Best Management Practices for Safe and Effective Application of Pesticides Using Unmanned Aerial Spray Systems (UASS)

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December 5th, 2024

Presented on behalf of the [1]Unmanned Aerial Pesticide Application System Task Force (UAPASTF), LLC. and CropLife INTERNATIONAL

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Overview

- Introduction and Overview of Best Management Practice Document
- General Pesticide Safety Considerations
- Regulatory Considerations and Landscape of Application Drones
- Pesticide Drone Application Checklist
  - Pre-flight
  - During Application
  - After application
- Conclusions

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Disclaimer: The BMPs provided here are intended to supplement information on the product label and the registered and current product label should ultimately be followed above any other source of information. Readers should therefore ensure that this guidance is adapted or supplemented by other country/state/region specific needs, conditions, laws, and regulations, as relevant, including official and required UAV pilot training, to ensure safe operations, which may not be explicitly mentioned on labels.

Introduction and Overview of Best Management Practices

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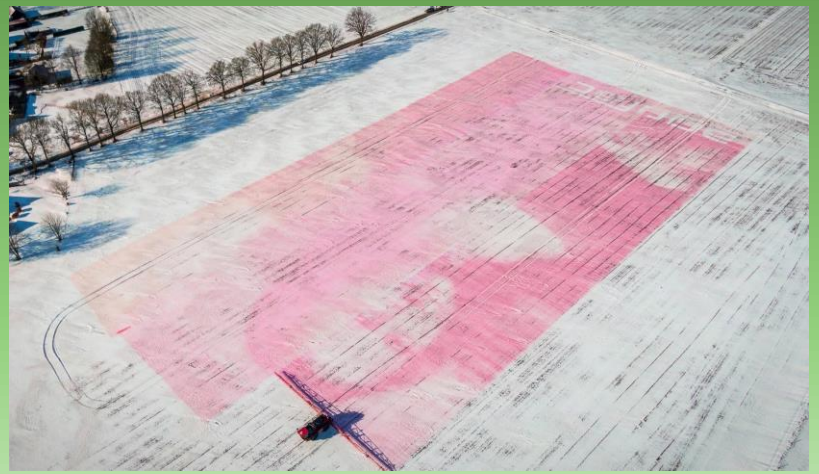
Economic pressures and the push toward more-sustainable practices are driving next-generation automation technologies, benefiting farmers, regulators, and consumers alike

Drones

Optical-assisted Sprayers



Farm Management Software and Field Mapping

Digital Product Information

Autonomous Equipment

Databases, models, and real-time information

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Potential benefits of drone technology in the U.S.

Examples!
Benefits will differ based on the region

Flexibility	Hard-to-access locations: (muddy fields, areas below power lines, irregular shaped fields etc.)
	Complements traditional application technologies
	Larger areas can be treated precisely with multiple coordinated drones (called swarms)
Cost	Less expensive equipment vs. conventional sprayers
	Decreased costs due to optimized applications and potential reduction of chemicals needed
	Decreased crop damage due to minimizing field passes
Worker Exposure	Decreased operator exposure due to physical separation of the application and the operator
Innovation	Targeted and optimized applications
	Attracts a diverse and technology-advanced workforce, creating new business models such as spray-as-a-service, and engaging technology partners not traditionally associated with agriculture
	Uses beyond agriculture that support public and environmental health: (mosquito applications, dam and railway maintenance, forestry, rights-of-way maintenance, land, invasive species, etc.)
Environment & Sustainability	Input reduction via customized rates, optimal timing, and placement: Drones can apply inputs such as fertilizers and pesticides more efficiently
	Emissions reduction: Using drones, which primarily rely on battery power, can lower the carbon footprint
	Reduced water consumption due to lower required water volumes
	Soil health due to less soil compaction
	Enables specialty crop care in small acreages, orchards, and vineyards, promoting agricultural diversity in the food supply

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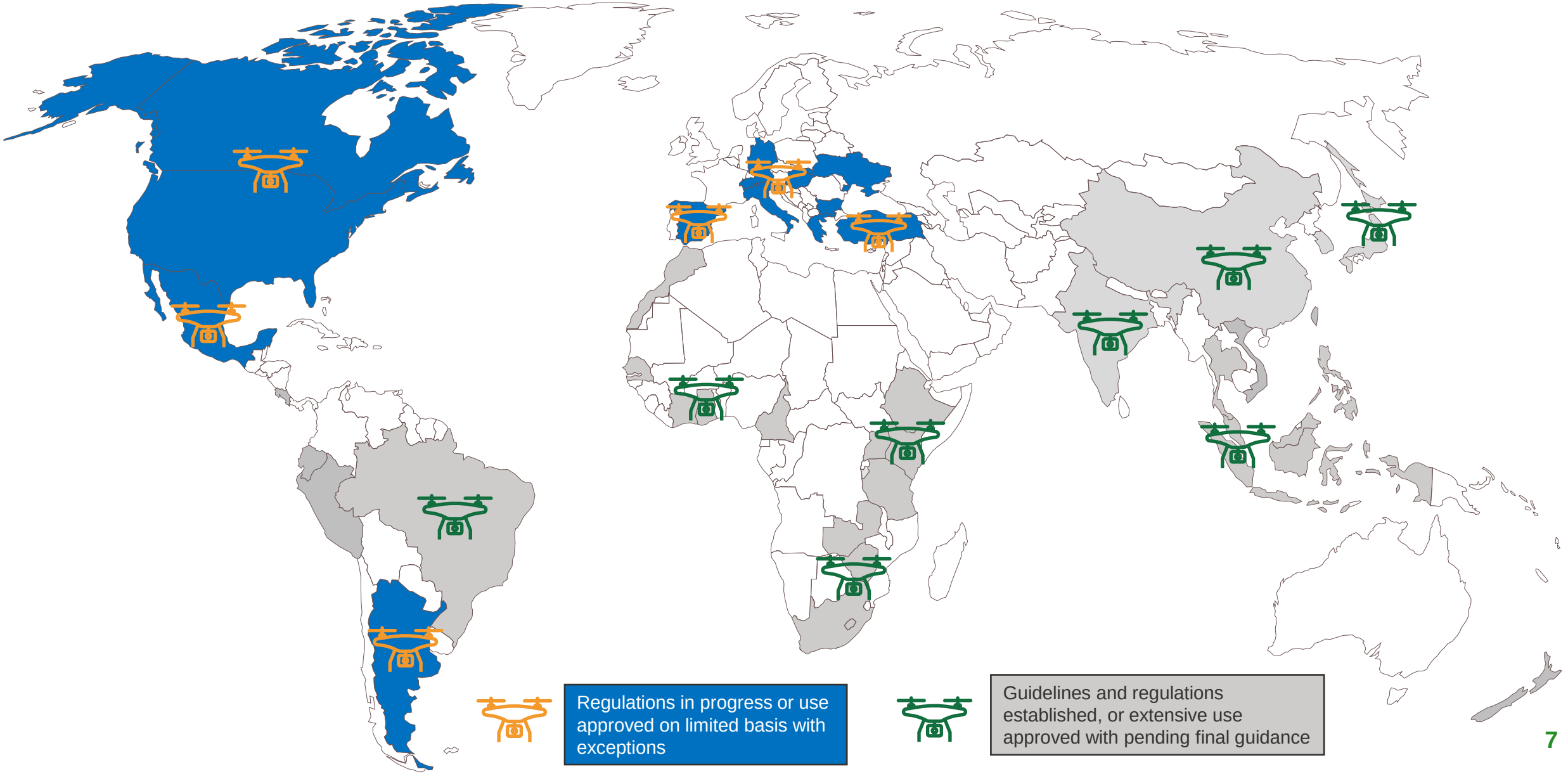
UASS Adoption Rapidly Growing



Regulations in progress or use approved on limited basis with exceptions

Guidelines and regulations established, or extensive use approved with pending final guidance

Unmanned Aerial Pesticide Application System Task Force (UAPASTF), LLC.

- Based in the US - but global in its work / focus
- UAPASTF global core mission is to supply regulatory data / information to inform the potential use of UAV-based pesticide application
  - Where appropriate, the UAPASTF will focus on generating data for submission to pesticide regulatory authorities to inform estimates for off-site movement, determine potential operator/handler exposure, and assess crop residue contribution to human dietary exposure in risk assessment and regulatory approval processes
- UAPASTF interacts with OECD Drone/UASS Subgroup of WPP, regional / national regulators, CropLife, & other stakeholders to develop & provide information / data
  - UAPASTF alignment with work of the OECD WPP Drone/UASS Subgroup critical to success
  - Established and seeking collaborative and confidentiality agreements with UAV-application companies and experts (e.g., additional UAV-application companies in other world areas, UAV & nozzle manufacturers)
- UAV-based pesticide application a part of progression toward precision / digital agriculture with the potential for increasing sustainability

https://uapastf.com/

Member Company	*Administrative Committee*	*Technical Committee*
BASF Corporation	Rebecca Willis	**Frank Donaldson (Chair)**
Bayer CropScience LP	**Sarah Hovinga (Vice Chair)**	Jane Tang
Corteva Agriscience	**Travis Bui (Chair)**	Rajeev Sinha
Gowan Company LLC	Raymond Layton	Jason A. McDonald
FMC Corporation	Hector Portillo	Roberto Barbosa
NuFarm Americas Inc.	Patti Turner	Tyler Gullen
Syngenta Crop Protection LLC	**Nestor Algarin (Treasurer)**	Jo Davies
Valent U.S.A. LLC	Robin Charlton	Christopher Read
Task force managers	*Rhonda Bichsel*	*Eric Bruce*

Reflects UAPASTF full members and leadership as of January 1st, 2025

Parties interested in the work of, or registrants interested in joining the UAPASTF should contact:
Dr. Travis Bui,
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OECD WPP Drone/UASS Subgroup – State of the Knowledge Report Recommendations

- **The Subgroup has become an advisory body to provide expert input on how to fill knowledge gaps**
  - Grouping of 'state of knowledge' recommendations needed to develop / implement
  - Workstreams Established, work in-progress

Work Package #1 – off-site exposure including exposure modeling
(BIAC / CDN / US)

Work Package #2 – scanning / survey to stakeholders
(Australia, UK)

Work Package #3 – 'best practices' guidance (BIAC)

Work Package #5 – connect to ISO
(Research Institute / ISO representative)

Grouping of Recommendations from 'State of Knowledge' Report
#7. Develop an empirical database and standard drift curve or model to estimate off target exposure. #9. Develop a useable publicly available model for predicting spray deposition and drift including parameters for static hovering, forward speed and spray equipment.
#1. Establish database to classify UASS into groups to reduce burden of testing each different platform/configuration. #2. Survey manufacturers about future trend of UASS design/ use profiles to produce a benchmark platform as a common starting point for regulators (others may differ and need bespoke assessment but would cover most common uses). #8. A data gathering exercise for operational practices mixing, loading, cleaning and transport scenarios.
#5. Develop and publish a user-friendly summary of best practice (including the essential nature of calibration), pitfalls and a trouble shooting guide (both for generating trials data and applying pesticides in practice), including preliminary recommendations for operational parameters (release height, application volumes, forward speed and spray quality). #6. Promote the advice in Annex D recommendations for researchers conducting UASS drift studies.
#4. Develop set of standard methodologies that will support regulatory decision making.
#3. Encourage manufacturers to develop improved spray systems including the pump systems, nozzle placement and closed transfer loading systems. * ISO standard project

OECD WPP Drone/UASS Subgroup – State of the Knowledge Report Recommendations

Work Package 3 Update (Best Practices)

Recommendation 5 & 6

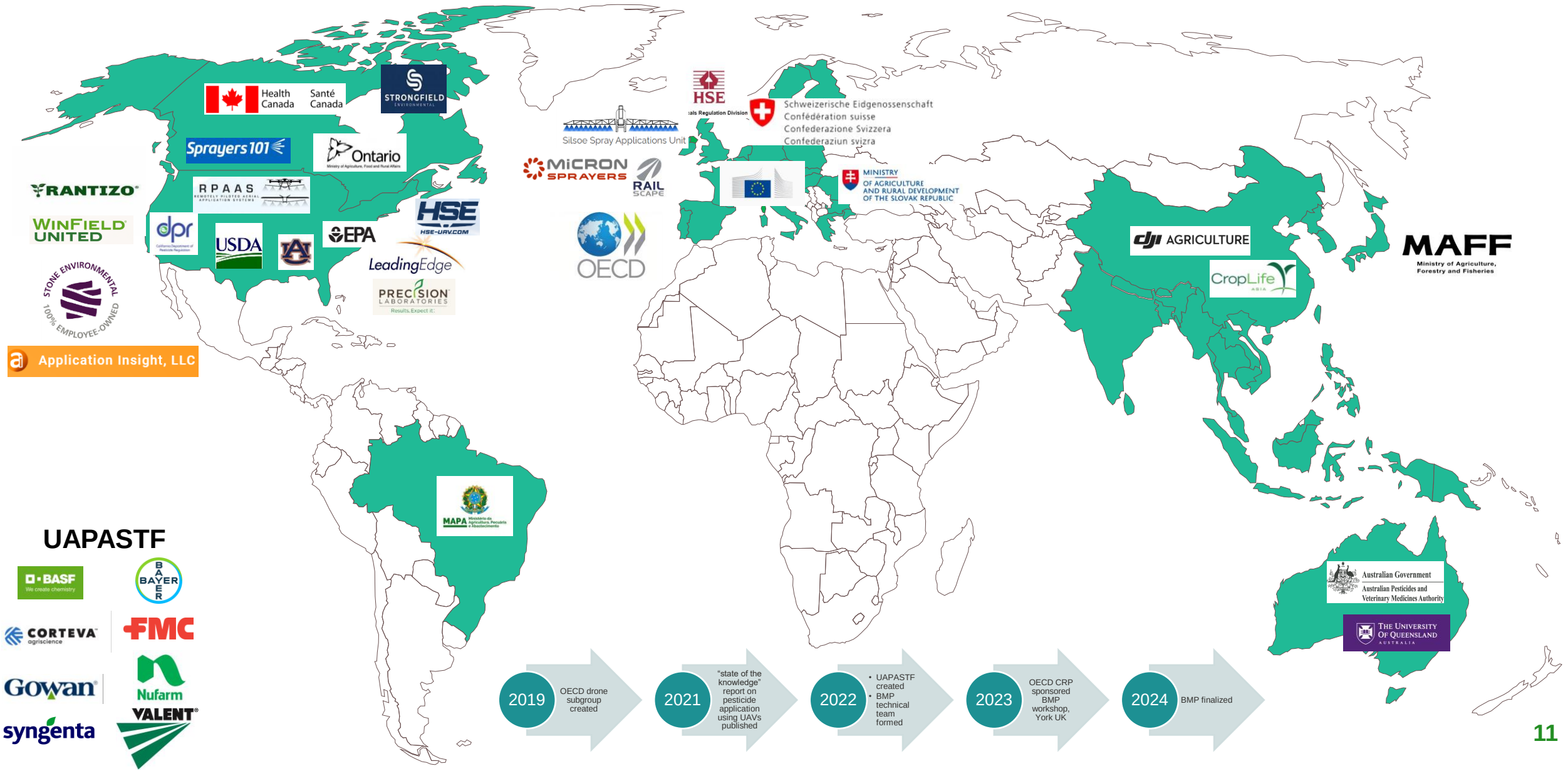
- Develop and publish a user-friendly summary of best practice (including essential nature of calibration), pitfalls and troubleshooting guide (both for generating trials data and applying pesticides in practice), including preliminary recommendations for operational parameters (release height, application volumes, forward speed and spray quality).
- Promote advice for researchers conducting UASS drift studies

Work Package 3 – OECD & UAPASTF

- BMP predominately focused on uses in agriculture
- Applicable to UASS using horizontal boom or nozzle/atomizers located under rotors and for products applied in liquid form
- Larger payload fixed wing UASS are outside of scope
- A summary of current regulations in key UASS use markets, including examples of certifications/licensing requirements
- Equipment set up and calibration parameters that impact spray deposition while reducing off target movement (drift), including impact of equipment selection and environmental conditions

Company/ Organization	UAPASTF BMP Tech Team Rep
BASF	Mark Ootslander
Bayer	Sarah Hovinga
Corteva	Rajeev Sinha
FMC	**Hector Portillo - Lead**
	Ted Lang
	Roberto Barbosa
Nufarm	Tyler Gullen
Syngenta	Neill Newton
Valent	Banugopan Kesavaraju

Organizations and Experts Input



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BAYER
CORTEVA agriscience
FMC
Gowan
Nufarm
syngenta
VALENT

- **2019** OECD drone subgroup created
- **2021** "state of the knowledge" report on pesticide application using UAVs published
- **2022** UAPASTF created; BMP technical team formed
- **2023** OECD CRP sponsored BMP workshop, York UK
- **2024** BMP finalized

Best Management Practice Outline

- Checklist
- Regulatory and Label Considerations
- Equipment
- Efficacy Considerations
- Environment and Effect on Drift

Best Management Practices for Safe and Effective Application of Pesticides Using Unmanned Aerial Spray Systems (UASS)

This document was developed by the **Unmanned Aerial Pesticide Application System Task Force (UAPASTF)**[1] and utilizes information from many entities also working in the Best Management Practice (BMP) space including but not limited to: CropLife organizations (CropLife International, CropLife America, CropLife Asia), International organizations (FAO, ISO), Government entities (India, Japan, USDA), Associations (NASDARF), Academia experts (Auburn University, Ohio State), Pesticide industry expertise (UAPASTF company members and others), Pesticide application specialists, and Drone spraying service providers. This BMP document also incorporates input from a 2023 conference/workshop of the government of the United Kingdom held in York, UK, titled "Applying Pesticides using Drones", sponsored by the Organisation for Economic Cooperation and Development (OECD) Co-operative Research Programme: Sustainable Agricultural and Food Systems. The conference/workshop was held to facilitate the exchange of knowledge, experiences, and perspectives on drone regulation from policymakers, industry experts, researchers, and stakeholders, including reviews of an earlier draft of this document. *While this document was reviewed by and incorporates inputs from these and other organizations, this document is not endorsed or approved by any other organization besides the UAPASTF; any mention of another organization is intended to identify a source of information utilized to create this document and how input into the review of the document was implemented.*

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[1]The Unmanned Aerial Pesticide Application System Task Force (UAPASTF) consists of the pesticide member companies: BASF Corporation, Bayer CropScience LP, Corteva Agriscience LLC., FMC Corporation, Gowan Company LLC, Nufarm Americas, Inc., Syngenta Crop Protection LLC, Valent U.S.A. LLC. The UAPASTF, convened by industry, generates, submits or shares/provides access to information and data to governmental agencies to address limitations in available regulatory information and to support risk assessment in relevant governmental agencies.

Best Practices for Safe and Effective Application of Agrochemicals Using Unmanned Aerial Spray Systems (UASS)

REGULATORY AND LABEL CONSIDERATIONS

- Certification and Licensing to apply pesticides using UAVs: select countries examples
- Pesticide Mixing, loading, spraying, cleaning and maintenance safety:

EQUIPMENT

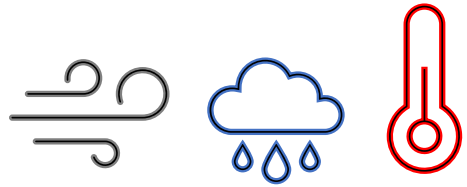
- Selection of equipment: UAV, nozzle/atomizer type, flow rate capacity for required water volume
- Effective Swath Width (ESW) and spray deposition
- Component check and parameters needed for calibration
- Calibration
- Monitor spray quality

EFFICACY: PEST AND CROP

- Assess if use of UASS is the appropriate method for the crop/pest targeted; use labeled
- Pest/disease/weed ID, threshold, timing
- Water volume/Spray coverage adequate for crop stage, pest location

EFFICACY: PRODUCT AND TANK MIX

- Product: attributes i,e., systemic Vs contact, use rate, rainfastness
- Clean tank, lines, and booms
- Tank mix: water quality and temp, adjuvants, buffers, compatibility, order of addition, suspensibility etc.
- Label requirements



ENVIRONMENTAL CONDITIONS

- Preferred conditions: wind, temperature, relative humidity
- Marginal conditions: low or high winds, Surface temperature inversions (thermal inversion), rain
- Label requirements to avoid operator exposure and sensitive areas: water bodies, pollinators etc.

General Pesticide Safety Considerations

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General recommendations for safe and compliant pesticide use

Improvements

Less Water Volume
3% water volume of manual application

Comparable Efficacy
Comparable or even better control efficacy vs manual

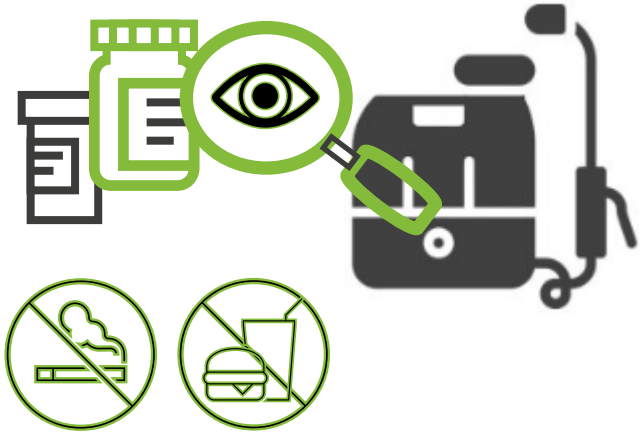
Cheaper Cost
50% treatment cost vs manual application

More Efficient
30 times faster vs manual application

Safer to Operator
Lower PPE requirements vs manual application

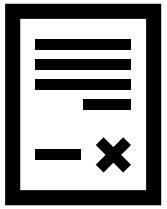
Labor Saving
Overcoming labor shortage

No Change



Source: TOOLBOX: Drone Operator Training, CropLife Asia

General recommendations for safe and compliant pesticide use



- Verify **authenticity** of the pesticide product (https://www.fmc.com/en/articles/9-signs-counterfeit-pesticides; https://www.bayer.com/en/agriculture/recognize-and-avoid-counterfeits)
- Read and follow the **product label**
- Wear **PPE** as specified on the product label or those mandated by regional regulations
- Ensure PPE is in proper condition (for example, certain precautions can be taken: https://www.epa.gov/pesticide-worker-safety/personal-protective-equipment-pesticide-handlers#:~:text=Keep%20pesticide%2Dcontaminated%20PPE%20away,pesticide%20labeling%20specifies%20other%20requirements; https://www.ccohs.ca/oshanswers/prevention/ppe/designin.html) and wash after use, including washing exposed clothes separately from other clothing
- **Calibrate equipment**, including checking the flow rate of all nozzle/atomizers against the target rate for the equipment settings and pesticide label requirements.
- Measure and mix pesticide in a well-ventilated area, away from ditches or open water, animals, livestock, food, and people not directly involved with the operation. Dispose of remaining liquid in the spray tank and equipment according to the pesticide product label or local regulations (for example, by spraying on targeted crop area). Only mix the volumes required for the job to reduce the amount of leftover product to dispose of.
- **Thoroughly rinse the spraying equipment externally** (refer to UAV manufacturer's rinse guidelines) and both the spray tank and internal plumbing, including the nozzle/atomizers (refer to pesticide labels).
- Manage empty pesticide containers appropriately by pressure rinsing or rinsing 3 times with the appropriate liquid as specified on the label and then dispose these and any contaminated material (like trays to contain spillage) in accordance with local regulations. Store and transport pesticides according to the pesticide product label
  - Store in a locked cabinet or secure area, away from food, feed, and PPE, and always in its original container.
  - Keep pesticides separated from food, feed, animals, vehicle passengers and always secure pesticide products/containers in the vehicle.

CHECKLIST WHEN MAKING PESTICIDE APPLICATIONS USING UASS

Pre-application

- Read and follow label directions/instructions (use rate(s), required buffer zones, precautions, potential impact on non-target organisms, restrictions, and personal protective equipment (PPE)
- Ensure the pesticide is allowed to be applied by UASS per local pesticide authority regulations and ensure pre-certification of the drone if necessary.
- Review chemical mixing, loading & readiness procedures
- Ensure potential bystanders that might not realize spraying is going on such as hikers, children, walkers, bicyclists, agricultural workers, neighboring farmers, etc., are identified ahead of time.

CHECKLIST WHEN MAKING PESTICIDE APPLICATIONS USING UASS

During and After Application

- If possible, prepare the spraying mixture in a nurse tank, in a delimited and demarcated area, away from sensitive areas, animals, people, etc.

CHECKLIST WHEN MAKING PESTICIDE APPLICATIONS USING UASS

During and After Application

- When reloading chemicals, make sure before approaching the drone that the rotor is inactive, check battery charge level, and change batteries if needed (have multiple recharged batteries available if possible). Change battery before reloading liquid in case of splashes on the power connecting part of the drone.

CHECKLIST WHEN MAKING PESTICIDE APPLICATIONS USING UASS

During and After Application

- While spraying, the operator and visual observers must keep visual line of sight with the UASS unit(s) if required by local regulations. In some field terrains (e.g., hills, slopes, etc.), this might require they venture along the side of the field or be slightly downwind of the UASS, which in general, should be avoided, but in the case that this is not possible, proper PPE must be worn

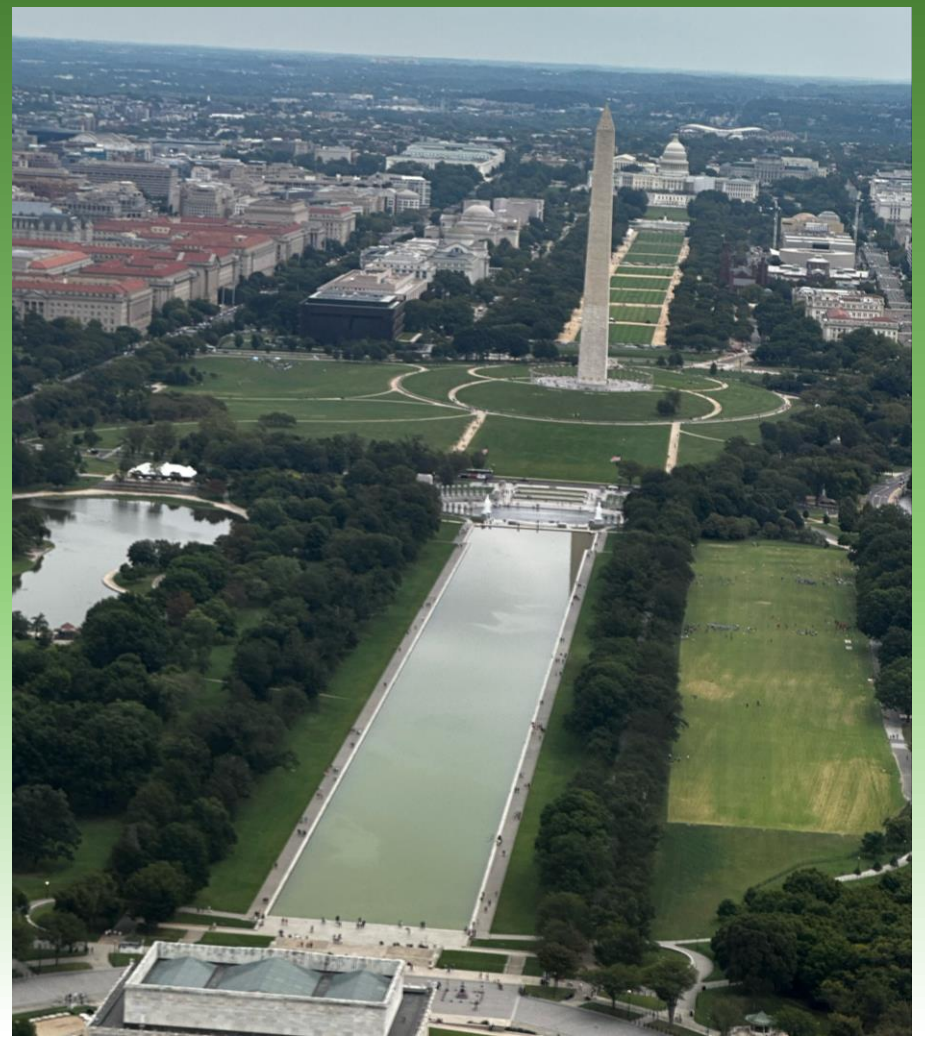
CHECKLIST WHEN MAKING PESTICIDE APPLICATIONS USING UASS

During and After Application

- When the spray operation is completed for the day, the application equipment must be cleaned and residues removed internally and externally, again by following the label including wearing proper PPE.

Follow local regulations for safe transporting of the UASS and chemicals

Regulatory Considerations and Landscape of Application Drones



Many Stakeholders Are Active in UASS Forums

Cross-talk is encouraged to maintain efficiency and effectiveness

*(*not exhaustive)*

USA

- Auburn University End-user Conference
- CropLife America(CLA) Drones Working Group (DWG)
- American Chemical Society (ACS) Reoccurring Drones Session
- Pesticide Educational Resources Collaborative (PERC)
- American Society for Agricultural and Biological Engineers (ASABE)
- Virginia Tech Mid-Atlantic Drone Conference
- Association of American Pesticide Control Officials (AAPCO)
- American Society for Testing and Materials (ASTM) Drone Task Force
- Pesticide Program Dialogue Committee (PPDC) Emerging Technology Work Group
- Center of Excellence for Regulatory Science in Agriculture (CERSA) Drones Workshop
- Remote Pilots and Aerial Applicators Association & Workshop (RPAAS/RPAAA)

Europe

- European Precision Application Task Force (EUPAF)
- JKI (Germany)
- DronSafe (Spain)
- BVL/Agroscope (Switzerland)
- PhytoDron (Spain)
- ICAERUS (Greece)

Africa

- CropLife Africa & Middle East

Global

- Organization for Economic Cooperation and Development (OECD) Working Part on Pesticides (WPP) UASS/Drone Subgroup
- CropLife International (CLI)
- International Standards Organization (ISO)
- Unmanned Aerial Pesticide Application System Task Force(UAPASTF)
- Food and Agriculture Organization (FAO) of the United Nations (UN)

Asia

- CropLife India Workgroup
- CropLife Asia Workstreams
- Agricultural Drone Association (New Zealand)

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Application drones are usually regulated by at least two government agencies, and more depending on local considerations

- National **Aerial** Regulatory Authority
- National **Pesticide** Regulatory Authority
- Additional Local Requirements (e.g., State, Province, County, Tribe, Municipalities, etc.)
- Usually depends on your drone weight/size

Different Regulatory Pathways are Considered for Pesticide Application by Drone

- Examples
  - No separate pathway – but fully incorporated (e.g., China)
  - Individualized pathway for application drones-specifically (e.g., Japan)
    - Drone application as part of product labels
    - Potential for other options to consider here (e.g., utilizing the outcome of what drones help to achieve as a mitigation measure – e.g., lower environmental/human impact)
  - Drones as part of crewed aerial framework following label instructions for those uses (often an interim solution) – (e.g., USA)
    - Potential challenge to adapt existing aerial label language to drone use, specifically, for end users
  - No allowance for pesticide applications with drones (e.g., until regulatory data needs are met) – (e.g., Canada)

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Authorities are generally looking to data on the areas identified in the OECD "State of the Knowledge" Report to inform regulatory frameworks

- Drift/offsite movement

- Operator exposure

- Crop residue

UAPASTF Technical Teams are Actively Working on Data/Information Generation in These Key Areas

- Off-site movement GLP study protocol & trials (Frank Donaldson, BASF) → *2023 & 2024 trials complete, data submissions planned*
  - Environmental / Ecological Exposure Subteam, database, and modeling (Naresh Pai, Bayer Crop Science) → *work underway*
- Occupational / Applicator / Non-dietary Exposure Subteam (Edgars Felkers, Bayer Crop Science) → *operator exposure survey being planned*
- Field crop residue project – Agriculture & AgriFood Canada (Greg Watson and Sheila Flack, Bayer Crop Science) → *2024 studies complete, data analysis in progress and initial data reported*
- 'Best practices' guidance (Hector Portillo, FMC) → *version 1.0 complete*

Visit the UAPASTF Website Periodically for Updates

https://uapastf.com/

Global regulatory landscape of UASS application technology

North America

USA: EPA defers to states provided aerial application is allowed on the federal label

CAN: Some registered labels for UASS, overall policy being developed

Latin America

BRA, CRI, URY, ARG: UASS application is allowed once aerial application is already approved on the label

GTL, COL: Some UASS application permitted

MEX: Some UASS application permitted, regulation under discussion

ECU, PER: UASS application not allowed Regulation under discussion

Europe, Middle East, Africa

EU: Mostly aerial application banned except with specific exemptions

HUN, CZE: UASS applications allowed

DEU, TUR, UK: UASS application allowed for specific applications

ESP, GRC, ITA, FRA: Strong interest

Other Europe:
CHE: UASS application allowed for specific applications

GBR: Strong Interest

Africa:
Ghana: UASS application allowed

Burkina Faso (BFA), Ivory Coast (CIV), Kenya (KEN), Zambia (ZMB), Zimbabwe (ZWE), Malawi (MWI), South Africa (ZAF): Strong interest

Asia Pacific

JPN, KOR: Most advanced countries for regulations on UASS and applications allowed

CHN: Leading drone platform innovation (XAG/DJI). Largest acreage globally treated by UASS. Regulation under discussion.

MYS, PHL, IND, TWN: Regulations in place.

THA, IDN, VNM: Commercial use permitted/permitted soon while guidance is developed in parallel

AUS: UASS application allowed under aerial framework

PAK, MMR: Regulations under development

Information not intended as legal guidance

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Best Practices for Safe and Effective Application of Agrochemicals Using Unmanned Aerial Spray Systems (UASS)

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- Certification and Licensing to apply pesticides using UAVs: select countries examples
- Pesticide safety: Mixing, loading, spraying, cleaning and maintenance

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- Selection of equipment: UAV, nozzle/atomizer type, flow rate capacity for required water volume
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- Tank mix: water quality and temp, adjuvants, buffers, compatibility, order of addition, suspensibility etc.
- Label requirements

ENVIRONMENTAL CONDITIONS

- Preferred conditions: wind, temperature, relative humidity
- Marginal conditions: low or high winds, Surface temperature inversions (thermal inversion), rain
- Label requirements to avoid operator exposure and sensitive areas: water bodies, pollinators etc.

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Pre-flight Considerations

Pilot training and certification

- Pilots must be:
  - Professionally trained
  - Permitted
  - Qualified
- Operations must fully comply with local and federal authorities' regulations
- Receive all proper approvals if required

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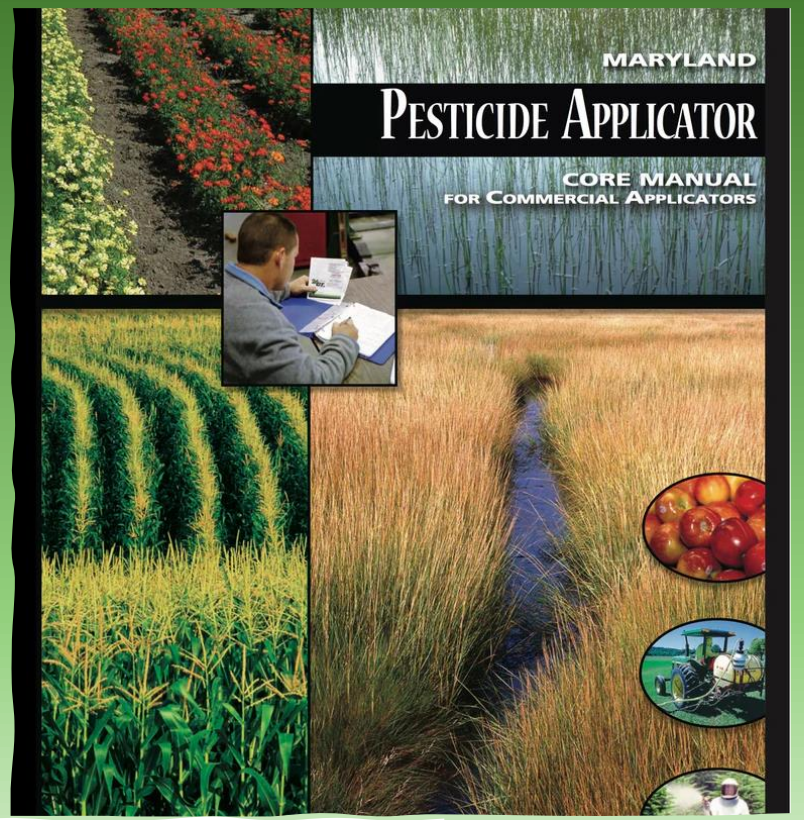
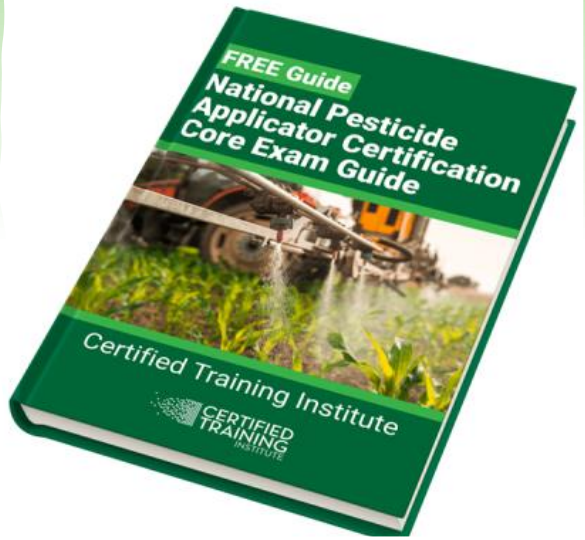
Pesticide Application Licensing and Training

- Ensure that you not only have proper license to fly but also to apply pesticides aerially
- Follow all regulations and requirements put in place by local ag and environmental institutions





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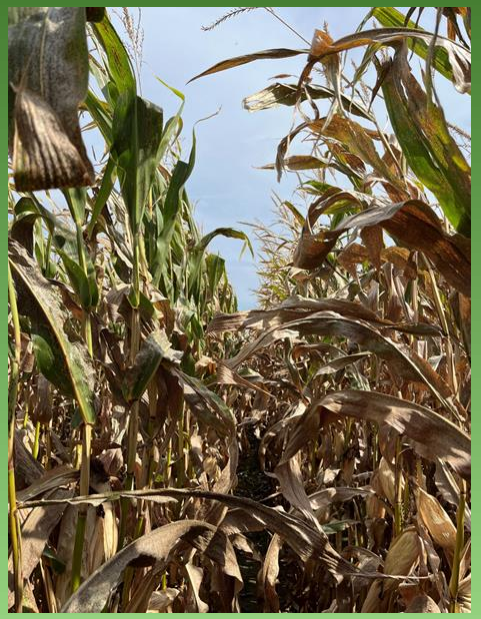
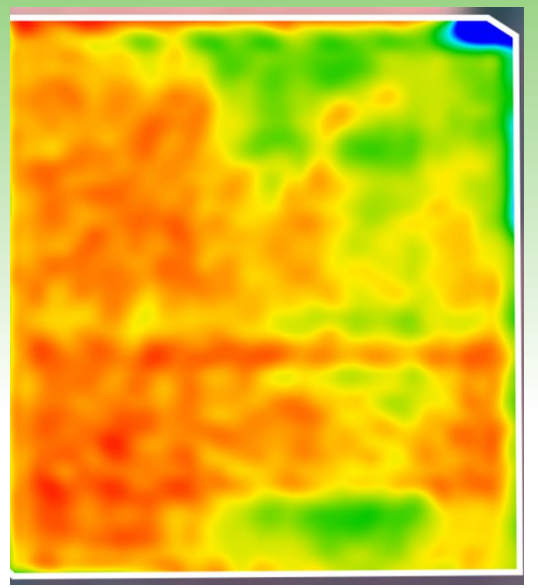
Sound Agronomic Decisions



- Ensure application decisions are based on IPM principles, and the pest is present and at a level where control is possible
- Ensure application via UASS makes sense
- Ensure you always follow label requirements to ensure a safe and effective use of the product(s)

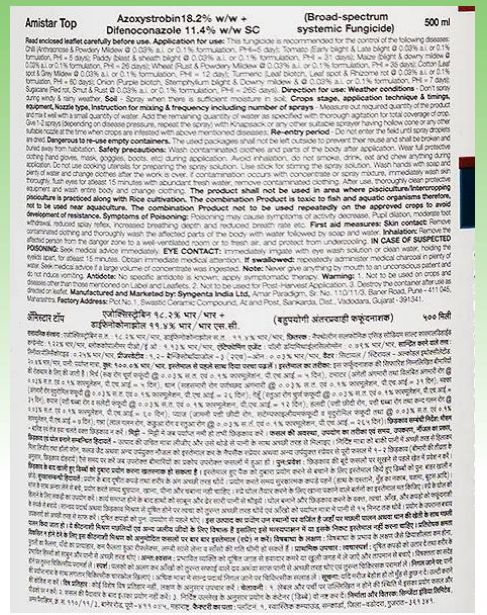


Pesticide Labels & Handling

- Ensure the desired product is allowed to be applied by UASS
- Always read and follow label requirements
  - Proper PPE
  - Proper use rates & application volumes
  - Application timing
  - Potential buffer zones
  - Impact on non-target organisms
  - Potential restrictions in place

- Understand compatibility and the proper handling of all products that may be going into the tank mixture

- Select the proper equipment to handle the intended application



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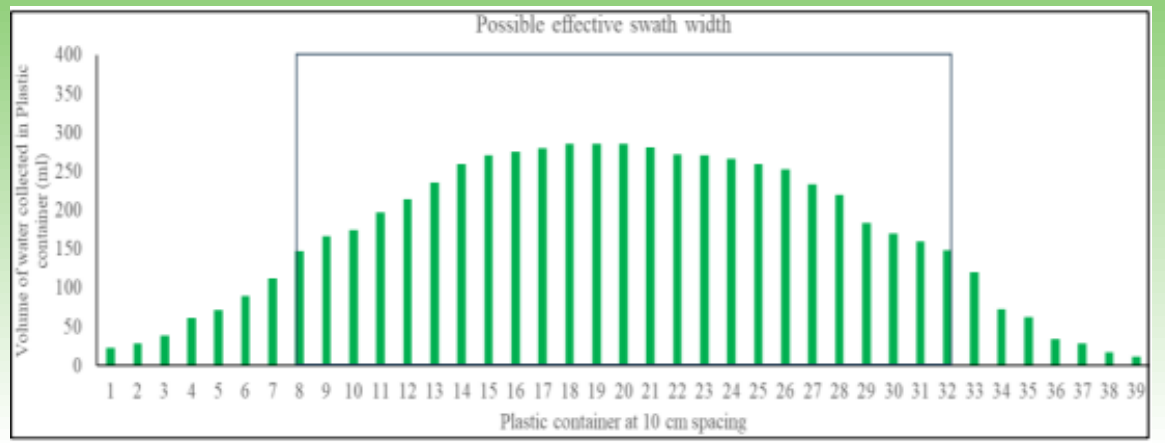
Equipment Calibration

- Three major factors influencing application
  - Ground speed
  - Effective swath width
  - Flow rate
- Calibrations are recommended:
  - Before the start of the season
  - Prior to starting a new job with new equipment settings
  - When changes or repairs are made to the drone
  - As deemed necessary by the operator



Verify Application Parameters

- When a calibration or re-calibration is done application parameters should be tested
- Utilizing water sensitive paper or receipt paper with blue dye you will want to evaluate that the coverage and deposition are uniform and will deliver the desired result

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Pre-flight check

- Follow the drone manufacturers pre-flight check list before making any application
  - Walk around of the aircraft for inspection
  - Ensuring connectivity is secured
  - Crew briefing
  - Site assessment

Pre-Flight Checklist

Pilot in Command:		FAA Reg. No.:	Date:
Observer (Optional):		Location:	
UAS Model: DJI Phantom 3 Pro			

Purpose of Flight (check 1): ☐ Recreation ☐ Commercial[1] ☐ SAR[2] ☐ Other (Describe):

NOTES: (1) - Commercial sUAS license required. (2) - Authorization by applicable authority required.

Authorization for flight in restricted airspace (Required for flight in restricted airspace only, otherwise N/A)

Authorized by: _____ Title: _____

A. Pre-Start Checklist

Important: Complete all check list items in the order they are presented. If any normal check-off can't be met, STOP! and correct the problem before continuing.

No.	Item	Acceptable Condition	Sat.
1	Airspace	Unrestricted airspace or flight authorized Potential obstructions near intended flight path identified	
2	Weather	Visibility >=3 miles(500 ft., Wind <=15mph, Precip. - None	
3	sUAS Airframe/Props	No structural defects visible	
4	sUAS Battery	Sufficient for intended flight, not less than 75%	
5	Controller Battery	Sufficient for intended flight, not less than 75%	
6	Display Device Battery	Sufficient for intended flight	
7	Memory Card	Installed, sufficient memory space available for flight	
8	Observer	Present, briefed and ready (Only if required, otherwise NA)	
9	Camera Gimbal Lock	Removed	
10	Display Device	On	
11	Controller Power	On	
12	sUAS Power	On	
13	sUAS Strobe Lights	Flashing GREEN	
14	Camera Check	FPV camera view normal	
15	Compass Calibration	Compass calibrated for current location	
16	Flight Limits Set	Alt. <=120 meters, Dist. <=500 meters	
17	Flight Mode Set to GPS	Controller mode switch in "P", display status GREEN - RTF	
18	Take-Off Location	Clear for >=25ft. radius, no overhead obstructions	

B. Motor Start Checklist

No.	Item	Acceptable Condition	Sat.
1	sUAS Motor Start	sUAS motors start and run at idle, no abnormal noise	
2	Home Point	Home Point Set	
3	Hover Check	Flight and Camera Gimbal control responses normal	
4	Flight Telemetry	Telemetry normal (Alt, Alt Dist, etc.)	

READY FOR FLIGHT

Notes:

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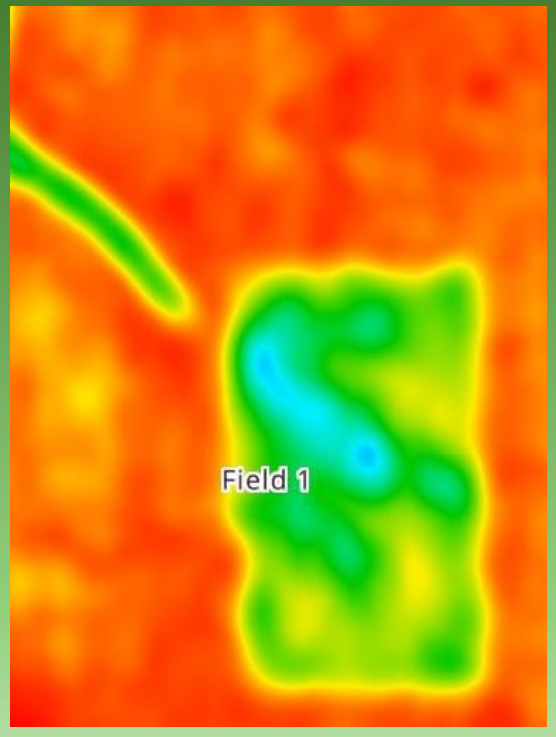
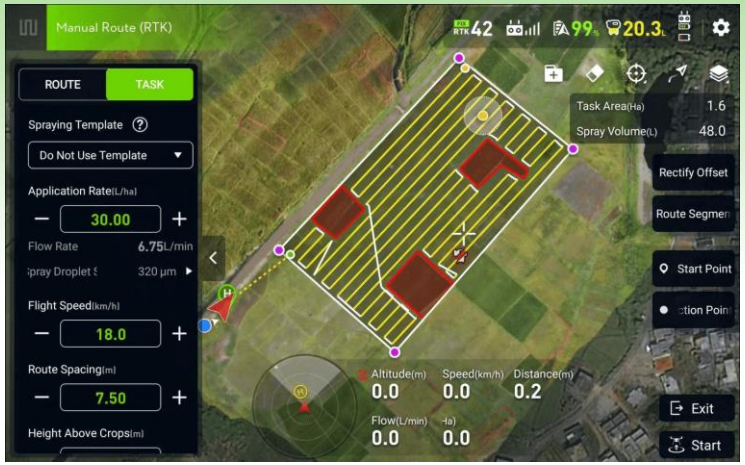
Site Preparation



- Survey and map the application area and identify any potential risks or hazards
  - Waterways & Natural habitats
  - Livestock, Pollinators and Adjacent crops
  - Roadways and Powerlines

- Based on calibration results set drone parameters to meet your application requirements:
  - Swath
  - Target volume
  - Forward speed
  - Height above target
  - Droplet size



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During Application

During Application

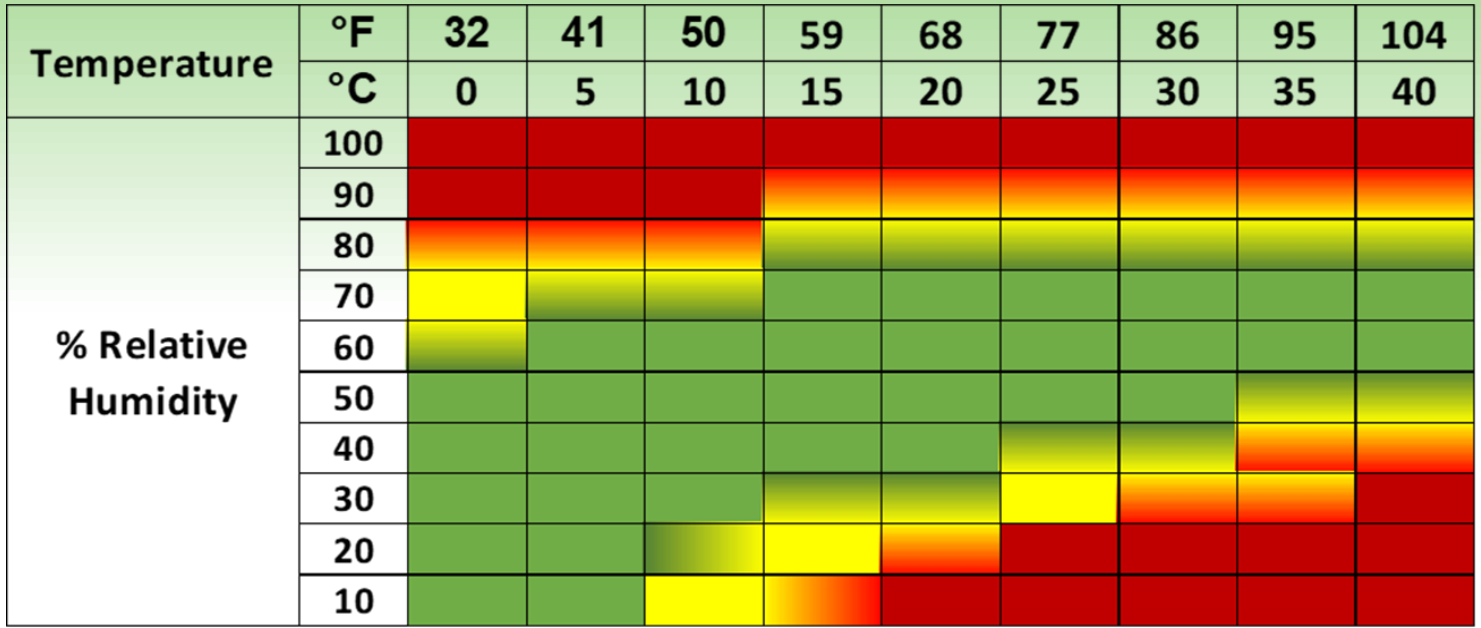
- During an application, monitor spray for any equipment malfunction or problems (loss of power, rotor failure, clogged nozzle/atomizer, leakage etc.)
- Track wind direction and speed change to reduce off-target movement, monitor temperature and air humidity to avoid inversions, and stop aircraft (and spray systems) immediately if a problem is detected.
- Taking breaks as needed and avoiding fatigue during operations is important.

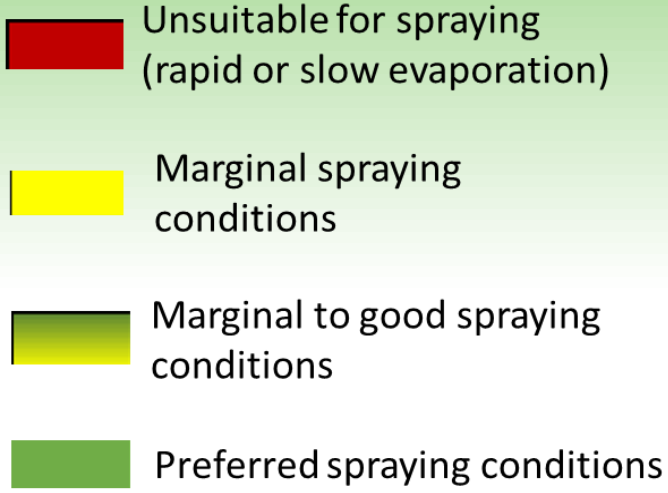
Weather conditions

- Weather conditions change throughout the day, and can significantly alter pesticide performance (and UASS performance)
- Conditions to monitor throughout the day include:
  - Wind speed/direction
  - Precipitation
  - Temperature
  - Relative humidity

Temperature/Humidity

- Applications at low relative humidity and high temperature conditions have greater risk of poor spray coverage and increased drift due to increased evaporation
  - Increase droplet size
  - Higher application volumes
  - Time the application in the morning or evening (keeping in mind local restrictions around flying in daylight only)
  - Certain drift reducing agents (refer to label)





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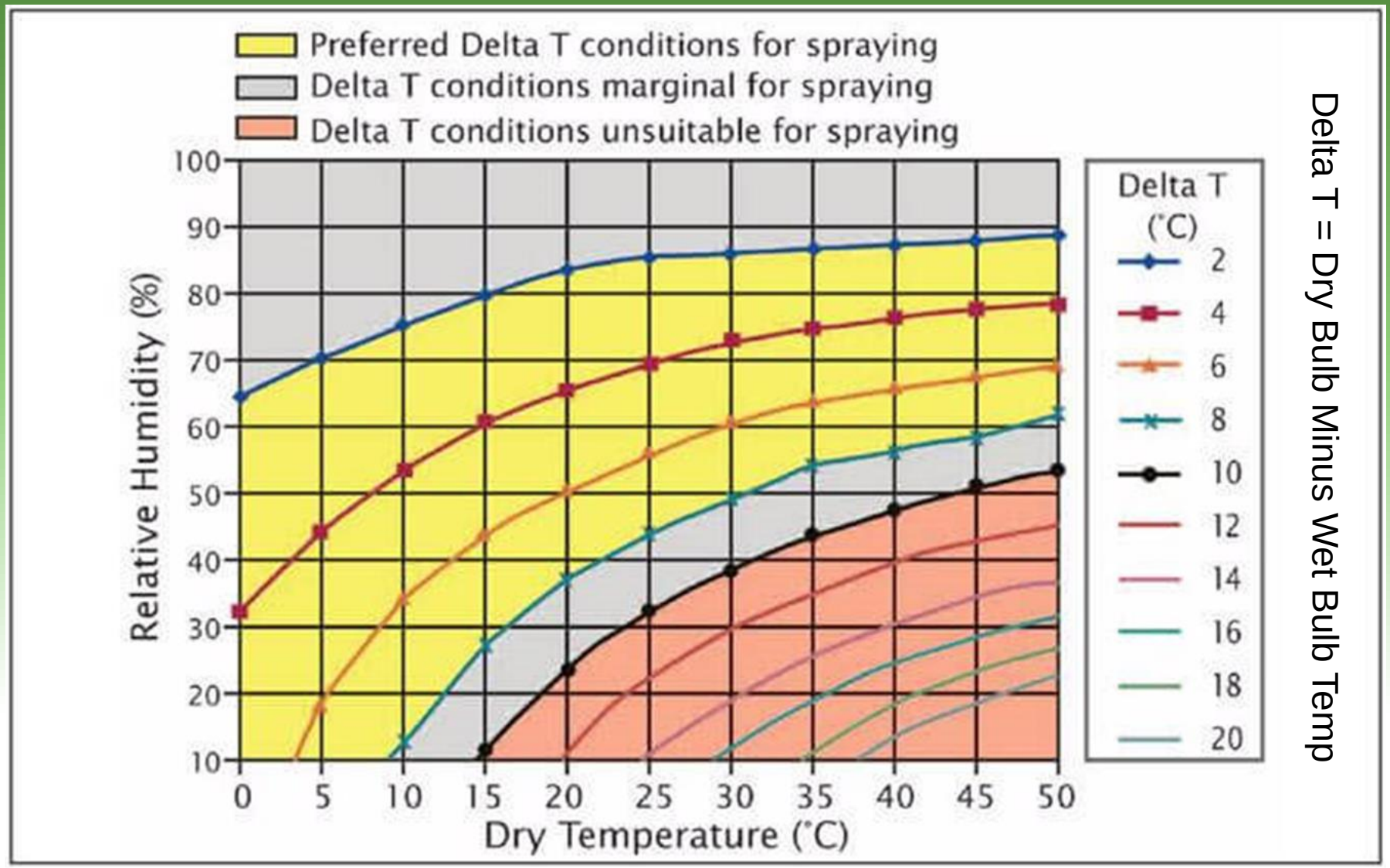

Source: Sprayers 101

Precipitation

- Be aware of the rainfast period on products being used
- If unexpected precipitation approaches, ground the UAV immediately to prevent damage

Wind and off-site movement

- Drift risk may be higher with drone/aerial application compared to ground
- Drift potential increases at wind speeds of less than 3 mph (5 kph, 1.4 m/s) (due to variable direction and inversion potential) or more than 10 mph (16 kph, 4.5 m/s).
- If high wind speeds are expected, compensate with larger droplet size, higher water volume rates where possible and addition of a drift reducing agent (where labels allow)
  - Some systems may not have the ability to easily/accurately change droplet size
  - Some rotary atomizer nozzles can easily switch from e.g. 60-400 microns
- High wind may also alter the flight dynamics of the UASS and be more restrictive- see manufacturer notes for specifics

Size Classification	Symbol	Upper Boundary		
		Nozzle	Pressure (kPa)	Flow Rate (L/min)
Extremely Fine	XF	IP-16 Impaction Pin	550	0.486
Very Fine	VF	TP11001	450	0.490
Fine	F	TP11003	300	1.175
Medium	M	TP11006	200	1.94
Coarse	C	TP8008	220	2.706
Very Coarse	VC	TP6510	120	2.529
Extremely Coarse	XC	TP6515	100	3.407
Ultra-Coarse	UC	-	-	-

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Wind and off-site movement

- During application, monitor and adjust spray parameters to the weather conditions
- Shut off spray nozzle/atomizers when making row turns or over irrigation ditches, washes, culverts, and other waterways.
- When spraying partial swaths, and if possible, shut off nozzle/atomizers that are not aimed at the target.
- Most commercial UASS platforms have terrain following capabilities. Make sure to activate the feature when spraying in uneven terrains for effective application and reduced drift.
- Follow the product label instructions carefully to make sure an application can be made that meets any restrictions around drift potential to sensitive non-target areas or organisms.
- Observe any no-spray buffer zones listed on the label

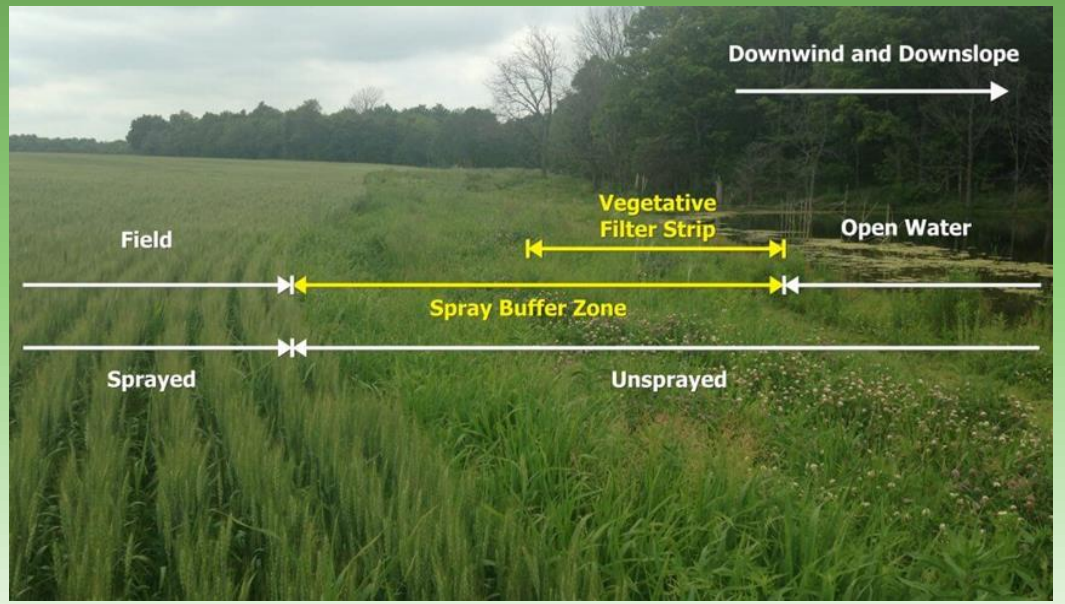
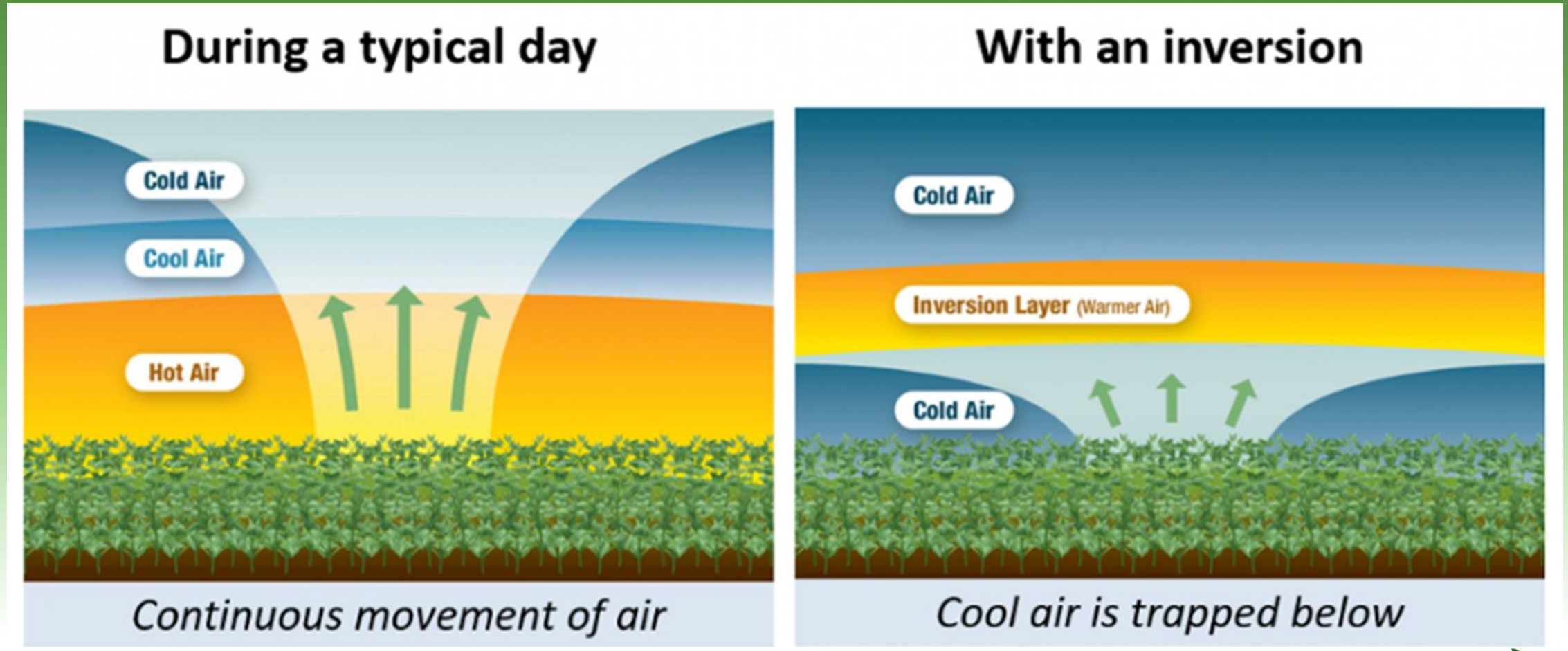


Photo source:
Sprayers 101

Inversions



- The result is the potential for drastic, unexpected movement of spray particles

Be on the Watch for Temperature Inversions | Integrated Crop Management (iastate.edu)

Inversions

- BASF made videos in Eastern Canada using colored smoke to visually simulate the movement of small invisible spray droplets during application in inversion and non-inversion conditions

https://youtu.be/HOOC-E0Whag?si=U_1FcP21gv_05Z8p

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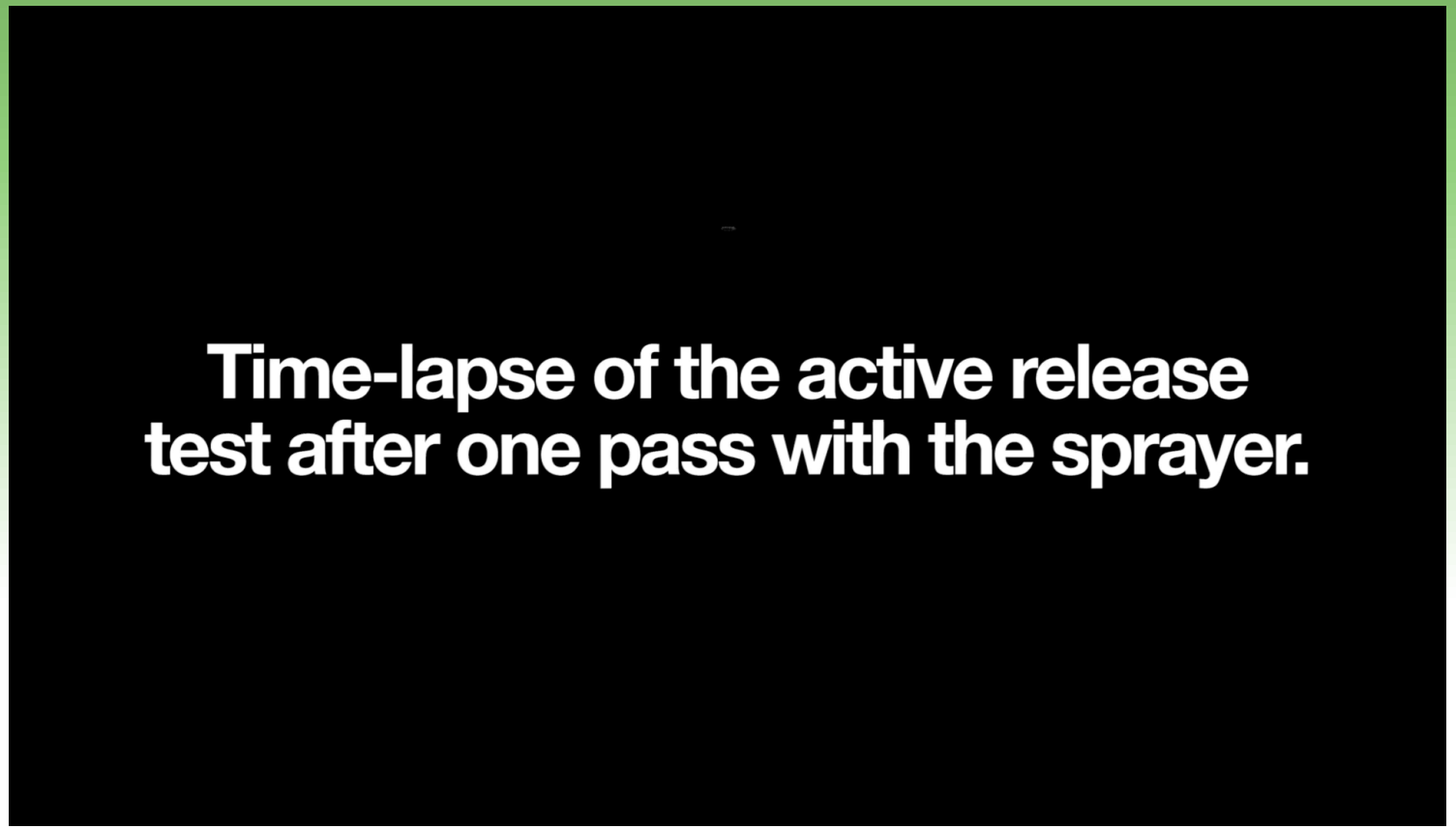
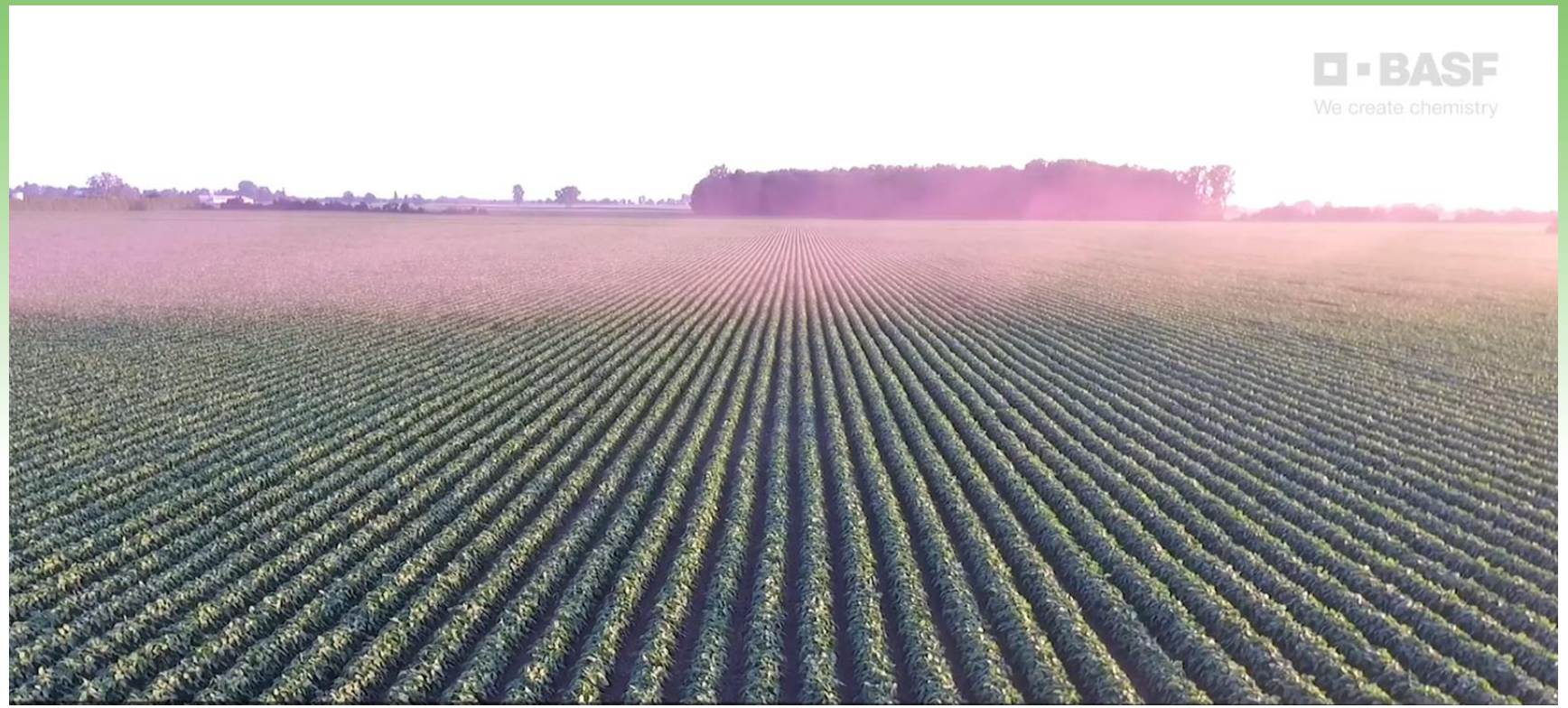


- In this example under inversion conditions, the smoke lasted over an hour, and drifted as far as 2.7 km (1.7 miles) away
- Instead of dispersing, the droplets hang around and are impacted by shifts in winds, movement of the sprayer, etc.
- Pesticide does not stay on target crop and has the potential to impact neighboring fields and natural habitats



Reloading of chemical/Battery checks

- Follow product label use directions and proper PPE to be worn for initial and subsequent mixing and loading procedures.

- If possible, prepare the spraying mixture in a nurse tank, away from sensitive areas, animals, people, etc., and use that mixture to refill the UASS tank when needed.
  - Saves time and reduce exposure to concentrated product, and ensures the product is fully dissolved or suspended.

- If mixing is done on-site, ensure the use of precautionary environmental safety equipment such as spill trays.

- When reloading chemicals, make sure before approaching the drone that the rotor is inactive, check battery charge level, and change batteries if needed (Start with fully charged batteries and have multiple recharged batteries available if possible).

- Change battery before reloading liquid in case of splashes on the power connecting part of the drone.

Photo: Sarah Hovinga

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Photos: nuWay AG, Sarah Hovinga

After Application

After application- Record keeping

- Adhere to all requirements mandated by regional regulations, if any, regarding record-keeping by professional users of pesticides.
- Local governments will have different regulations in regards to record keeping- the applicator is responsible for knowing and following the appropriate legislation
- Note that in some areas, there will be different regulations for pesticide application vs UASS record requirements

- For example, in Western Canada:
  - Flight logs must be retained for at least **12 months**
  - Maintenance logs must be retained for **24 months**

  } Transport Canada requirement

  - Pesticide application records must be retained for **5 years**

  } AB Provincial Pesticide Legislation requirement

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Record keeping

- Prior to leaving the application site, all records of flight activity and product application should be completed and delivered to the treated field owner and to the competent authorities, if required by regional regulations
- Flight records should include date and time of each flight, pilot in command, as well as battery usage and consumption for each flight
- Product applications should at a minimum include the following:
  - company name
  - date, time, location, and duration of application
  - crop type, crop growing stage, target insect, disease, weed, and/or other pest
  - applicator name and license number
  - name(s) of assistant(s) and role(s)
  - environmental conditions (temperature, wind speed, wind direction, relative humidity, soil type and moisture, cloud level and surrounding land use) and the height/location/equipment used to collect this information
  - drone equipment used, including model, configuration, nozzle/atomizer type, number, and angle, tank volume
  - operating parameters (height, forward speed, droplet size, spray angles, rotation rate for rotary atomizer types, spray pressure for hydraulic nozzles and flow rate)
  - product used and rate applied including how this was measured
  - total volume applied
  - total product applied
  - flight map of the area sprayed

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Example: Alberta Pesticide Legislation

Sample Record Form for Pesticide Application

Pesticide Applicator_____ Certificate #_____

Date _____ Time_____ Customer _____

Job Location (legal land description) _____Pest _____

Pesticide Name_____ PCP# _____

Application Rate _____ Area _____Total Amount Used_____

Application Method _____Crop/Vegetation Cover _____

Adjacent Sensitive Areas: None _____As Follows _____

_____

Damaged Vegetation (prior to application): None _____ or As Follows_____

_____

Environmental Conditions:

Temperature _____ Relative Humidity _____ Wind Speed _____
Wind Direction _____ Soil Moisture _____ Precipitation _____
Site Conditions (drainage, construction, erosion, etc.)

_____

_____

Application Within 30 Metres of An Open Body of Water? _____yes _____no

If YES, Legal Land Description of Open Body of Water_____

- Special Use Approval Number:_____ OR
- Application according to Environmental Code of Practice for Pesticides _____

FOR APPLICATIONS ACCORDING TO THE CODE - COMPLETE A SEPARATE RECORD KEEPING FORM DETAILING THE RESTRICTIONS OBSERVED IN THE 30 METRE ZONE OF AN OPEN BODY OF WATER.

PESTICIDE APPLICATION RECORD WITHIN 30 METRES OF AN OPEN BODY OF WATER (OBW)

(NOTE: Do not use without first completing the Sample Record Keeping Form)

General Weed Control:

___ only Prohibited Noxious or Noxious Weeds Sprayed

___ brush Interfering with Water Flow _____ height of brush

___ backpack use only ____ Handgun use only ____ Single stem application

___ no more than 10% of vegetation sprayed in zone1-5 metres from OBW

___ no more than 30% of vegetation sprayed in zone 5-30 metres from OBW

___ in Green Area: Name of Land Manager Notified _____

Purple Loosestrife Control:

_____ no closer than 1 metre from standing water

_____ no more than 10% of land within 100 square metres sprayed

Forest Regeneration Sites:

___ glyphosate not deposited within 5 metres from OBW

Non-vegetated Developed Area:

___ trails ___ roads/parking lot/yards ___ railway ballasts ___ industrial site

___ glyphosate applied

___ imazapyr deposited no closer than 15 metres of OBW

Shoreline Rip-Rap

___ glyphosate applied no closer than 1 metre from OBW

___ no more than 30% of vegetation sprayed within any 100 square metres

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Sample combined flight log and maintenance log

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Airframe Serial	Date	Location	Airworthy?	Time Start	Time End	Flight Time	Takeoffs	Landings	Battery Serial	Maintenance Action(s) Performed	Pilot in Command	Visual Observer	Person Conducting Maintenance
2	583EF2122	2/3/2022	CYNJ	☐	8:00:00 AM	8:30:00 AM	0.50	4.00	4.00	11425R	none	Sample Pilot	Sample Observer	
3	583EF2122	2/3/2022	CYNJ	☐	9:45:00 AM	9:55:00 AM	0.17	1.00	1.00	11434B	Replace Front Right Propeller	Sample Pilot	Sample Observer	Sample Pilot
4				☐			0.00							
5				☐			0.00							
6				☐			0.00							
7				☐			0.00							
8				☐			0.00							
9				☐			0.00							
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Source: coastaldrone.co

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Cleaning and Maintenance

- Tank cleaning is important! Small quantities of residues in a tank/lines/filters can damage crops in subsequent applications (especially with herbicides when switching crops)
  - Problem can be magnified in a small UASS tank
- Spray tank and drone exterior should be cleaned after each use to remove residues, and flushed thoroughly with water at the end of each day's spraying (at a minimum)
- Cleaning a UASS after use would be similar to cleaning a backpack and other small tank sprayers and typically would follow a triple-rinse procedure.
  - Ideally the UASS spray tank is removed (if model does not have a fixed tank), filled one-quarter the way with clean water, replace lid, agitate to ensure coverage of all interior walls and dispense into appropriate treatment or disposal area
  - Repeat for 3 rinses (rinse may include a specific cleaning agent- see product label for guidance but in general):
    - Water and detergent for water-based sprays
    - Suitable solvent for oil-based sprays
- Cleaning and maintenance of spray nozzle/atomizers, pumps, and tubes would be treated similar to those procedures followed with backpacks and other small tank application methods.
- After cleaning, check all equipment for any potential repairs or maintenance needs required before the next application.

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Photo credit: https://www.cropscience.bayer.ca/articles/2022/sprayer-tank-clean-out-tips

Cleaning and Maintenance

Other UASS specific instructions:

- Do not power wash drone exterior as water can be forced into electronic parts causing malfunction
- Follow any additional instructions provided by your UASS manufacturer or supplier, such as monitoring the integrity of plastic tanks
- On UASS with fixed tanks, a similar triple rinse procedure can be followed, and the rinsate can be sprayed out in an appropriate area for disposal.
- Ensure rotary atomizers are clear of debris (where appropriate)
- Ensure the unit is fully powered down before approaching for cleaning

Conclusions

UAPASTF Final Considerations

- Not our intention to make this a standard (for example ASAE) but the UAPASTF BMPs could be utilized in works towards standards
- Because standards haven't yet fully captured best practices for evolving UASS uses (e.g. models, countries, and uses) these BMPs are general and meant to be a starting point
- Can be used as guide to expand on local BMPs
- The registered and current product label should ultimately be followed above any other source of information
- This document is not endorsed or approved by any other organization besides the UAPASTF

Unmanned Aerial Spray Systems (UASS):

Start Here for Best Practice Resources

UAPASTF

Drone Pesticide Application is Unique and Growing in Popularity

- Changes in UASS technology and regulations are happening rapidly.
- UASS has broad global appeal, with uptake examples in all four regions of the world.
- Regulatory frameworks and best practices are available and will differ based on the local situation.

Best Management Practices (BMPs) and UASS

- Pesticide application requires expertise and stewardship for proper use and safe handling, especially with a new technology like UASS.
- BMPs increase the likelihood of good environmental and operator practices while considering economic factors, availability, technical feasibility, and effectiveness.
- The BMPs provided here are intended to supplement information on the local product label. The registered and current product label should ultimately be followed above any other source of information. Readers should therefore ensure that this guidance is adapted or supplemented by other country/state/region specific needs, conditions, laws, and regulations, as relevant, including official and required aviation training, to ensure safe operations, which may not be explicitly mentioned on pesticide labels.

Purpose and Scope

- This BMP document intends to provide general guidance on best practices for the safe and effective application of pesticides when using UASS primarily for agriculture. The following areas are discussed:
  - **Current licensing regulations in key UASS markets**
  - **User safety in the context of pesticide handling**
  - **Equipment set up and calibration parameters that impact spray deposition while reducing off target movement (drift), including impact of equipment selection and environmental conditions**
- Because changes in UASS technology and regulations are happening rapidly, this document is intended to be updated regularly to ensuring the guidance and references within stay relevant.

While this is an exciting space, it should also be noted that in many geographies, UASS represent a complementary application technique to existing methods, and further understanding of their unique value and best local practices will help position their use appropriately and more effectively.

The Unmanned Aerial Pesticide Application System Task Force (UAPASTF) consists of the pesticide member companies: BASF Corporation, Bayer CropScience LP, Corteva Agriscience LLC., FMC Corporation, Gowan Company LLC, Nufarm Americas, Inc., Syngenta Crop Protection LLC, and Valent U.S.A. LLC. The UAPASTF, convened by industry, generates, submits, and/or shares/provides access to information and data to governmental agencies to address limitations in available regulatory information and to support risk assessment.

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