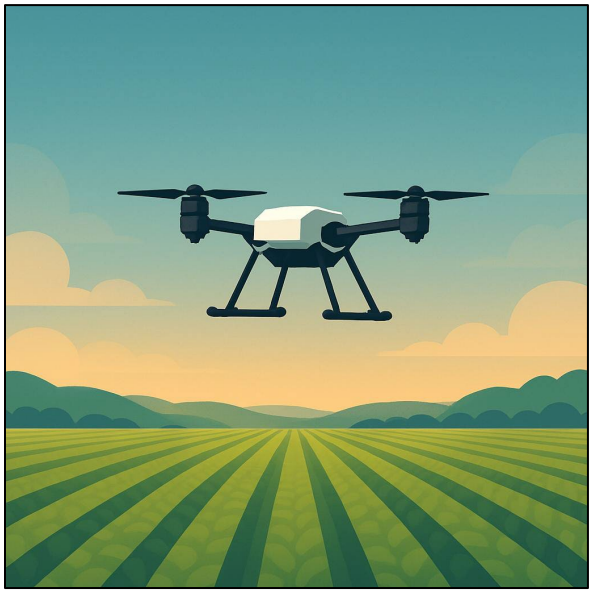
Report from the Pesticide Educational Resources Collaborative (PERC) Unmanned Aerial System (UAS) Task Force (Phase 1)

Recommendations to the PERC Advisory Board for Training Materials for UAS Applicators



PERC
Pesticide Educational Resources Collaborative

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Key Terms and Acronyms

AAPCO: American Association of Pesticide Control Officials.

AAPSE: American Association of Pesticide Safety Educators.

ASABE: American Society of Agricultural and Biological Engineers

ASTM: American Society for Testing and Materials.

BMP: Best management practices.

Calibration: The process to measure the output of pesticide application equipment so that the proper amount of pesticide can be applied to a given area.

CEU: Continuing education unit. States require licensed pesticide applicators to earn a certain number of CEUs within a specified time to maintain their state-issued credentials.

Drift: The movement of pesticide particles, spray, or vapor through the air away from the application site.

EPA: Environmental Protection Agency.

FAA: Federal Aviation Administration. This agency creates and enforces federal regulations that apply to pilots of both manned and unmanned aircraft, such as Part 107 and Part 137, referenced in this report.

FAA Part 107: The Small Unmanned Aircraft Systems Rule, which governs commercial drone operations in the US under the Federal Aviation Administration. It establishes guidelines for drone pilots flying drones weighing less than 55 pounds for commercial purposes.

FAA Part 137: The Federal Aviation Administration (FAA) regulations governing agricultural aircraft operations. These regulations outline the requirements for operating aircraft for agricultural purposes, such as applying pesticides, fertilizers, or treated seed.

FAA Section 44807: The Special Authority for Certain Unmanned Systems, which allows the Federal Aviation Administration to grant exemptions for drone operations that would otherwise be restricted under existing regulations. It is commonly used for beyond visual line of sight (BVLOS) operations, flights over people, and other commercial or industrial drone applications that do not fit within standard Part 107 rules.

FARs: Federal Aviation Regulations.

Hydraulic: Operated by the resistance offered or the pressure transmitted when a quantity of liquid (such as water or oil) is forced through a comparatively small orifice or through a tube.

NAAA: National Agricultural Aviation Association.

OECA: Office of Enforcement and Compliance Assurance. The law enforcement arm of the EPA.

PERC: Pesticide Educational Resources Collaborative.

PSEP: Pesticide Safety Education Program. PSEPs are run by the states.

Risk of concern: A known risk that can be reduced when applicators are educated properly on safety techniques and industry best practices.

Rotary atomizers: Devices where liquid spray is injected onto a spinning disk and the atomized particles are delivered in a spray to the target site. Droplet size is a function of the speed of the disc.

RPAAA: Remote Pilots and Aerial Applicator Association.

SLA: State Lead Agency.

Swath displacement: Lateral movement of the spray pattern away from its intended target area.

TPSA: The Pesticide Stewardship Alliance.

UAPASTF: Unmanned Aerial Pesticide Application System Task Force.

UAS: Unmanned Aerial System (also known as UAV [unmanned aerial vehicle], drone, or RPAAS [Remotely Piloted Aerial Application System]).

USDA: United States Department of Agriculture.

UAS Task Force (Phase 1) Recommendations to PERC Advisory Board for Training Materials for UAS Applicators

Task Force Goals

The Unmanned Aerial System (UAS) Task Force was convened under the auspices of the Pesticide Educational Resources Collaborative (PERC) to

1. Identify nationally applicable regulations, risks of concern and best practices related to the application of pesticides using an UAS
2. Determine what type of educational materials that may be useful to states, tribes, and territories with certification authority in order to properly certify applicators using an UAS for pesticide applications
3. Recommend learning objectives and content that could be included so certification authorities can assess potential applicators accurately

The PERC UAS Task Force

In July 2024, the UAS Task Force project was initiated. Dwight Seal was hired to chair the task force and develop a team of subject matter experts from the UAS industry. Individuals from academia, research, pesticide safety education, state regulatory agencies, pesticide registrants, the Federal Aviation Administration (FAA), certification and training organizations, UAS manufacturers, and companies that are licensed to apply pesticides by UAS were recruited. Table 1 lists the task force members and their affiliations.

Table 1: Task Force Members and Their Affiliations

Name	Affiliation	Constituents
Anonymous	EPA, OECA	EPA OECA Representative
Matt Beckwith	Guardian Ag	Applicator/ Manufacturer Representative
Dana Beegle	Virgina Tech Pesticide Program	PSEP and AAPSE
Amy Blankinship	EPA, OPP	EPA OPP Representative

Scott Bretthauer	NAAA Educational Representative/Previous PSEP Illinois	Director of Policy, Education and Safety with NAAA
Gary Buckner	WA State Department of Agriculture	AAPCO Technology Workgroup
Dirk Charlson	University of Nebraska-Lincoln	Pesticide Safety Education Program
Nathan J Davis	AAPCO, Office of Indiana State Chemist, Certification and Training Specialist, Purdue IOSC	AAPCO Technology Workgroup Chair
Sarah Hovinga	Bayer/CropLife America	Pesticide Registrant
Joel Jones	Orange Coast College	Educator Part 107/Applicator
Dan Martin	US Department of Agriculture	UAS and manned aerial Researcher
Eric T Ringer	Rantizo	NAAA's UAS, Safety and FARs, and Precision Agriculture Committees
Dwight Seal	UC Davis, North Carolina Department of Agriculture & Consumer Services (ret.)	Project Coordinator
Jennifer Thomasen	Bayer/The Pesticide Stewardship Alliance	Pesticide Registrant
John Watson	Wilbur Ellis	Industry Training
Jeramy Williams	American Drone	UAS Industry Representative

Summary of Task Force Findings

Our findings indicate that the use of Unmanned Aerial Systems (UASs) for pesticide applications is increasing in the US, despite the lack of limited educational materials and shared vocabulary, and, in many places, no dedicated pesticide applicator certification category for UAS operators. This situation leaves many states, tribes, and territories with limited means of assessing the competence of people using UASs to apply pesticides or comparing regulations to discover best practices across the regulatory landscape. Instead, certifying agencies are relying on the more conventional aerial applicator category certification, which fails to fully cover the training areas for assessing or certifying applicators for safe and effective applications of pesticides using an UAS. This Task Force has identified several target audiences who currently lack sufficient UAS training resources and standardized vocabulary, including:

- Aspiring pesticide applicators without experience as either pilots or applicators

- Aspiring pesticide applicators with experience as pilots but without application experience
- Experienced licensed pesticide applicators without experience as pilots
- Licensed aerial pesticide applicators who wish to add the UAS platform
- Professionals working in Pesticide Safety Education Programs, Cooperative Extension, regulatory agencies, and industry who are seeking reliable UAS training resources

Our findings clearly indicate that states, tribes, and territories need to create a dedicated pesticide applicator certification category for UAS operators due to the potential for risk to human health and the environment from misapplication of pesticides using such complex equipment. Establishing a new certification category will require the development of a common specialized vocabulary, study guides, and continuing education materials to support the proper education of this new class of applicators. The Task Force recommends that materials address federal and state regulations and teach industry terms and best practices to address the risks of concern identified in Table 3. Written study guides, a standardized glossary of terms, and continuing education materials such as webinars and in-person trainings will help regulatory agencies ensure that certified applicators:

- Ensure that they follow required laws and regulations in their work
- Understand how to reduce the risks to people and the environment
- Pass certification exams and maintain earned credentials for UAS operation through continuing education opportunities

In addition, the Task Force has found that UAS technology changes rapidly over time. Therefore, when possible, study materials for certification and continuing education should be offered in digital formats that can be updated quickly and easily by SLAs and affiliated organizations.

Detailed Task Force Findings

Target Audience

UAS applications are a relatively new phenomenon that is creating interest among pesticide applicators and others who are considering becoming UAS applicators. For the traditional ground and aerial applicator, the UAS has created a new platform and market for their business. A UAS can be used to reach inaccessible areas, areas with rough terrain, and unsafe areas in fields that are crossed by powerlines or are surrounded by trees. The Task Force observed that the manned aerial industry has adopted the technology very cautiously but has begun to see the advantages of the UAS in their business. The target audience the task force has identified includes:

- aspiring pesticide applicators without experience as either pilots or applicators
- aspiring pesticide applicators with experience as pilots but without application experience
- experienced licensed pesticide applicators without experience as pilots
- licensed aerial pesticide applicators who wish to add the UAS platform
- professionals working in Pesticide Safety Education Programs, Cooperative Extension, regulatory agencies, and industry who are seeking reliable UAS training resources

Table 2 lists a sampling of some common devices used by the more experienced members of the target audience, as identified by the task force.

Table 2: Examples of Some Common UAS Models Used by Applicators Today

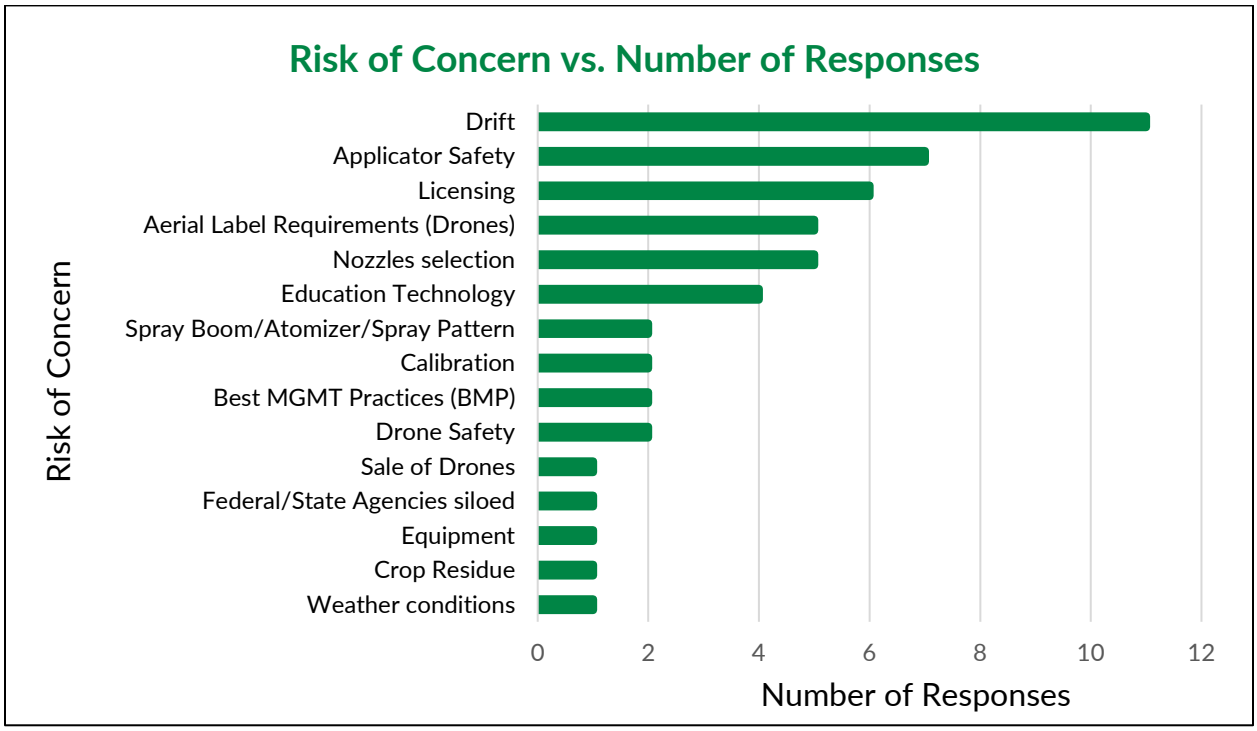
DJI models T10, T20, T30, T40, and T50 Rotary Nozzle	XAG models P150, P60, P100 Pro, P100, V50, and V40 Rotary Nozzle
Hylio 272 Hylio 230 Hydraulic Nozzle	PrecisionVision40X Type-Hydraulic Nozzle
EAVision J100 Rotary Nozzle	Guardian Ag Hydraulic Nozzle
Pyka Pelican Hydraulic (80-gallon capacity, fixed wing platform)	Ag Rotor Sprayhawk (110-gallon capacity, rotary platform) Not approved by FAA yet

As SLAs develop their licensing programs, there will be an additional audience for the educational materials we are recommending be developed: licensed UAS applicators seeking continuing education units (CEUs) to maintain their state-issued credentials.

Risks of Concern

Task Force members were asked to identify the risks of concern associated with UAS pesticide applications. Table 3 illustrates how task force members responded to the "risks of concern" poll.

Table 3: Risks of Concern Poll Results



Concern 1: **Drift.** Our members indicated that pesticide drift is the number one risk-of-concern associated with UAS applications. The offsite movement of pesticides by wind, temperature inversion, or volatilization is of paramount concern to pesticide handlers, since applicators can be held legally responsible for damage caused by pesticide drift.

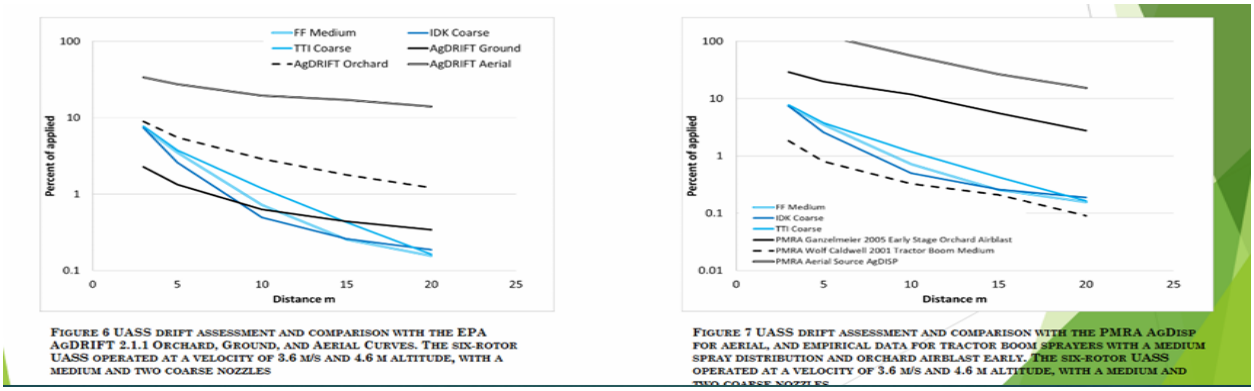


FIGURE 6 UASS DRIFT ASSESSMENT AND COMPARISON WITH THE EPA AGDRIFT 2.1.1 ORCHARD, GROUND, AND AERIAL CURVES. THE SIX-ROTOR UASS OPERATED AT A VELOCITY OF 3.6 M/S AND 4.6 M ALTITUDE, WITH A MEDIUM AND TWO COARSE NOZZLES

FIGURE 7 UASS DRIFT ASSESSMENT AND COMPARISON WITH THE PMRA AGDISP FOR AERIAL, AND EMPIRICAL DATA FOR TRACTOR BOOM SPRAYERS WITH A MEDIUM SPRAY DISTRIBUTION AND ORCHARD AIRBLAST EARLY. THE SIX-ROTOR UASS OPERATED AT A VELOCITY OF 3.6 M/S AND 4.6 M ALTITUDE, WITH A MEDIUM AND TWO COARSE NOZZLES

Bonds, Jane A.S., et al. "Spray Drift, Operator Exposure, Crop Residue and Efficacy: Early Indications for Equivalency of Uncrewed Aerial Spray Systems with Conventional Application Techniques." Journal of the ASABE, vol. 67, no. 1, 2024, pp. 27–41, doi: 10.13031/ja.15646

Concern 2: Applicator Safety. The second most concerning risk is the impact of pesticide applications on the applicator's personal safety. As with other pesticide applications, an accident during mixing and loading, spraying, reloading, or during cleaning and maintenance of UASs could cause irreversible harm to applicators. The limited amount of materials covering safe and effective UAS operation is currently putting applicators at risk.

Concern 3: **Insufficient Licensing Opportunities**. The lack of official pesticide applicator licensing for UAS operators is the third most concerning issue, according to the task force. The American Association of Pesticide Control Officials (AAPCO) recently polled state lead agencies, tribes, and territories to determine the prevalence of UAS licensing programs. They received 50 responses from across the US. Only 3 respondents indicated that their state had a licensing category for unmanned aerial application of pesticides. Of the three, only California requires both apprentice and journeyman licenses be acquired before a person can legally supervise or conduct pesticide applications for hire using an UAS. This lack of licensing programs is of great concern because it exacerbates the other risks identified by the task force.

Concern 4: **Lack of Clear Label Requirements**. The lack of label language for aerial application of pesticides using UASs is the fourth risk of concern listed by the task force. There exists only very limited language allowing UAS-specific applications. One possible interpretation is that if a pesticide label has no prohibition against aerial application, then a UAS application is not in violation of the label. This situation is not ideal because UASs differ in many ways from manned aircraft used to apply pesticides. Differences in speed, release heights, and nozzle types are not accounted for on current labels, which can worsen some of the other risks of concern indicated in Table 3.

EPA is working on developing a policy for UASs, in the interim, EPA notes:

- Applicators must follow any and all Federal Aviation Administration requirements applicable for a given drone/UAS being used to make a pesticidal application.
- Applicators may apply a pesticide product using a drone/UAS as long as these three conditions are all met:

(1) the product label does not prohibit aerial application or limits application to only a specific type of aerial application or to only ground application

(2) the drone application rate will be consistent with the application rates provided on the product label

(3) the application complies with all other directions for use and safety and precautionary language requirements EPA would normally expect to be complied with.

Other Concerns of Note: Many of the other risks of concern identified by the Task Force have to do with a lack of access to educational materials, including easy-to-access best management practices (BMPs) and vocabulary lists, that can be adapted by states, territories, and tribes to

meet the needs of UAS applicators. The ability to offer relevant continuing education to licensed UAS applicators is also important to ensure that the risks of concern are mitigated as UAS applications become more common.

There is also some confusion around the difference between federal and state regulations and how these differences affect state credentialling agencies, as well as a pilot's confidence when attempting to make safe, effective, and legal UAS pesticide applications. Addressing the lack of clear communication among various state and federal agencies using tools such as data-retrieval apps and an easy-to-access glossary of terms can help mitigate a number of the Task Force's identified risks of concern.

Task Force Recommendations to Address the Risks of Concern

Drift: Several factors can help reduce drift during a UAS pesticide application. As with ground or manned aerial applications, nozzle selection, calibration, height of release, droplet size, weather conditions, spray patterns, and system design are factors that can reduce or eliminate drift. BMPs for manned aerial applications are often applicable to UAS applications and should be followed.

Bonds et al, 2024, evaluated published literature studies and concluded that spray drift from UASs are within current application methods for ground and aerial. The authors acknowledge that this is based on limited data. Therefore, further confirmation and evaluation may be warranted to fully understand spray drift potential from UASs and how it compares to other application equipment. Further data generation (e.g., spray drift, operator exposure) will facilitate their fit into the regulatory risk assessment process.

We recommend that educational materials be developed to cover the unique attributes of UAS applications, such as lower aircraft speeds and unique nozzle types. For example, a typical UAS will not exceed 30 mph while spraying, and may hover during targeted applications (moving between 0 and 30 mph as needed). Such low speeds tend to eliminate wind shear on released spray which impacts the potential for spray drift, which would be addressed in more targeted educational materials. Additionally, many UASs are equipped with rotary atomizer nozzles, which may be unfamiliar to aerial applicators who are used to less complex nozzles. While not all these materials need to be created from scratch, new study materials should include information on how to select, maintain, and clean these and other common UAS nozzles to prevent drift and accidental misapplication. We also recommend that BMPs for the installation and use of rotary atomizers (fig. 1) be developed as well as materials covering specialized boom designs for hydraulic nozzles for UASs to help reduce the risk of drift and other forms of pesticide contamination.

Fig. 1 UAS using rotary atomizers

Applicator Safety: The use of UASs for pesticide application is rapidly evolving and is a very promising new tool for growers. We believe that the use of UASs for pesticide application will benefit from the kind of standardization in technique and process (that is, the adoption of BMPs) we have seen with other pesticide application devices and methods, such as the wide use of closed loading, mixing, and transfer systems to protect pesticide handlers from exposure. Supporting the development of UAS-specific BMPs to reduce exposure potential is a valuable approach as the technology and use of UASs becomes more standardized.

Documenting the various processes involved in making pesticide applications using a UAS is critical to determining potential sources of exposure and subsequently developing the BMPs applicators can use to increase job safety. Typically, UAS pesticide applications are performed by teams consisting of a pilot and assistant. We recommend documenting the processes for the following four jobs as a good first step in the development of a comprehensive study guide for the licensing of UAS applicators:

1. initial mixing and loading
2. spraying
3. subsequent mixing and loading
4. equipment cleaning and maintenance

Recommendations on how to minimize exposure potential during these jobs through training, engineering controls, work practices/work organization, and PPE use should be developed as BMPs, and should be included in any study material developed for this license category. The Unmanned Aerial Pesticide Application System Task Force (**UAPASTF) BMPs** cover these issues well, but there are some areas where more detailed practices should be developed. We recommend developing more detailed and specific content around:

- PPE use by the pilot (applicator) and crew
- equipment contamination reduction (end of life, repairs)
- interactions with bystanders during a UAS pesticide application
- contingency planning for accidents, crashes, and spills when applying by UAS
- safe and effective tender trailer builds for UAS applications
- preapplication batch mixing of pesticides for UAS applications
- post-application equipment cleaning techniques at the application site

The differences between manned and unmanned applications are numerous and must be addressed by including instructions covering all aspects of UAS safety. One of the major differences between manned and unmanned aircraft is that a UAS typically never leaves the field during the application. All turns and spray releases are within the confines of the field and no taxiing is performed from a landing zone, as with a fixed wing aircraft. This information may not be well understood by entry-level pilots in this space.

Overall, the task force identified a need for educational materials aimed at assisting UAS operators on pesticide application techniques unique to an UAS. As a starting point using available resources, we recommend using Dr. Whitford's book, The Evolution of Spray Drones: Their Capabilities and Challenges for Pesticide Applications as the national UAS category study manual (see Appendix C for sample content). **The manual is now available for purchase on the Purdue Edustore website**. And, since some of the current practices covered in manned applications are applicable to the UAS industry, the latest edition of the National Aerial Applicators Manual can also be used to educate UAS applicators. Because there are differences between the two platforms, the Task Force identified data gaps in the existing educational materials in the recommendations to the PERC Advisory Board. We also recommend creating a web-based glossary of terms to help beginners learn the basics of UAS technology and operation. This glossary will help mitigate both safety concerns and the problems with label reading comprehension discussed below.

Licensing: Based on the author's observation, licensing of UAS applicators has been a priority of SLAs since UAS technology emerged 8 years ago in the US. FAA and SLA personnel are responsible for assuring that anyone applying pesticides by UAS is properly certified and licensed to do so. The FAA is consistent nationwide, however, with 50 states plus numerous territories and tribes, local licensing requirements for pesticide applicators can vary considerably. States typically have an aerial methods exam, core exam, and a specialty exam that an applicator must pass to become a certified and licensed pilot. Most states do not have licensing exams established for UAS pilots, and the differences between state and federal regulations have often been poorly communicated, according to Task Force members who are familiar with local and federal regulatory agency policies and procedures. In order to address this concern more fully, we recommend developing a digital tool (a mobile or web-based app) that will help applicators find the regulations they must follow to make legal UAS applications in their state or territory. This tool could also serve the public and federal and state regulators who are interested in comparing the regulations developed in various places across the US, which will help reduce issues with siloing among federal and state regulatory agencies. The tool should be able to search for and display the relevant regulations from a given state, as well as compare regulations from various federal and state regulatory agencies. For more about specific federal regulations that pertain to licensing of pilots, please see "Key Terms and Acronyms" or review the more detailed information provided in Appendix A.

The issue of most concern to the Task Force in the area of UAS applicator licensing is the siloing of agencies involved in the process. This siloing results in federally licensed aerial applicators with

little knowledge of state pesticide regulations and no state-issued applicator credential. The problem became obvious when states began referring aerial applicators in search of widely accepted credentials to FAA websites and Field Safety District Offices. Because of the increase in people seeking federal certification, the FAA created an online application. This new option streamlined the process, and certificates are now typically issued within 180 days. The result has been a sharp increase in the number of UAS pilots with federal, but not state, credentials in the past year. Therefore, the Task Force recommends that SLAs move quickly to create meaningful training and informational resources (such as lists of common terms and BMPs), preferably in easy-to-update digital formats, to address the lack of specific, localized education provided to these pilots. We also recommend that PERC coordinate the creation of an exam question bank for SLAs and their partners to use for building licensing exams in this category.

Label Language: It is the understanding of the Task Force that EPA is currently evaluating what and how best to address potential UAS specific label language, however, as a group, the Task Force believes that pesticide labels should contain specific directives to UAS applicators. The Task Force hears that industry experts tend to believe labels with non-food uses will be the first to include label language for unmanned systems. As mentioned earlier, we have identified a lack of UAS-specific language on most of the pesticide labels that allow for aerial applications. “The label is the law” is cited by regulatory agencies, but if there is no prohibition against aerial application, a UAS application is not in violation of the label. States have in their laws and regulations that aerial applications by any method are prohibited if a label does not specifically state that aerial applications are allowed. How FIFRA 2ee fits into this type of application could be considered. Because labels do not specify how and when to use a UAS for applications, UAS operators must make assumptions based on existing language. For example, a label may provide mandatory restrictions on droplet size, boom widths, nozzle deflection, nozzle types, and maximum wind speeds, but often these instructions do not apply to a much slower and smaller UAS that may or may not require a boom. The Task Force is especially concerned that an inexperienced UAS pilot may find label language difficult to interpret if they have not been exposed to some form of education on the use and operation of unmanned aircraft using rotary atomizers. Labels that allow aerial application should contain, at a minimum, the following information for UAS pilots:

- lists of acceptable nozzles and boom sizes for various UAS models
- instructions for proper orientation of different nozzle types
- application rate tables appropriate for safe, effective UAS use
- a glossary of terms specific to UAS operation

The following is a real-world example of label language confusion, derived from the AAPCO survey, Q25:.

“A certified and licensed UAV applicator wants to apply an aquatic herbicide but has a question on the label. The label states, “aerial applications to aquatic sites are restricted to helicopter use

only." The label states helicopter use only. Would your state allow a UAS to make the application? Most responses state that the application by a UAS would be in violation. The task force suggested contacting the authority that has jurisdiction and ask for an interpretation

Other Concerns of Note: There are three main areas to increase awareness and educational opportunities. These include: 1) a need for increased collaboration between state and federal agencies about regulations surrounding the licensing of UAS applicators (reducing siloing); 2) provision of accessible educational content for both aspiring applicators and those who will eventually hold UAS-specific applicator licenses, and 3) the identification of organizations to assist with digital delivery of materials developed for both applicators and those seeking CEUs. Developing educational resources in digital formats is one way to provide up-to-date, accessible materials that address most of the items identified in Table 3.

To begin this process, we recommend that two resources be developed:

1. a list of relevant BMPs
2. a glossary of common terms

These two documents should be laid out in an accessible manner to be delivered via the web. The Task Force discussed possible hosts for these resources and recommends that PERC servers be used to deliver this content. If PERC cannot continue to host the BMPs and glossary, other organizations have been identified that can be asked to host them, such as:

- The National Agricultural Aviation Association (NAAA)
- The Pesticide Stewardship Alliance (TPSA)
- Nationally relevant and sustainable UAS applicator associations

Additional information about the above first two organizations can be found in the Summary of Recommendations below.

Key Sources of Task Force Information

AAPCO UAS Program Survey

The American Association of Pesticide Control Officials (AAPCO) conducted a survey in 2024 of SLAs, tribes, and territories that asked about the status of their UAS program. It was sent to 443 people, asking key questions such as:

- Has your agency received requests to apply pesticide products using Unmanned Aerial Vehicles (UAV)?
- Does your agency have a UAV specific [licensing] category?
- Does your agency have a training manual and/or licensing exams for UAV applicators?

The survey garnered 50 responses, representing every EPA Region. The AAPCO survey found that 44 respondents have been contacted regarding requests to apply pesticides using a UAS. This response demonstrates a demand from the public for information about the legality of and best practices for making pesticide applications via UAS.

The AAPCO survey found 47 of the respondents do not have an UAS-specific licensing category. According to the survey, California has the most progressive licensure requirements on record, with a three-step licensing process: Unmanned Apprentice Pest Control Aircraft Pilot, Unmanned Journeyman Pest Control Aircraft Pilot, and Unmanned Vector Control Technician. Two other states have a license specific for unmanned aerial applicators, but only one, California, has separate licenses for manned and unmanned aerial applicators.

Survey responses indicate that regulators in states, territories, and tribes have been slow to adopt laws and regulations pertaining to pesticides applied by UAS because the technology is relatively new and evolving rapidly. At the current time, poll respondents feel their aerial regulations are sufficient to meet the needs of their agencies, though a few reported that some of them are developing UAS-specific laws and regulations. Respondents also indicate that both regulatory agency personnel and applicators are having difficulty interpreting label language regarding application method, nozzle type/angle, boom configuration, application rates, certification requirements, and worker protection standards as it pertains to specific UAS usage situations.

Most SLAs want to license UAS applicators but lack training materials for a proposed UAS operator category. Only Virginia and Indiana have developed addendums to their aerial manual or written a specific manual for UAS applicators, though only one of these documents have been released as of this report (Indiana). This situation confirms the Task Force's conclusion that there is an urgent need for training materials as the UAS industry continues to expand.

To review the entire survey please visit the AAPCO website and open the **2024 Survey results**.

Unmanned Aerial Pesticide Application System Task Force "Best Management Practices" Report and Other Resources

The UAPASTF released a report in 2024 entitled "Best Management Practices for Safe and Effective Application of Pesticides Using Unmanned Aerial Spray Systems." The PERC UAS Task Force thoroughly reviewed this report to inform our recommended next steps in UAS pilot education and licensing, as well as potential changes to label language. We found the report to be fairly comprehensive, covering many effective and safe UAS operations topics pertinent to pesticide applicators (see Table 3), though Task Force members indicated that there are some gaps. These gaps include:

- PPE use by the pilot (applicator) and crew
- reducing contamination of equipment (end of life, repairs)
- spray mission (label comprehension of aerial instructions, sensitive areas, and hazards)
- dealing with bystanders during an UAS pesticide application

- contingency planning for accidents, crashes, and spills when applying by UAS
- UAS spraying with rotary atomizer nozzles
- UAS spraying with hydraulic nozzles
- recommendations for building a safe and effective tender trailer for UAS applications
- batch mixing concerns of pesticides prior to an UAS application
- verifying controller output regarding droplet size (calibration of equipment)
- pesticide application with swarms (multiple drones, an advanced technique)

The PERC Task Force recommends that additional BMPs be developed that cover the missing information. Once this task is completed, it is recommended that the additional BMPs be combined with the UAPASTF BMPs and published in a user-friendly layout on a PERC-administered website. In addition, because adult learners benefit from audio-visual instruction, complementary training videos would be beneficial in demonstrating the more hands-on BMPs, because the activities described are unique to unmanned aerial application equipment. Our hope is that states, territories, and tribes will base future educational materials on the UAPASTF BMPs. Because UAPASTF allows for use and dissemination of their publications, it will be easy for local regulators to adapt the BMPs when creating much-needed educational materials.

The Task Force also reviewed the National Agricultural Aviation Association (NAAA) website, and notes that it has a tremendous amount of information and training opportunities that are available to the UAS applicator with membership, though it does not fully cover issues specific to UAS operation. See https://www.agaviation.org/ for details. The link available for Professional Operating Guidelines is currently applicable to UAS pilots, as are the Agricultural Airman Guidelines. The UAPASTF report can be found here.

Table 4: List of BMPs Compiled by the UAPASTF, Sorted by Category

UAPASTF Best Management Practices	Topic
Checklist when making pesticide applications using UAS	
Pre-application checklist when applying by UAS	Application
During and post application checklist when applying UAS	Application
Regulator considerations	
Licensing and certifications when applying by UAS	License
General pesticide safety considerations	
Mixing/loading and applying using UAS	Safety
Initial mixing/loading	Safety

Spraying	Safety
Subsequent mixing/loading	Safety
Cleaning, maintenance, and handling	Safety
UAS-specific handling instructions	Safety
Important topics in application efficiency	
Equipment	Application
Effective swath width	Application
Spray coverage	Application
Components check	Application
Application parameters for calibration	Application
Calibration	Application
Efficacy considerations	
Target pest and crop	Application
Pest control products attributes	Application
Tank mixes	Application
Spray tank prep and quality, tank mixing, adjuvants, and drift retardants	Application
Environmental variables and effects of off-target movement	
Wind	Drift
Hot and dry weather conditions	Drift
Temperature inversions	Drift
Adjusting spray parameters for environmental and sensitive areas	Drift

Purdue Publication "The Evolution of Spray Drones: Their Capabilities and Challenges for Pesticide Applications"

Dr. Fred Whitford, Clinical Engagement Professor and Director, Purdue Pesticide Programs, has published a safety manual titled *The Evolution of Spray Drones: Their Capabilities and Challenges for Pesticide Applications* (see Appendix C). **The manual is now available for purchase on the Purdue Edustore website**. Before its publication in February 2025, Dr. Whitford allowed the PERC UAS

Task Force to review the manual. To avoid any appearance of conflict of interest on the part of this Task Force, we acknowledge that several members served as peer reviewers and subject matter experts for this publication. Other contributors to the manual are leading researchers at land grant universities and are well respected in the UAS space. Though many of the practices relevant to manned aerial pesticide applications are applicable to UAS applications, our review indicates that Dr. Whitford's publication fills in the gaps left by the current national *Aerial Applicator's Manual* for UAS operators. Some Task Force members teach UAS technology and have so much confidence in this publication that they plan to use it for their classes.

Summary of Recommendations from the PERC UAS Task Force

1. Since the UAS space is constantly evolving, training materials used for continuing education should be limited to digital media because changes and edits can be made as soon as they are needed. PERC should utilize all social media avenues to promote new offerings and alert users immediately when updates to older materials are made.

2. PERC should dedicate some space on their website to information focused on UAS industry best practices and unique terminology. We foresee this site being widely adopted by individuals who are becoming interested in the UAS pesticide application business and for more advanced applicators. In the event PERC is unable to do this, there are several organizations that can potentially host the information. These entities would have to seek approval but have offered the potential for storing and administering the data. Three organizations are at the top of our list of alternate hosts:
    - The National Agricultural Aviation Association (NAAA). This association currently focuses on manned aerial training but has adopted the UAS industry as a viable platform for aerial application.
    - The Pesticide Stewardship Alliance (TPSA). This organization is already well-known for its focus on pesticide safety and efficacy before, during, and after application, so would be a natural destination for those seeking information about how to improve the safety of UAS applications.
    - Nationally relevant and sustainable UAS applicator associations.

3. Since every state has different laws and regulations covering pesticide applications, a digital tool (a mobile or web-based app) should be built that will help applicators find the regulations they must follow to make legal UAS applications in their state or territory. This tool could also serve the public and federal and state regulators who are interested in comparing the regulations developed in various places across the US. In order to accomplish these tasks, the tool should be able to search for and display the relevant regulations from a given state, as well as compare regulations from various federal and state regulatory agencies.

4. A glossary of terms and acronyms associated with the UAS industry should be developed. The creation of this glossary should be coordinated with the International Organization of Standardization (ISO), the American Society of Agricultural and Biological Engineers (ASABE) the CropLife America Drones Working Group, and the American Society for Testing and Materials (ASTM). This glossary can be hosted along with the BMPs by PERC or other organizations as indicated in recommendation 2, above.

5. BMPs written by UAPASTF should be presented in a user-friendly format with supplemental training videos on identified BMPs to demonstrate the management practice being described. Additional BMPs that cover topics not included in the UAPASTF list should be developed and integrated into the existing UAPASTF BMPs.

6. *The Evolution of Spray Drones: Their Capabilities and Challenges for Pesticide Applications* should be adopted as the national UAS study guide and adapted by states, territories, and tribes to fit their needs, along with the recently updated national *Aerial Applicator's Manual*. The Task Force also recommends that PERC coordinate the building of a secure exam pool (question bank) based on these study guides, thereby eliminating a state-by-state approach. We believe centralizing this task will result in more consistent, cost-effective, and efficient credentialing across the US.

Table 5: Chart of Recommendations and Difficulty of Delivery

Deliverables	Development	Needs	Difficulty
1. Develop UAS website and deliver information digitally due to changing nature of subject. **Output**: web page	PERC currently has a website that can be used as a launch point; PERC funding contract ends July 1, 2026. Alternate hosts are identified	IT Personnel to maintain URL. Identify host. Site Administrator has permission to change website. Build so information can be transferred easily.	**Medium**—finding host and webmaster/ administrator to create and maintain the site
2. Write additional BMPs and integrate them into the UAPASTF BMPs **Output**: web page	PERC currently has a website that can be used as a launch point; PERC funding contract ends July 1, 2026. Alternate hosts are identified	Writer to craft additional BMPs and experts to review them; webmaster/ administrator to add page to PERC website	**Medium**—finding writer and reviewers, and host and webmaster/ administrator to create and update the page
3. Digital tool (mobile app or web app) to search for and compare national and state regulations **Output**: mobile app or web-based app	Mobile or web-based application that will compile national and state regulations pertaining to UAS and manned aerial applications and allow for comparisons among state and federal regulations.	Resources to program a sophisticated information-retrieval application that meets various platforms' app store standards, host and maintain/update the application.	**High**—a lot of data gathering, programming, and quality assurance testing to develop application and maintain/host/update application. Information returned

	AAPCO Emerging Tech Workgroup source of information		should be regularly reviewed for accuracy
4. UAS Glossary of terms and acronyms **Output**: web-based linkable page and PDF	Develop a list of terms and acronyms	Assistance from industry, ISO, ASABE, and/or ASTM.	**Medium**—time-consuming gathering of information
5a. Adoption of UAPASTF and NAAA BMPs and guidance for UAS applications **Output**: training videos and web page linkable and PDF	BMPs as written, select BMPs for video companion (TBD); format for the web in an organized, user-friendly layout	Video production/script writing/edits capabilities and cooperating company or educational institution producing video recordings	**High**—design and points covered; production resources identified and contracted
5b. Additional BMPs recommended by PERC Task Force **Output**: training videos and web page PDF	Write BMPs and companion video scripts on selected BMPs (TBD)	Video production capabilities and cooperating company allowing video recordings	**High**—design and points covered; production resources identified
6. Recommend study guide and develop exam question pool/ bank **Output**: online secure website for SLAs to access	Write exam questions/exam for SLA agency use	Subject matter experts (SLAs, Industry reps, Academic) to serve on committee to write questions pertaining to UAS use when applying pesticides	**High**—assembling committee to develop and review questions; time to write quality questions

Appendix A:
Aerial Systems and Related FAA Regulations

Introduction to Unmanned Aerial Systems

Unmanned Aerial Systems (UAS) are becoming a more popular option for applying pesticides in the US. Pesticides can be applied as liquid sprays or granular formulations through an interchangeable spreader. An UAS is often referred to as a drone, UAV, or internationally as a Remotely Piloted Aerial Application System (RPAAS). In this document the term UAS will be used. The UAS has been used extensively in Asia since the 1990's, therefore the technology has its origins there and most manufacturing of the equipment is currently undertaken in Asian countries. However, several US drone manufacturers have begun manufacturing UASs in recent years because this industry is having a substantial economic impact in agriculture, and the future of the market appears to be increasing annually. The US has been slower to adopt this emerging technology due to regulatory compliance with the Environmental Protection Agency (EPA) and the Federal Aviation Administration (FAA).

UAS technology has evolved rapidly in the past several years. Initially, the UAS had a capacity of 10 liters, but through battery technology improvements, the UAS carrying capacity has steadily increased by 10 liters annually, and now a Hylio 72-liter UAS is available. Each year UAS manufacturers add additional features that improve the functionality of the equipment. Currently in production are the Ag Rotor Sprayhawk R550 and Robinson R44 uncrewed helicopter (a smaller scale helicopter) and the Pyka Pelican fixed wing uncrewed aircraft. The Ag Rotor AI Sprayhawk R550 and Robinson R44 have a 110-gallon capacity and Pyka Pelican has a 70-gallon capacity. The focus of this PERC UAS Task Force will be the smaller UAS aircraft. The UAS is identified by the number of rotors on the UAS. Single rotor UAS like the Yamaha RMAX has been used in Japan since the 1990's. Twin rotor UAS are available but typically have lower payloads. The multi-rotor UAS with 4-8 rotors are often larger and have the highest payloads up to 70 liters. The UAS are propelled by Lithium Polymer batteries (LiPo), but with the larger UAS, hybrid (liquid fueled and battery combination) technologies are coming into play.

The **OECD "State of the Knowledge"** and **CropLife America UAV Pesticide Application: Benefits and Fit into the Current Regulatory Framework document** on how the UAS fits into the current regulatory framework was one of the original publications on how the pathway forward for the technology to be successful had enormous insight. The industry is seeing positive results from recommendations made by CropLife America.

Introduction to FAA Aerial Pesticide Application Regulations

The FAA established certificates as of 2017 that a person must acquire to legally operate an UAS in the US. Remote pilots are required to hold FAA UAS Part 107 **Small Unmanned Aircraft Systems (UAS) Regulations (Part 107) | Federal Aviation Administration** and Part 137 (applying economic poisons) certificates to operate an UAS **Dispensing Chemicals and Agricultural Products (Part 137) with UAS | Federal Aviation Administration**. To have a legal UAS Part 137 operation, the operator must acquire a UAS Part 137 Certificate. For drones under 55 pounds operating under Part 107, relief (exemption) is only needed for the carrying of hazardous material, and several rules under Part 137 which can only be applied to crewed operations. For drones greater than 55 pounds, relief is also required from Part 61 and Part 91 rules, since Part 107 prohibits the use of drones weighing 55 pounds or greater. This greater-than-55-pound exemption has more restrictive conditions and limitations than a fully developed regulation would have. Some examples include requiring Class III Medical, monthly reporting, maximum altitude of 200 feet, and requirements for training flights. Once an operator has received their exemption, registered their UAS with the FAA, either through N-number registration for 55 pounds and greater or for under 55 pounds registered on **dronezone.faa.gov**, they may apply for an UAS Part 137 Operators Certificate. At the issuance of the UAS Part 137 Operators Certificate, the operator, as long as local application requirements are met, may legally begin aerial pesticide applications. Any UAS operation that is prohibited or not allowed by FAA rule must have an exemption issued with operational Conditions and Limits that grants the operator requesting relief, permission to operate within the National Air Space (NAS) either under part 107 or under a Blanket Certificate of Authorization which prescribes rules for accessing the NAS. The authority of this exemption comes from Section 44807 from the FAA Reauthorization Act of 2018, reaffirmed by the FAA Reauthorization Act of 2024, allowing the FAA to grant relief for UAS operators who provide operations and training documents that sufficiently define a risk-mitigating strategy to conduct operations in the NAS. The FAA lists approved UAS platforms that are permitted to fly in the US. Only an UAS on this list will be allowed to receive certificates for operation. This information can serve as a primer for any reference in PERC documents used about certifications by the FAA. The FAA has announced it will be making further changes to the remote pilot and Part 137 in 2025 and reclassify all UAS pilots into Part 108. The PERC UAS Task Force will focus recommendations with pesticide resources only. The PERC UAS Task Force recommends using the FAA website for information around FAA licensing and regulations.

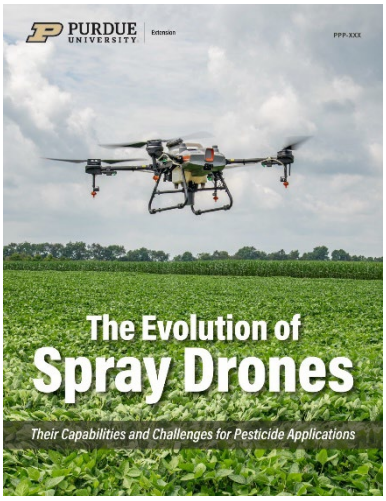
The EPA approves pesticide labels that include conditions, directions, and precautions that define who may use a pesticide, as well as where, how, how much, and how often it may be used. Currently a few pesticides have been registered with UAS labeling in the US but only give spray parameters such as droplet size, release heights, and aerial restrictions by label. The primary authority for pesticide regulation in the US lies with State Lead Agencies (SLAs). These SLAs are often in the state's Department of Agriculture. Each state has a variety of laws and regulations pertaining to pesticide registration, storage, licensing, and use. The pesticide label is legally

binding that describes the proper, lawful use of the product. The label language is cited in enforcement actions. The SLA has discretion over their enforcement of the laws and regulations they are charged to enforce. Most SLAs allow UAS applications to be performed under their current regulatory framework for manned aircraft. Currently, there is interest in developing certifications for UAS pilots with specific information about UAS applications and training materials that differ from manned aerial materials.

The Pesticide Education Resource Collaborative (PERC) also responded to the need for more training and information and created the UAS Task Force to identify the gaps in training that has been published.

Appendix B:
Recommended Study Materials

The Evolution of Spray Drones: Their Capabilities and Challenges for Pesticide Applications



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Hunter Medenwald, Assistant, Purdue University

Tommy Butts, Clinical Assistant Professor and Extension Weed Scientist, Purdue University

Adam Shanks, Digital Agriculture Curriculum Lead, Purdue University

Kevin Leigh Smith, Continuing Lecturer and Communication Specialist, Purdue Agricultural Sciences, Education and Communication (will edit entire pub after national review)

Contents:

- History of Drones
- Drones Finding Broader Uses in Agriculture and Other Industries
- User Interests in Spray Drones for Pesticide Applications
- Current Challenges of Using Spray Drones
- Learning to Fly with Computers
- Calibrating the Spray Drone for Liquid Applications
- Operational Setup in the Field
- Common Questions Regarding Spray Drone Applications
- Drone Maintenance and Winterization
- Pesticide Labels—A Quandary for Clear Guidance
- Federal Aviation Administration Regulations
- Considerations Before Purchasing a Drone
- Insurance For Protecting Your Investment and Challenges from Lawsuits

- Conclusion
- Acknowledgements
- Disclaimer

Dana Beegle, PERC Task Force member and Virginia Tech Pesticide Programs, has written an addendum to Virginia's Aerial Pesticide Application Manual for UAS applicators. She shared her publication with the task force. Ms. Beegle's addendum covers much of the material covered in Dr. Whitford's manual but is more of a brief overview of the issues.

Chapter 7. Uncrewed Aerial Vehicle Use in Pesticide Application

What Is an Uncrewed Aerial Vehicle?

How can UAVs Be Used for Pest Control?

Pest/Crop Monitoring and Integrated Pest Management

Pollinator Protection

Chemical Application

UAV Applicators and Certification

Applicator Types

Certification Requirements

Types of UAVs

Multirotor UAVs

Single-Rotor Helicopters

Fixed-Wing Drones

Fixed-Wing Hybrids

UAV Pesticide Dispersal Systems

UAV Service Trailers for Pesticide Application

Trailer and Equipment Set-up and Safety

Safety INSIDE the Trailer

Safety OUTSIDE the Trailer

UAV-Specific Operations and Best Practices

Concerns BEFORE Flight/Application