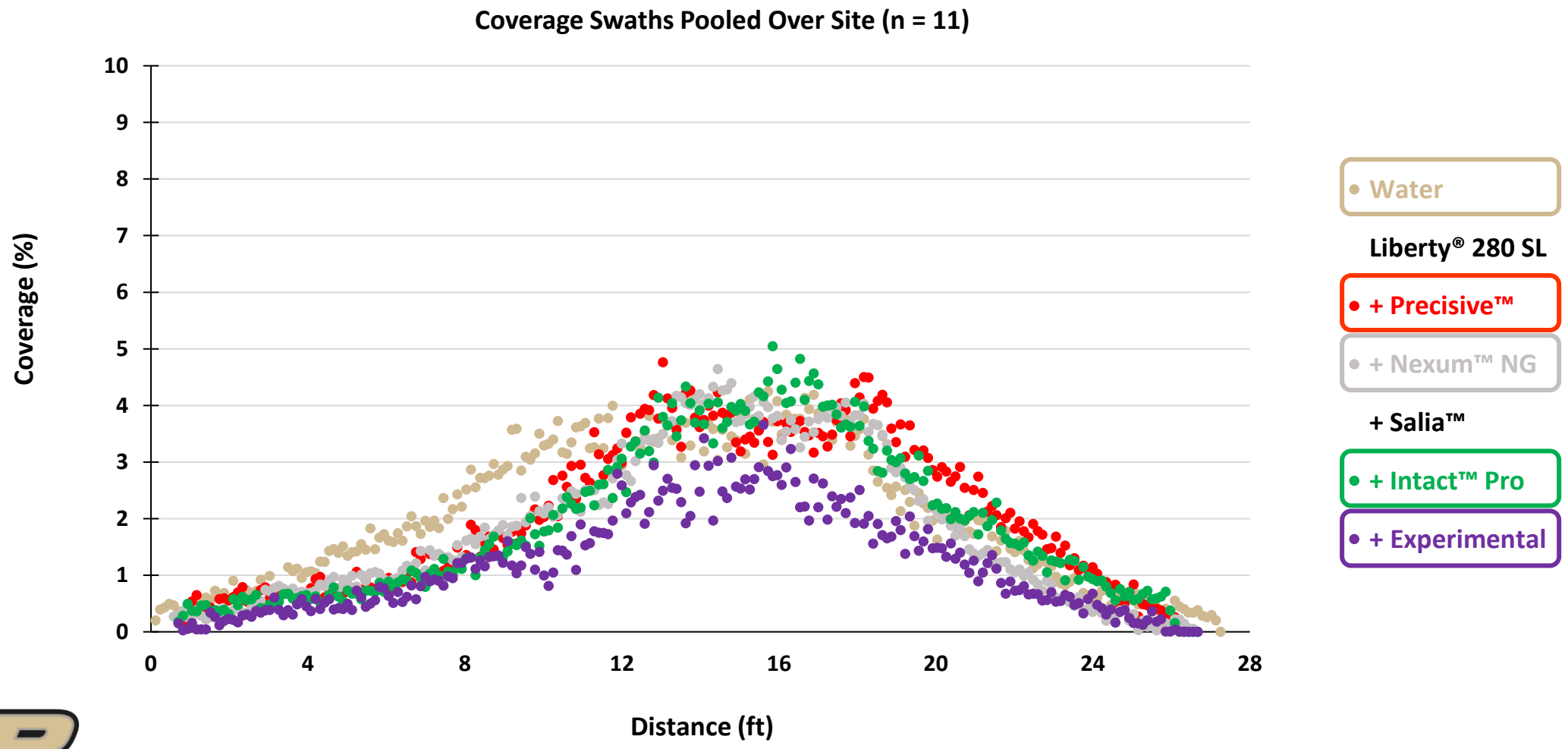
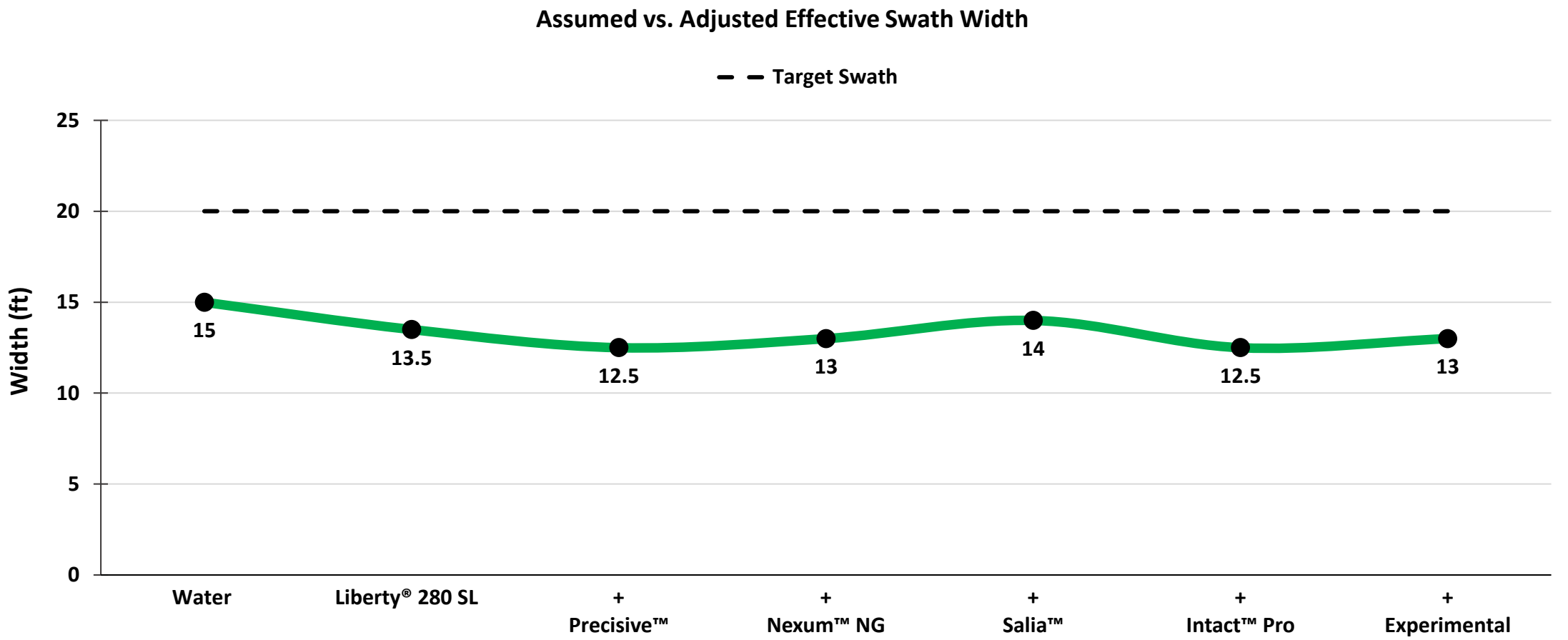
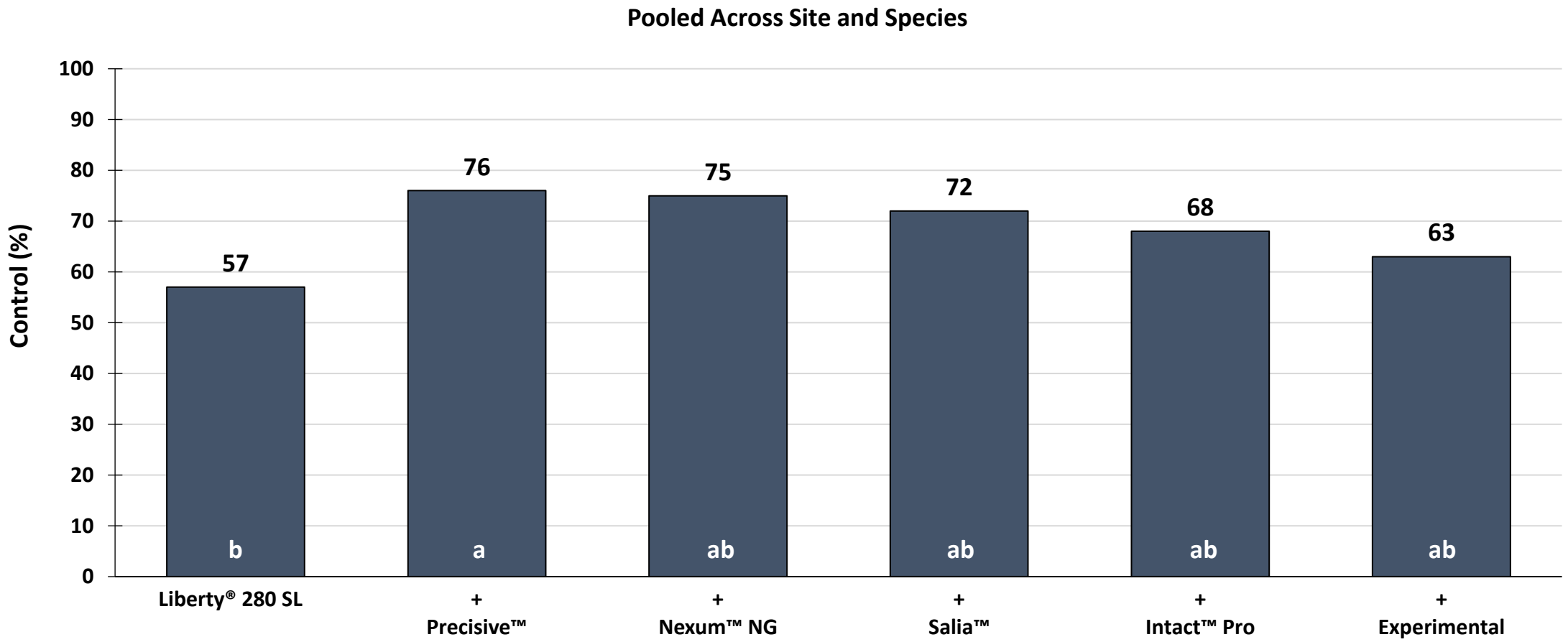


Effective Swath Width



Weed Control 14 DAA



All treatments included AMS

Summary – Study 2

- As expected, spray coverage and spray deposition was greatest in the center card locations and decreased towards the edges of the spray swath
  - The experimental deposition aid had the greatest spray coverage (11%)
  - Treatments with glufosinate had greater deposit density than water alone
  - Spray deposition ranged from 50 to 90% of the theoretical maximum
- We observed minimal differences between the effective swath width for each treatment
  - Effective swath widths ranged from 12.5 to 15 ft
  - All treatments with Liberty 280® SL compared to the water alone treatment decreased the effective swath width
- Incomplete weed control was observed with Liberty® 280 SL treatments (63 to 76%)

Implications – Study 2

- Applicators may choose to add a deposition aid to the spray solution, but it is important to understand deposition aids may decrease the effective swath width
- From a weed control perspective, commercial formulations of glufosinate may not consistently benefit from the inclusion of a deposition aid
- Observed levels of weed control may be attributed to the high amount of spray deposition in the central portion of the swath

Center rows **Outer rows**

2024 Materials and Methods – Study 3

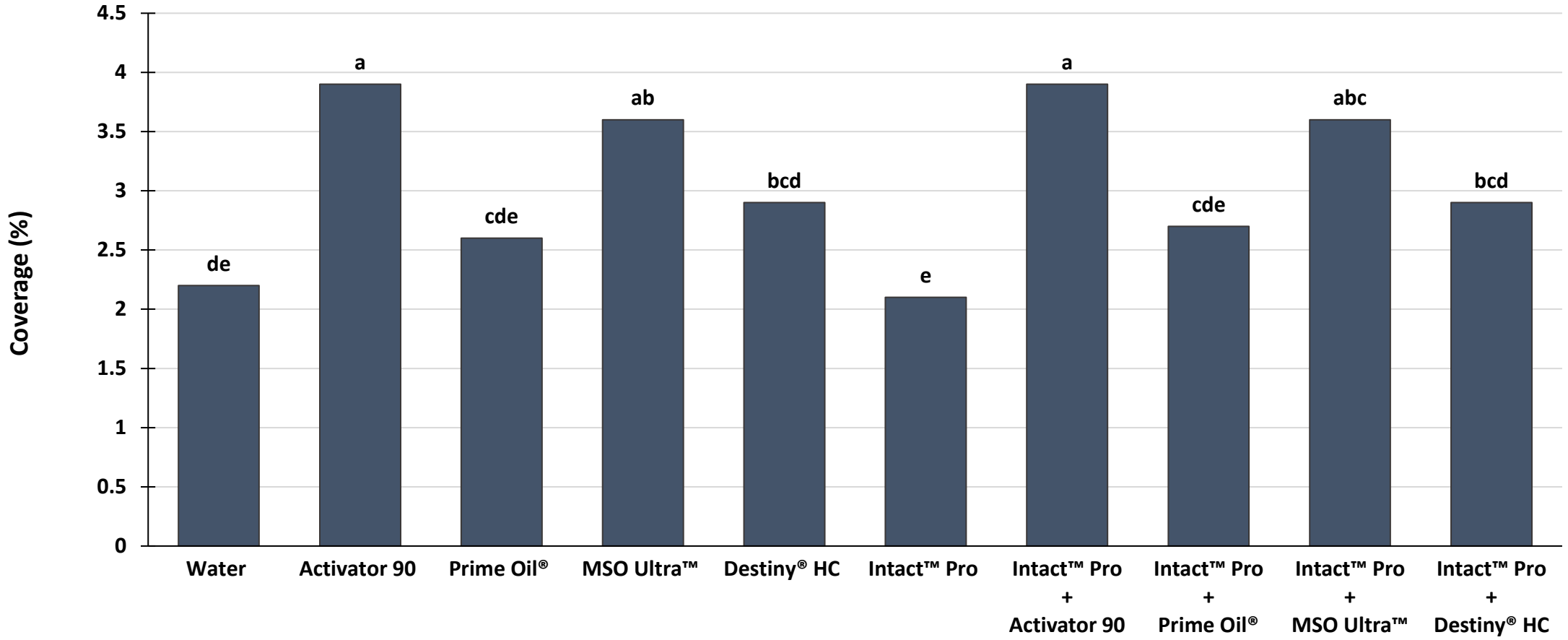
- Drone = DJI Agras T30
- Application parameters:
  - Swath width: 20 ft
  - Height: 10 ft
  - Speed: 15 mph
  - 2 GPA
- TeeJet® XR80015 nozzles

- **Objectives:**
  - Quantify the spray coverage, deposit density, and spray deposition of activator adjuvants applied with and without a drift reduction agent in a drone application
  - Determine the effective swath width as influenced by adjuvant categories applied with and without a drift reduction agent in a drone application
- **Adjuvants and Rates (Activator adjuvants x DRA):**
  - Water

  <u>Activator adjuvants</u>
  - Activator 90 (Nonionic surfactant) @ 0.25% v/v
  - Prime Oil® (Crop oil concentrate) @ 1% v/v
  - MSO Ultra™ (Methylated seed oil) @ 1% v/v
  - Destiny® HC (High surfactant oil concentrate) @ 1% v/v

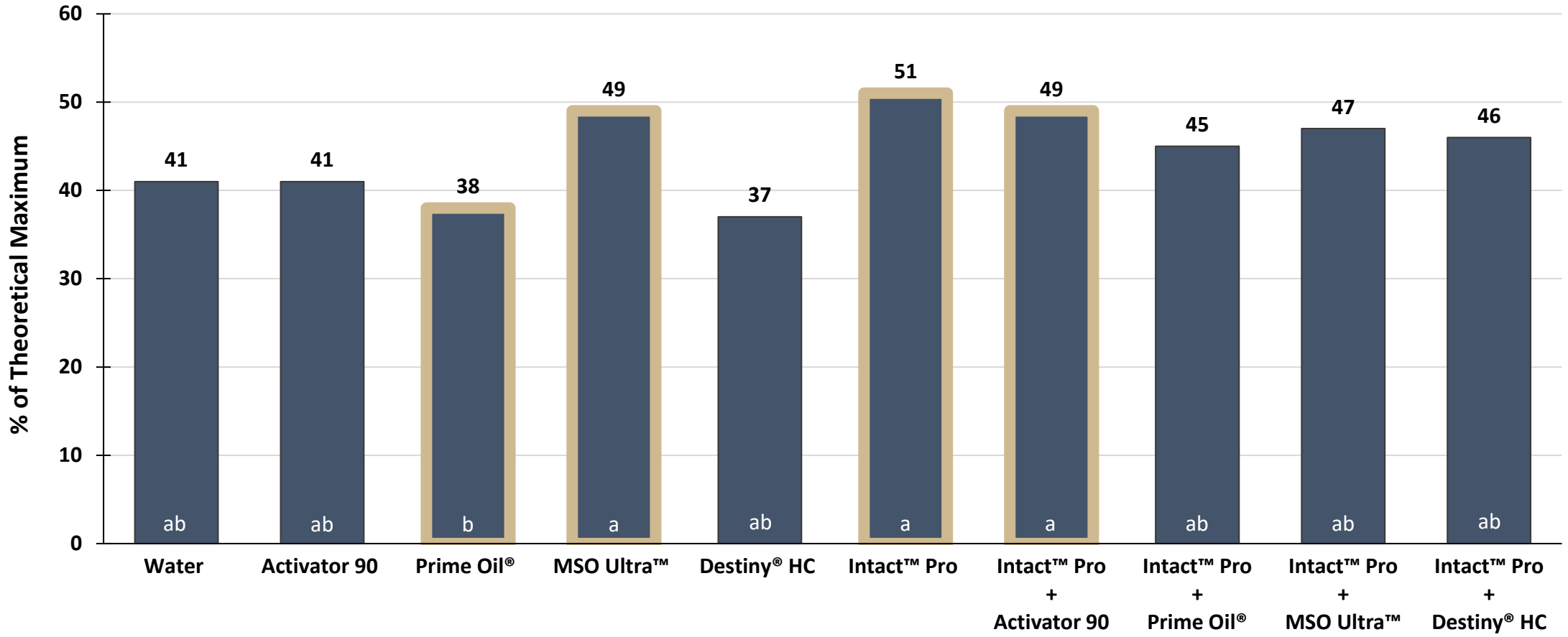
  <u>Drift reduction agent</u>
  - Intact™ Pro @ 0.25% v/v
- *All treatments contained pink marker dye (0.375%) and fluorescent tracer dye (600 ppm)*

Spray Coverage



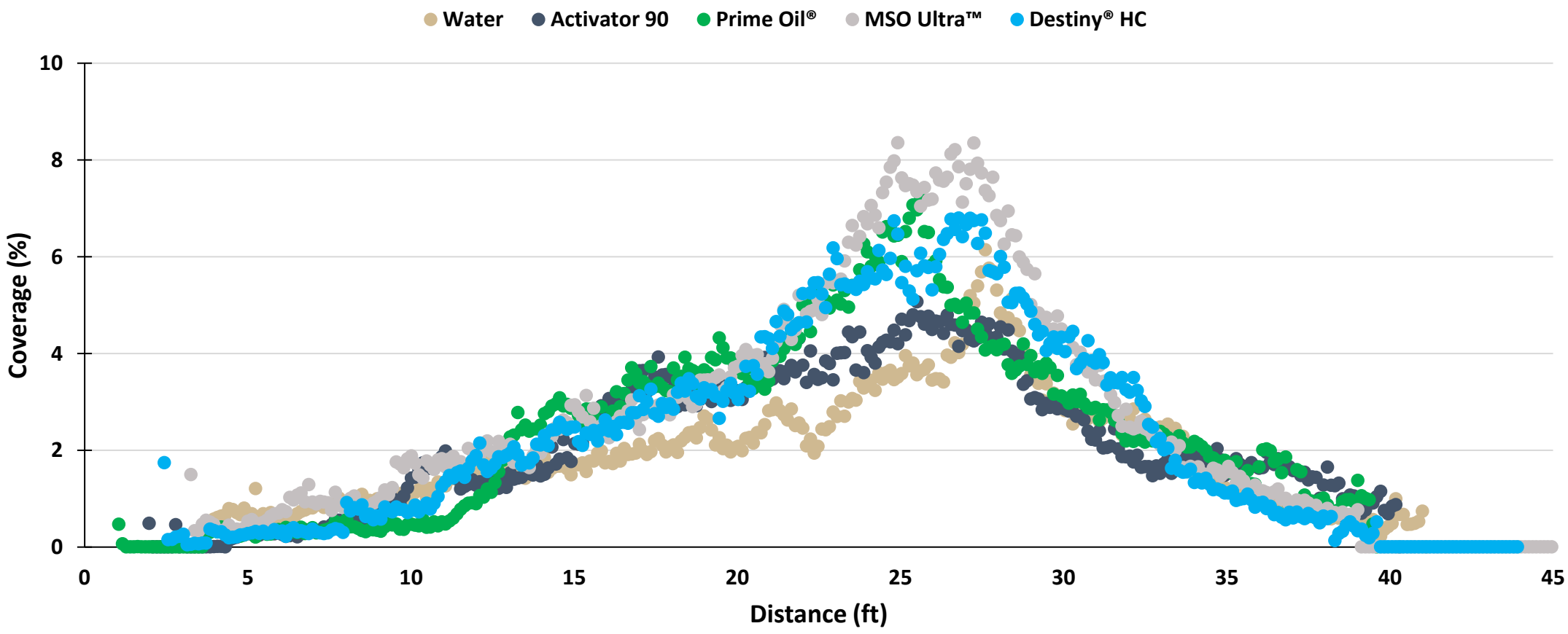
Averaged Across Card Location

Spray Deposition

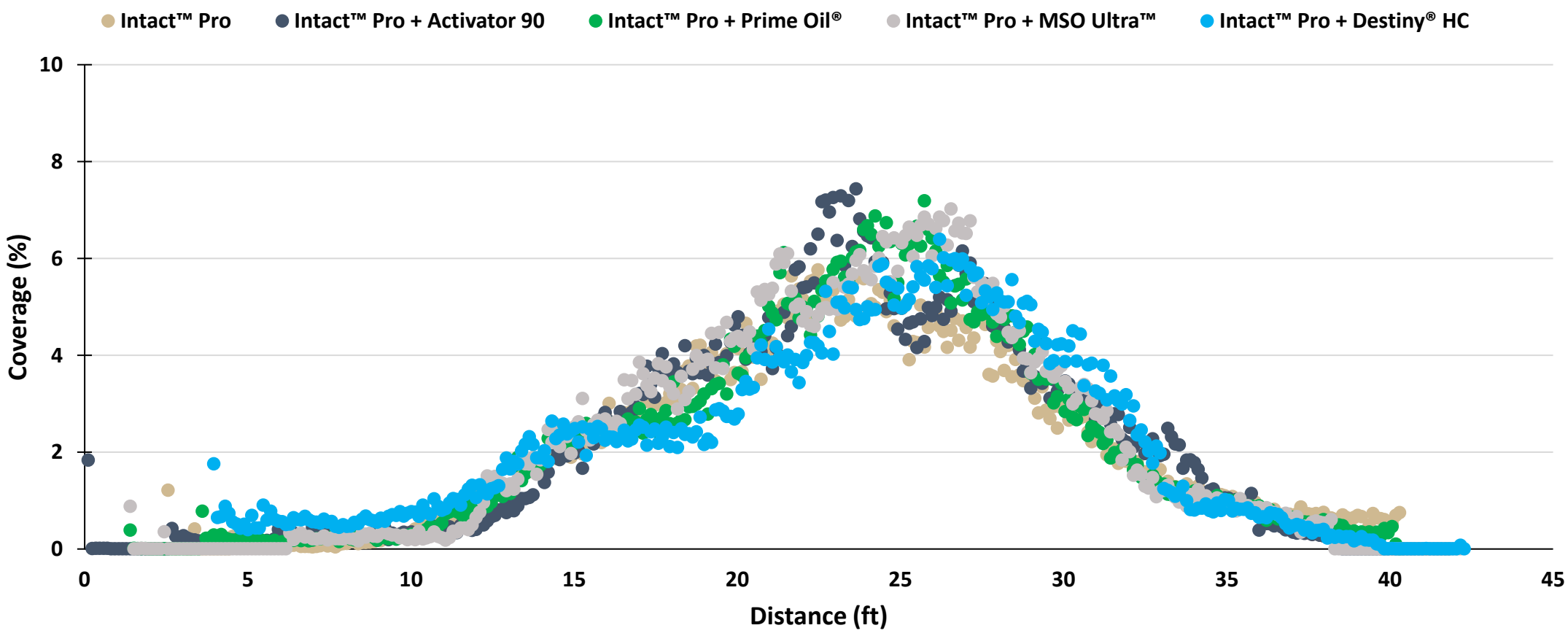


Averaged Across Card Location

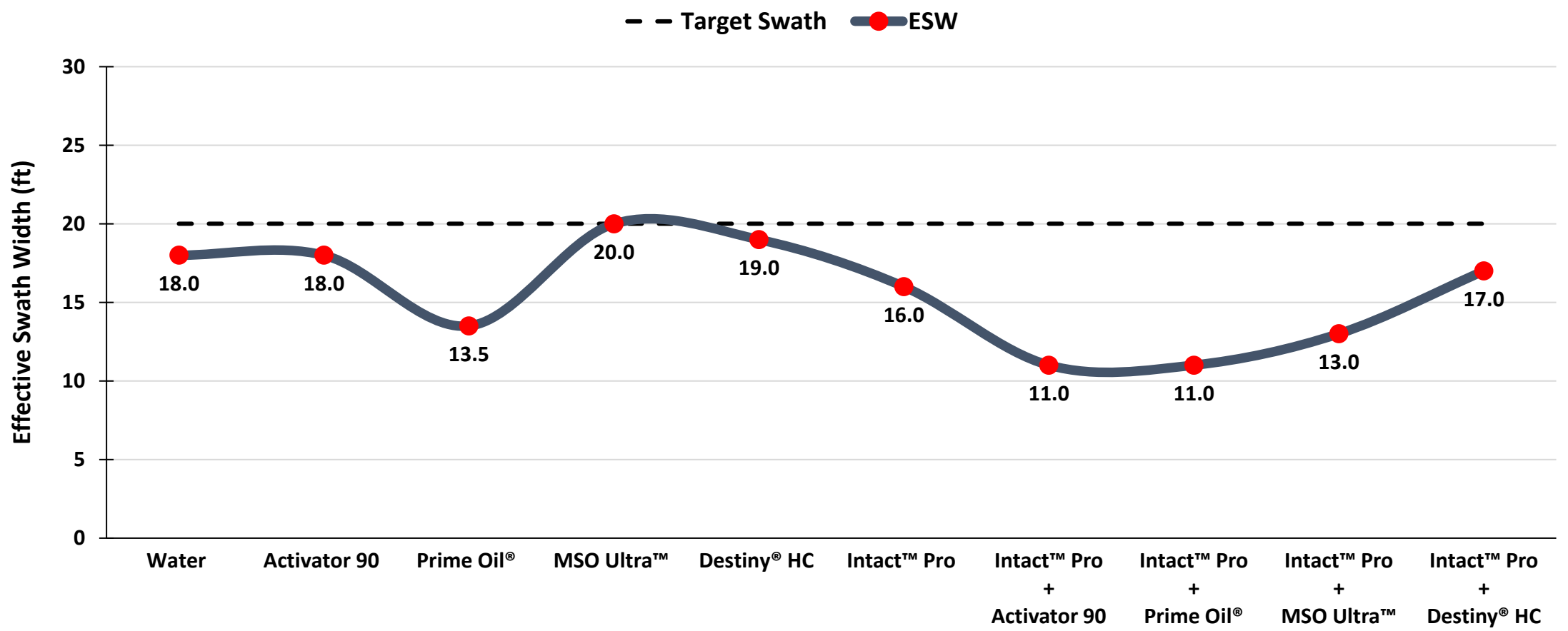
Treatments Without DRA



Treatments with DRA



Average ESW Across Collection Types



Summary – Study 3

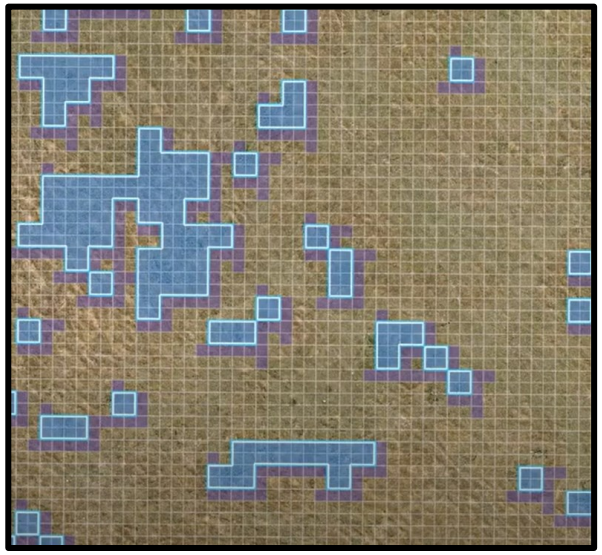
- Adjuvant treatments without the DRA resulted in wider and more uniform spray swaths with gradual increases in coverage from the outside edges to the center of the spray distribution
- When the DRA was included with each activator adjuvant treatment, spray swaths resulted in more compact, narrow swaths with sharp increases in coverage from the outside edges of the spray swath to the center of the spray distribution
- Applicators may not be able to use a consistent effective swath width under applications that require different adjuvant types.

Implications

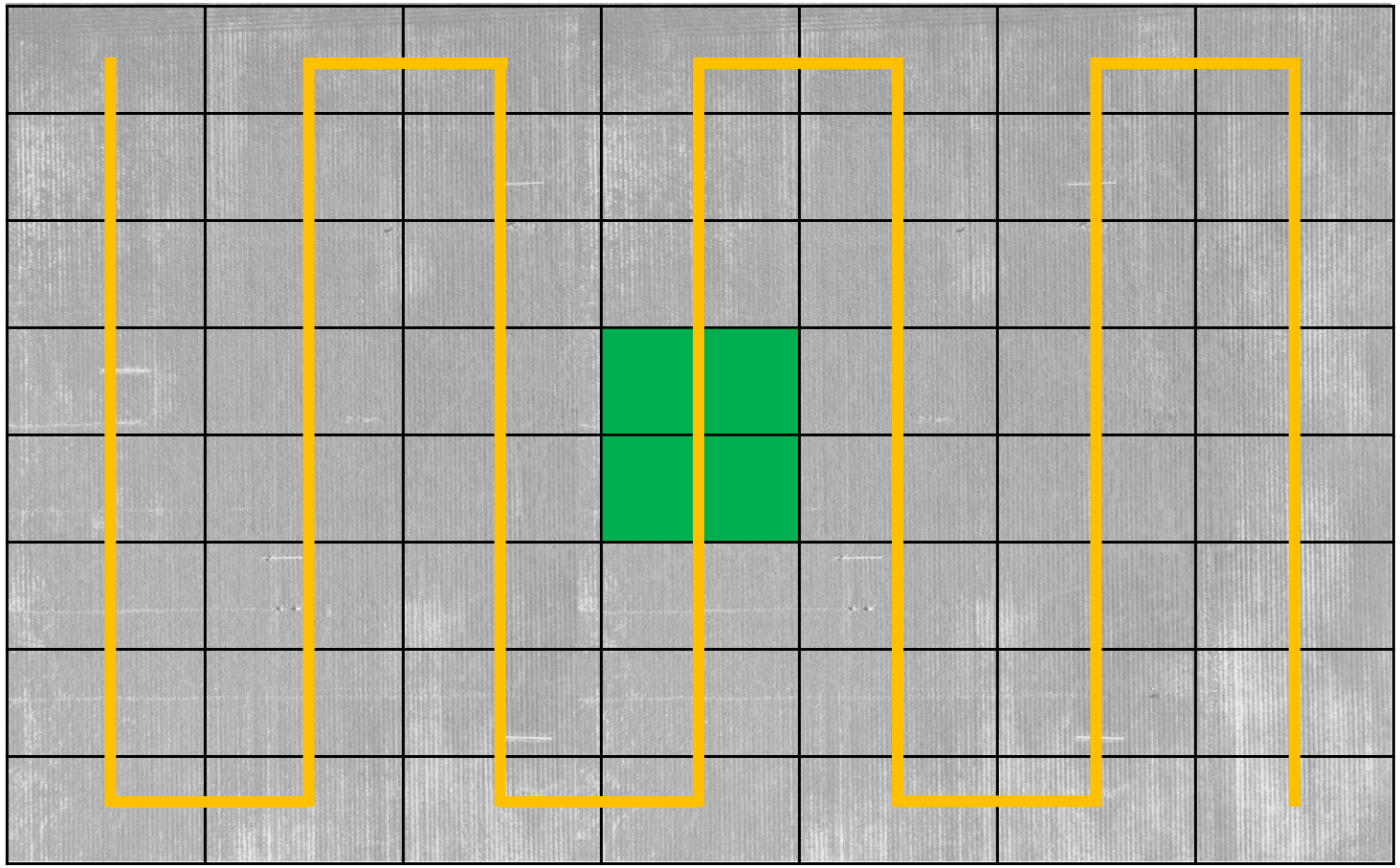
Spot Spraying

- More practical for herbicide applications than broadcast herbicide applications

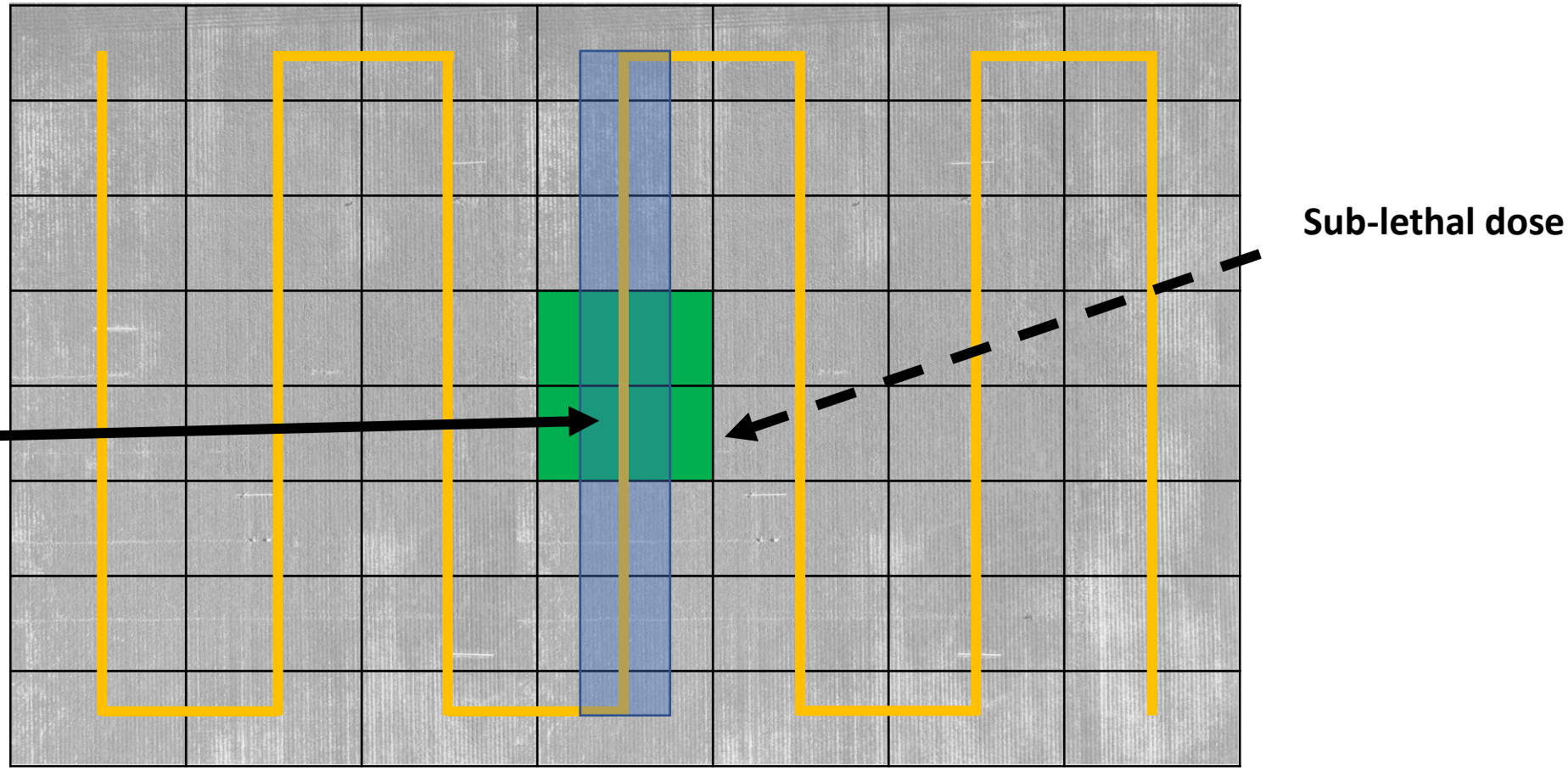
- Your effective swath width is no longer the same as a broadcast application!



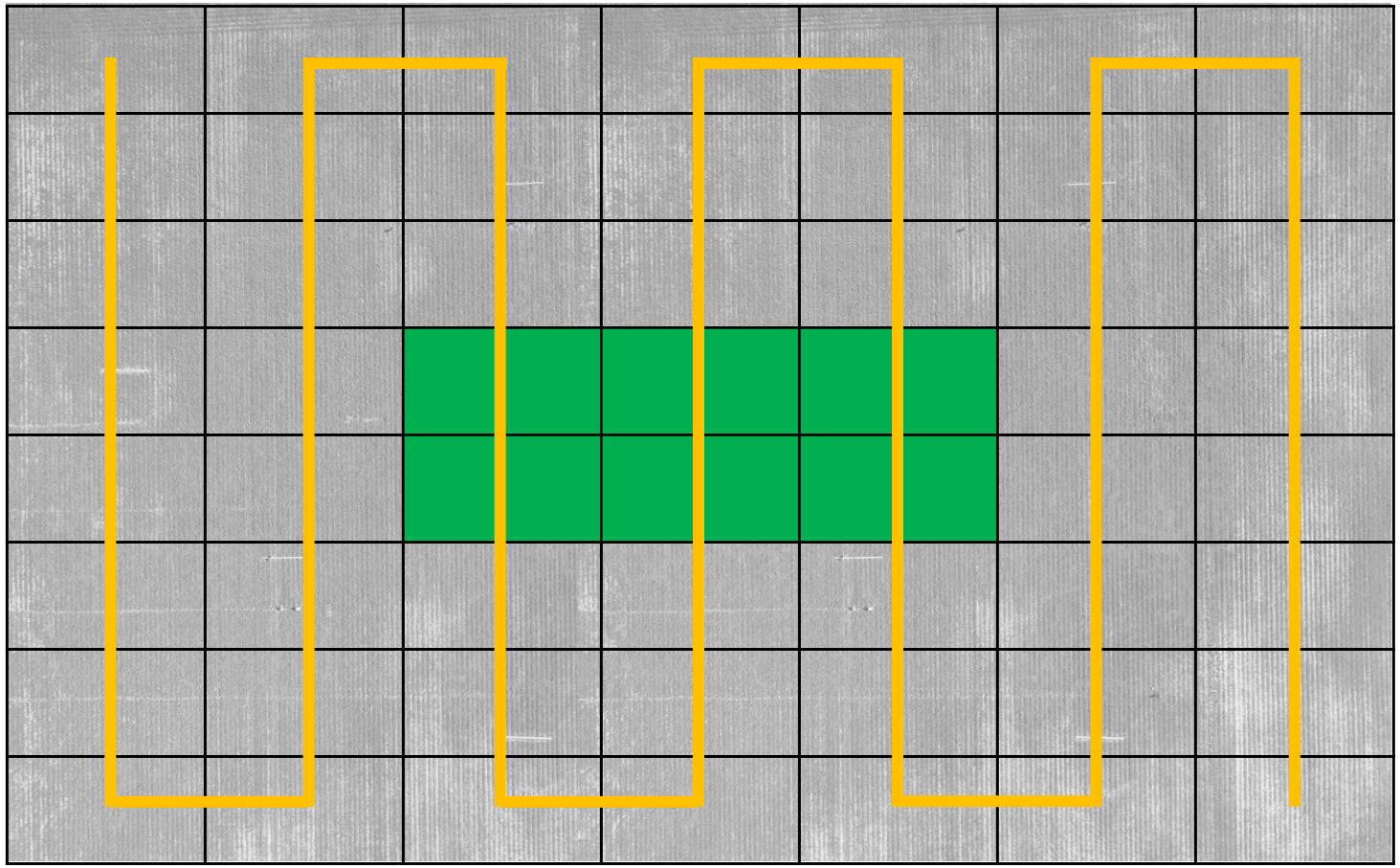
Spot Spraying



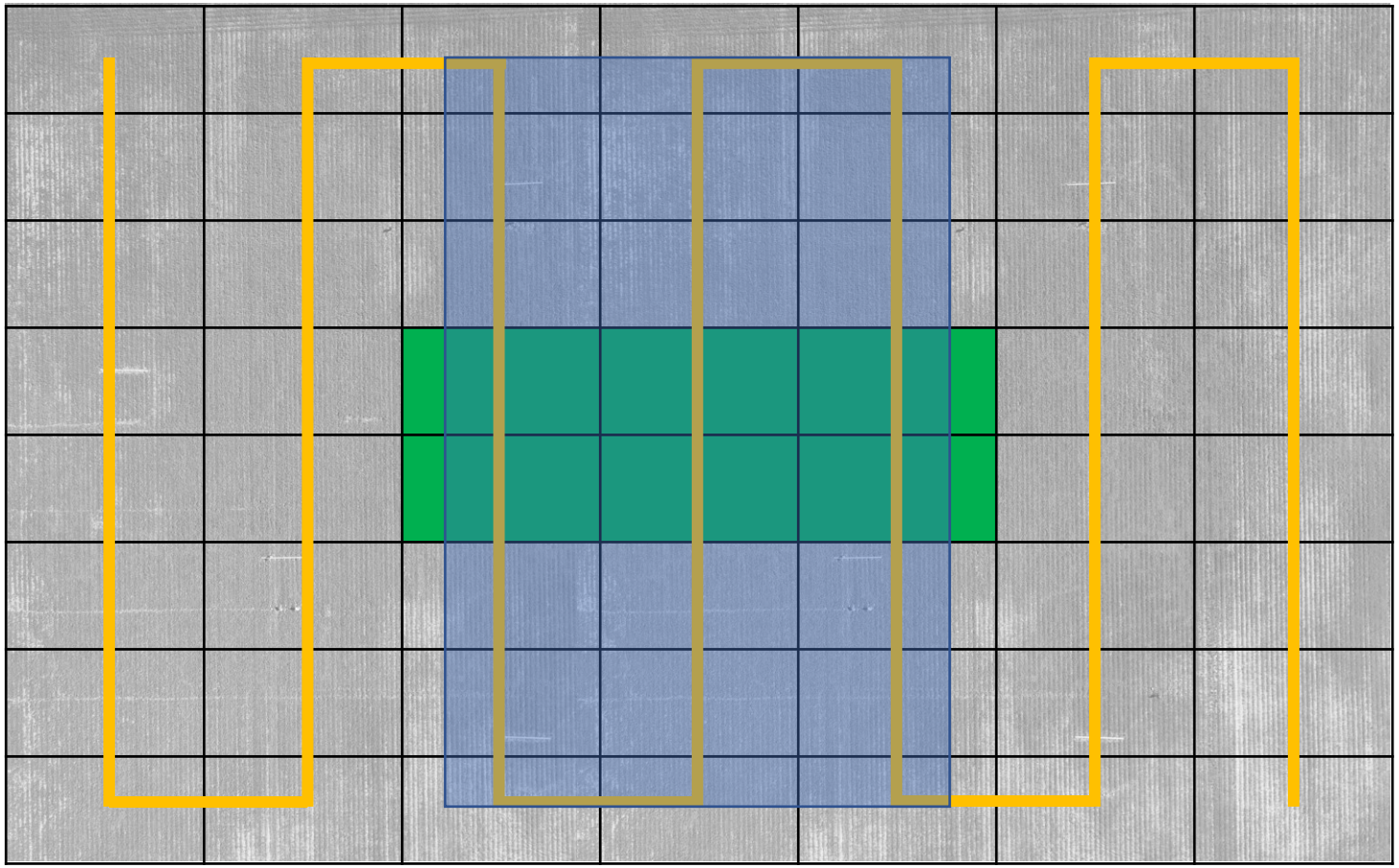
Spot Spraying



Spot Spraying



Spot Spraying



Center rows

Outer rows

Conclusions – Spray Coverage and Deposition

- Higher speeds may provide greater uniformity, but lower speeds provide greater coverage and spray deposition
- Greater application height may provide wider effective swath widths, but less coverage and more susceptible to environmental conditions
- Droplet size matters! Larger droplets collapse the spray pattern and result in lower effective swath widths than smaller droplets
- No adjuvant is created equally, understand that deposition aids and drift reduction agents may alter your effective swath width

Conclusions – Weed Control

- While we have observed better than expected herbicide efficacy at low carrier volumes, the consistency of these applications still remains in question
- Systemic products do NOT mean wider effective swath widths than contact products
- Understand adjuvant components and what you are asking these products to do
- Broadcast applications may not be suitable for herbicide applications due to variability in the outer swath regions

Considerations

- Use a ground-rig when possible as we have been optimizing these applications for decades
  - When ground-rig applications are not logistically feasible, use a helicopter or traditional manned aircraft
  - If no other option is available, a spray drone may be a viable last resort
- When in doubt, use higher carrier volumes
- Make sure the drone reaches desired speed before reaching the application area
- Pay attention to environmental conditions
  - Wind speed and direction
  - Temperature and relative humidity

Label Restrictions and Guidelines

- University of Missouri: *Drones and Herbicides: Are we there yet?*
- Most herbicide labels specify a minimum carrier volume of 5 GPA for aerial applications
- Majority of fungicide and insecticide labels are a minimum of 2 GPA for aerial applications

Aerial Application Restrictions and Parameters

✕ Table 1, Common Corn and Soybean Herbicides

Herbicide Trade Name	Active Ingredient(s)	Site of Action	Aerial Label ?	Minimum GPA for Aerial Application	Relevant Label Comments
2, 4-D LV6	2, 4-D	4	Yes	2	
AAtrex 4L	Atrazine	5	Yes	at least 1 depending on rate of product or 2 for POST	Apply in a minimum of 1 qt of water for each qt of this product applied per acre.
AAtrex Nine-O	Atrazine	5	No	n/a	
Accent Q	Nicosulfuron	2	Yes	3	No aerial application in New York and California
Acuron	Atrazine + Bicyloprone + Mesotrione + S-metolachlor	5+27+15	No	n/a	
Acuron Flexi	S-metolachlor + Mesotrione + Bicycloprone	15+27	No	n/a	
Acuron GT	S-metolachor + Glyphosate + Mesotrione + Bicycloprone	15+9+27	No	n/a	
Affinity Broadspec	Thifensulfuron + Tribenuron	2	Yes	2	No aerial application in New York
Agility SG	Dicamba + Metsulfuron + Tribenuron + Thifensuluron	4 + 2 + 2 + 2	Yes	1	
Aim EC	Carfentrazone	14	Yes	3	
Alite 27	Isoxaflutole	27	No	n/a	
Ally Extra SG	Thifensuluron + Tribenuron + Metsuluron	2 + 2 + 2	Yes	1	No aerial application in New York
Ally XP	Metsulfuron	2	Yes	1	
Amber	Triasulfuron	2	Yes	2	

https://ipm.missouri.edu/croppest/2024/6/drones_and_herbicides-kb/

Considerations

- Follow pesticide label instructions and consult manufacturers for additional information

- Use a CPDA-certified adjuvant
  - Several adjuvant manufacturers have released revised labels with language specific for spray drones

USE RATES

Ground:	0.125-0.5% v/v (1–4 pints pint per 100 gallons of spray solution).
Aerial:	0.25-0.5% v/v (2–4 pints per 100 gallons of spray solution).
Drones / UAVs:	0.5% v/v (4 pints per 100 gallons of spray solution).

CPDA Certified

Final Thoughts

- Spray drone swaths are highly variable; just about anything may influence the effective swath width!
- A failed application is a wasted application: Set yourself up for success by recognizing the components of an optimal application
- A developing technology that continues to improve
  - Future research
  - New models with higher payloads
  - Software updates
  - Terrain following

Thank You! Questions?

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