STATE OF MAINE
DEPARTMENT OF AGRICULTURE, CONSERVATION AND FORESTRY
BOARD OF PESTICIDES CONTROL
28 STATE HOUSE STATION
AUGUSTA, MAINE 04333

JANET T. MILLS
GOVERNOR

AMANDA E. BEAL
COMMISSIONER

BOARD OF PESTICIDES CONTROL

January 14, 2022

9:00 AM Board Meeting
11:00 AM-12:00 PM Public Forum
12:00 Board Meeting Continued As Necessary

Video conference hosted in MS Teams, to join the meeting:
Join on your computer or mobile app
Click here to join the meeting
Or call in (audio only)
+1 207-209-4724 United States, Portland
Phone Conference ID: 440 033 928#

AGENDA

1. Introductions of Board and Staff

2. Public Hearing on Proposed Rule Amendments to Chapters 20 and 41

The Board will hear testimony on the proposed amendments:

Chapter 20—Three amendments are proposed:
1. Define “Perfluoroalkyl and Polyfluoroalkyl Substances” or “PFAS”.
2. Add a requirement for registrants to submit a confidential statement of formula to register their product with the state of Maine.
3. Add two affidavit requirements; one affidavit that asks registrants to disclose if their pesticide product has ever been stored in a fluorinated high-density polyethylene container and a second affidavit asking registrants to disclose if the formulation of the pesticide product contains any perfluoroalkyl or polyfluoroalkyl substances.

Chapter 41—Two amendments are proposed:
1. Add a new section pertaining to neonicotinoids (dinotefuran, clothianidin, imidacloprid, or thiamethoxam) to restrict registration and prohibit use in outdoor residential landscapes for the purposes of managing pests in turf and ornamental vegetation. Add a clause allowing use for management of invasive invertebrate pests in ornamental vegetation.

MEGAN PATTERSON, DIRECTOR
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2. Add a new section prohibiting the use of chlorpyrifos, except for licensed applicators who obtain a use permit from the Board to apply chlorpyrifos products purchased prior to December 31, 2022.

3. Minutes of the November 19, 2021 Board Meeting

Presentation By: Megan Patterson, Director

Action Needed: Amend and/or approve

4. Request for Financial Support from the Maine Mobile Health Program and the Eastern Maine Development Corporation

Since 1995 the Board has supported the Migrant and Seasonal Farmworker Safety Education program. The Maine Mobile Health Program (MMHP) and the Eastern Maine Development Corporation (EMDC) provided training to 128 farmworkers during the 2021 season. Funding to support the effort in 2022 is being requested in the amount of $6,432, which is the same funding amount provided by the Board in 2021. The funding has been accounted for in the Board's FY22 budget.

Presentation By: Elizabeth Charles McGough, Director of Outreach and Deputy Director, Maine Mobile Health

Chris Huh, Program Manager, Farmworkers Jobs Program, Eastern Maine Development Corporation

Action Needed: Discussion and determination if the Board wishes to fund this request

5. Medical Advisory Committee Interim Report on Herbicide Use at Schools and Human Health

At the July 16, 2021, meeting, the Board reviewed pesticide-related bills enacted by the Maine Legislature. LD 519—An Act to Protect Children from Exposure to Toxic Chemicals, directed the Board to convene the Medical Advisory Committee (MAC) to assess the human health impacts of herbicide use on school grounds. At the same meeting, the Board agreed that the MAC should take up the LD 519 directive to evaluate the potential impact of herbicides used on school grounds on human health. Following three meetings of the MAC, staff have prepared an interim report incorporating commentary from MAC members. This report has been reviewed by MAC members and includes recommended next steps approved by MAC members. Staff will provide an overview of the report for Board consideration, discussion, and approval/disapproval. LD 519 required submission of a report by February 1, 2022.

Presentation By: Megan Patterson, Director

Dr. Pam Bryer, Toxicologist

Action Needed: Approve/disapprove submission of the interim report to the Maine Legislature Agriculture, Conservation and Forestry Committee

6. Other Old and New Business

a. LD 264 Final Report

b. LD 524 Final Report

c. Executive Order 41 FY 20/21 Listening Session and Final Report

d. Staff Update on the Contract for Testing Center Exam Administration

e. CropLife Article on First U.S. T-30 Drone Approval Granted

f. Organization for Economic Co-operation and Development Literature Review on Unmanned Aerial Spray Systems in Agriculture

g. Other items?

7. Schedule of Future Meetings

February 18, 2022 and April 1, 2022 are tentative Board meeting dates. The Board will decide whether to change and/or add dates.

The Board will also decide if there is a continuing need to meet remotely.

Adjustments and/or Additional Dates?

8. Adjourn

NOTES

- The Board Meeting Agenda and most supporting documents are posted one week before the meeting on the Board website at www.thinkfirstspraylast.org.

- Any person wishing to receive notices and agendas for meetings of the Board, Medical Advisory Committee, or Environmental Risk Advisory Committee must submit a request in writing to the Board's office. Any person with technical expertise who would like to volunteer for service on either committee is invited to submit their resume for future consideration.
- On November 16, 2007, the Board adopted the following policy for submission and distribution of comments and information when conducting routine business (product registration, variances, enforcement actions, etc.):
  - *For regular, non-rulemaking business*, the Board will accept pesticide-related letters, reports, and articles. Reports and articles must be from peer-reviewed journals. E-mail, hard copy, or fax should be sent to the Board's office or pesticides@maine.gov. In order for the Board to receive this information in time for distribution and consideration at its next meeting, all communications must be received by 8:00 AM, three days prior to the Board meeting date (e.g., if the meeting is on a Friday, the deadline would be Tuesday at 8:00 AM). Any information received after the deadline will be held over for the next meeting.
- During rulemaking, when proposing new or amending old regulations, the Board is subject to the requirements of the APA (Administrative Procedures Act), and comments must be taken according to the rules established by the Legislature.

01 DEPARTMENT OF AGRICULTURE, CONSERVATION AND FORESTRY

026 BOARD OF PESTICIDES CONTROL

Chapter 20: SPECIAL PROVISIONS

SUMMARY: These provisions regulate the use, storage and disposal of pesticides with specific emphasis on registered pesticides, right of way and aquatic applications and employer/employee requirements.

Section 1. Registered Pesticides

A. **Definitions**

"Perfluoroalkyl and Polyfluoroalkyl Substances" or "PFAS" means substances that include any member of the class of fluorinated organic chemicals containing at least one fully fluorinated carbon atom.

~~A~~B. The use of any pesticide not registered by the Maine Board of Pesticides Control in accordance with Title 7 M.R.S.A. §601 is prohibited except as otherwise provided in this chapter or by FIFRA, Section 2(ee).

~~B~~C. The use of registered pesticides for other than registered uses, or at greater than registered dosages, or at more frequent than registered intervals is prohibited, provided that application or use of unregistered pesticides and unregistered applications or uses of registered pesticides may be made for experimental purposes if in accordance with requirements of the Maine Board of Pesticides Control, and the U.S. Environmental Protection Agency.

~~C~~D. Retailers and end users of pesticides no longer registered in Maine may continue to sell and use those items provided they were properly registered when obtained and such distribution and use is not prohibited by FIFRA or other Federal law.

~~D~~E. In conducting review of registration or re-registration pursuant to 7 M.R.S.A. §607-A, the Board may consider the potential for environmental damage by the pesticide through direct application on or off-target or by reason of drift. If the Board finds that the use of the pesticide is anticipated to result in significant adverse impacts on the environment, whether on or off-target, which cannot be avoided or adequately mitigated, registration or re-registration will not be granted unless the Board finds that anticipated benefits of registration clearly outweigh the risks. In any case where the Board may request data in connection with registration or re-registration of any pesticide, such data may include that concerning pesticide residues, propensity for drift and testing therefor. Such data, if requested, shall provide information regarding residues and residue effects on plant tissues, soil and water and other potential deposition sites, and shall take into consideration differences in plants, soils, climatic conditions at the time of application and application techniques.

F. In conducting review of registration or reregistration pursuant to 7 M.R.S.A §607-A, the Board shall require submission of the confidential statement of formula and the following affidavits:

1. a completed and signed form provided by the Board at the time of application for product registration review or reregistration which attests that the pesticide has or has never been stored, distributed, or packaged in a fluorinated high-density polyethylene container; and

2. a completed and signed form provided by the Board at the time of application for product registration review or reregistration which attests that the pesticide formulation does or does not contain perfluoroalkyl or polyfluoroalkyl substances as defined by the Board for this purpose of this section.

Section 2. Right-of-Way

Deciduous growth over six feet in height and evergreen growth over three feet in height shall not be sprayed with a herbicide within the right-of-way of any public way except that deciduous growth which has been cut to the ground and which has grown more than six feet during the growing season following the cutting, may be sprayed that following season. In addition, chemical pruning of single limbs of trees over the prescribed heights may be performed.

Section 3. Pesticide Storage and Disposal

A. Unused pesticides, whether in sealed or open containers, must be kept in a secure enclosure and otherwise maintained so as to prevent unauthorized use, mishandling or loss; and so as to prevent contamination of the environment and risk to public health.

B. Obsolete, expired, illegal, physically or chemically altered or unusable pesticides, except household pesticide products, shall be either:

1. stored in a secure, safe place under conditions that will prevent deterioration of containers or any contamination of the environment or risk to public health, or

2. returned to the manufacturer or formulator for recycling, destruction, or disposal as appropriate, or

3. disposed of in a licensed hazardous waste facility or other approved disposal site that meets or exceeds all current requirements of the Maine Department of Environmental Protection and the U.S. Environmental Protection Agency for facilities receiving such waste.

Section 4. Aquatic Applications

No person, firm, corporation or other legal entity shall, for the purpose of controlling aquatic pests, apply any pesticide to or in any waters of the state as defined in 38 M.R.S.A. §361-A(7) without approval of the Maine Department of Environmental Protection.

Section 5. Employer/Employee Requirements

A. Any person applying pesticide shall instruct their employees and those working under their direction about the hazards involved in the handling of pesticides to be employed as set forth on the pesticide label and shall instruct such persons as to the proper steps to be taken to avoid such hazards.

B. Any person applying pesticides shall provide and maintain, for the protection of their employees and persons working under their direction, the necessary safety equipment as set forth on the label of the pesticide to be used.

Section 6. Authorization for Pesticide Applications

A. Authorization to apply pesticides to private property is not required when a pesticide application is made by or on behalf of the holder of an easement or right of way, for the purposes of establishing or maintaining such easement or right of way.

B. When the Maine Center for Disease Control and Prevention (CDC) has identified that an organism is a vector of human disease and the vector and disease are present in an area, a government entity shall obtain authorization for ground-based applications by:

1. Sending a written notice to the person(s) owning property or using residential rental, commercial or institutional buildings within the intended target site at least three days but not more than 60 days before the commencement of the intended spray applications. For absentee property owners who are difficult to locate, mailing of the notice to the address listed in the Town tax record shall be considered sufficient notice; and

2. Implementing an “opt out” option whereby residents and property owners may request that their property be excluded from the application by submitting written notice to the government entity at least 24 hours before spraying is scheduled to commence. Authorization is considered given for any property for which written notice was submitted and no “opt out” request was received by the sponsoring government entity.

C. When the Maine Center for Disease Control and Prevention (CDC) recommends control of disease vectors, government entities are not required to receive prior authorization to apply pesticides to private property, provided that the government entity sponsoring the vector control program:

1. Provides advance notice to residents about vector control programs using multiple forms of publicity which may include, but is not limited to, signs, newspaper, television or radio notices, direct mailings, electronic communication or other effective methods; and

2. Implements an “opt out” option whereby residents and property owners may request that their property be excluded from any ground based control program and the government entity makes a reasonable effort to honor such requests; and

3. If aerial applications are made, takes affirmative steps, to the extent feasible, to avoid applications to exclusion areas as identified by Board policy.

D. **General Provisions**. For any pesticide application not described in Chapter 20.6(A),(B) or (C), the following provision apply:

1. No person may contract with, or otherwise engage, a pesticide applicator to make any pesticide application to property unless that person is the owner, manager, or legal occupant of the property to which the pesticide is to be applied, or that person has the authorization of the owner, manager or legal occupant to enter into an agreement for pesticide applications to be made to that property. The term "legal occupant" includes tenants of rented property.

2. No person may apply a pesticide to a property of another unless prior authorization for the pesticide application has been obtained from the owner, manager or legal occupant of that property. The term "legal occupant" includes tenants of rented property.

3. No commercial applicator may perform ongoing, periodic non-agricultural pesticide applications to a property unless:

i. there is a signed, written agreement with the property owner, manager or legal occupant that explicitly states that such pesticide applications shall continue until a termination date specified in the agreement, unless sooner terminated by the applicator or property owner, manager or legal occupant; or

ii. the commercial applicator utilizes another system of verifiable authorization approved by the Board that provides substantially equivalent assurance that the customer is aware of the services to be provided and the terms of the agreement.

Section 7. Positive Identification of Proper Treatment Site

A. Commercial applicators making outdoor treatments to residential properties must implement a system, based on Board approved methods, to positively identify the property of their customers. The Board shall adopt a policy listing approved methods of positive identification of the proper treatment site.

STATUTORY AUTHORITY: Title 22 M.R.S.A., Chapter 258-A

EFFECTIVE DATE:
July 6, l979

AMENDMENT EFFECTIVE:
April 1, 1985
January 1, 1988

May 21, 1996

EFFECTIVE DATE (ELECTRONIC CONVERSION):
March 1, 1997

AMENDED:
May 7, 1997 - Section 5

CONVERTED TO MS WORD:
March 11, 2003

CORRECTED HEADER CHAPTER NUMBER:
January 10, 2005

AMENDED:
January 1, 2008 – new Sections 6 and 7, filing 2007-65
September 13, 2012 – Section 6(E) and references added, filing 2012-270 (Emergency – expires in 90 days unless proposed and adopted in the meantime as non-emergency)
December 12, 2012 – emergency filing expires, chapter reverts to January 1, 2008 version
September 13, 2012 – Section 6(E) and references added, filing 2012-270 (Emergency – expires in 90 days unless proposed and adopted in the meantime as non-emergency)
December 12, 2012 – emergency filing expires, chapter reverts to January 1, 2008 version
June 12, 2013 – Emergency major substantive filing 2013-134

CORRECTIONS:
February, 2014 – agency names, formatting

AMENDED:
September 11, 2014 – filing 2014-163 (Final adoption, major substantive)
December 9, 2014 – Section 7 added, filing 2014-279

01 DEPARTMENT OF AGRICULTURE, CONSERVATION AND FORESTRY

026 BOARD OF PESTICIDES CONTROL

Chapter 41: SPECIAL RESTRICTIONS ON PESTICIDE USE

SUMMARY: This chapter describes special limitations placed upon the use of (1) aldicarb (Temik 15G) in proximity to potable water bodies; (2) trichlorfon (Dylox, Proxol); (3) hexazinone (Velpar, Pronone), (4) aquatic herbicides in the State of Maine; ~~and~~ (5) plant-incorporated protectants; (6) neonicotinoids (dinotefuran, clothianidin, imidacloprid, thiamethoxam); and (7) chlorpyrifos (Dursban, Lorsban).

Section 1. ALDICARB (TEMIK®)

The registration of aldicarb (Temik 15G) is subject to the following buffer zone requirements:

A. Aldicarb (Temik 15G) shall not be applied within 50 feet of any potable water source if that water source has been tested and found to have an aldicarb concentration in the range of one to ten parts per billion (ppb). The 50 foot buffer would be mandatory for one year with a required retesting of the water at the end of the period.

B. Aldicarb (Temik 15G) shall not be applied within 100 feet of any potable water source if that water source has been tested and found to have an aldicarb concentration in excess of 10 ppb. The 100 foot buffer would be mandatory for one year with a required retesting of the water at the end of this period.

Section 2. TRICHLORFON (DYLOX, PROXOL)

The registration of trichlorfon (Dylox, Proxol) is subject to the following requirements:

A. Trichlorfon shall only be used for control of subsurface insects on turf.

B. Prior to application the target pest must be identified and the severity of the infestation must be determined, including the extent of the damage.

C. Only infested areas shall be treated with trichlorfon. Broadcast treatments of the entire turf area are prohibited.

D. Following application, the trichlorfon must be watered into the soil with at least ½ inch of water and according to the label directions. The applicator must assure that the appropriate watering will take place prior to re-entry by any unprotected person.

Section 3. HEXAZINONE (VELPAR, PRONONE)

The registration of hexazinone is subject to the following limitations and conditions.

A. Licenses Required

No person shall use or supervise the use of any pesticide containing the active ingredient hexazinone unless they have obtained an applicators license in accordance with 22 M.R.S. §1471-D.

Section 4. AQUATIC HERBICIDES

The registration of pesticides for which there is an aquatic herbicide use on the product label shall be subject to the following limitations and conditions.

A. Board Publication of List

The Board of Pesticides Control will publish by May 23, 2003 and by March 15th of each year thereafter a list of herbicide products registered in Maine for which the manufacturer has verified that there is an aquatic use on the pesticide label. Based on available information, the Board may exempt from this list pesticides that it determines are not for use in the control of aquatic vegetation. Pesticides labeled solely for use in aquariums and antifouling paints, are specifically exempt from this list.

B. Licenses Required

I. Unless exempted under Chapter 41, Section 4 (B) (III), no person shall purchase, use or supervise the use of any aquatic herbicides identified on the Board's annual listing unless they have obtained a private or commercial pesticide applicator's license from the Board.

II. No person shall:

a. Distribute any aquatic herbicides identified on the Board's annual listing without a restricted use pesticide dealer's license from the Board; or

b. Unless exempted under Chapter 41, Section 4 (B) (III), distribute any aquatic herbicides identified on the Board's annual listing to any person who is not licensed as a private or commercial applicator by the Board.

III. Registered herbicides containing only the active ingredients erioglaucine (Acid Blue 9 or FD&C Number 1, CAS Registry No. 1934-21-0) and/or tartrazine (Acid Yellow 23 or FD&C Yellow Number 5, CAS Registry No. 2650-18-2 (trisodium salt) or 3844-45-9 (triammonium salt)) are exempt from the applicator licensing requirements described in Chapter 41, Section 4 (B) (I) and Chapter 41, Section 4 (B) (II) (b).

C. **Disclosure**

The Board will make a disclosure form available to dealers distributing any aquatic herbicides identified on the Board's annual listing. The Board requests that dealers present to customers the disclosure form that advises purchasers that, (1) an aquatic discharge license must be obtained from the Maine Department of Environmental Protection before any application may be made to any surface waters of the State as defined in 38 M.R.S.A. Section 361-A(7) including any private ponds that may flow into such a body of water at any time of year, (2) that Best Management Practices developed jointly by the Board and the Maine Department of Environmental Protection on the use of aquatic herbicides are available.

D. **Records and Reporting**

Dealers distributing any aquatic herbicides identified on the Board's annual listing shall keep records of such sales and provide reports to the Board as described for restricted use pesticides in Chapter 50, "Record Keeping and Reporting Requirements."

E. **Use of Best Management Practices**

Aquatic herbicides applied to private ponds and not subject to an aquatic discharge permit may only be applied consistent with Best Management Practices developed jointly by the Board and the Maine Department of Environmental Protection.

Section 5. PLANT-INCORPORATED PROTECTANTS

The registration, distribution and use of plant-incorporated protectants are subject to the following limitations and conditions:

A. **Definitions**

"Plant-incorporated protectant" means a pesticidal substance that is intended to be produced and used in a living plant, or in the produce thereof, and the genetic material necessary for the production of such a pesticidal substance.

B. **License Required**

No person shall distribute any plant-incorporated protectant without either a general use pesticide dealer license or a (restricted or limited use) pesticide dealer license from the Board.

C. **Dealer Requirements**

Dealers distributing plant-incorporated protectants are subject to the following requirements:

I. General use and (restricted or limited use) pesticide dealers shall notify the Board of their intent to distribute plant-incorporated protectants on all initial license and license renewal application forms provided by the Board.

II. General use and (restricted or limited use) pesticide dealers shall maintain sales records showing the list of the names and addresses of all purchasers of plants, plant parts or seeds containing plant-incorporated protectants. These records must be made available to representatives of the Board for inspection at reasonable times, upon request, and must be maintained for two calendar years from the date of sale.

III. Any general use and (restricted or limited use) pesticide dealer who discontinues the sale of plant-incorporated protectants shall notify the Board in writing and shall provide the Board, upon request, with all records required by Section 5(C)II of this chapter.

D. **Grower Requirements**

I. All users of plant-incorporated protectants shall maintain the records listed below for a period of two years from the date of planting. Such records shall be kept current by recording all the required information on the same day the crop is planted. These records shall be maintained at the primary place of business and shall be available for inspection by representatives of the Board at reasonable times, upon request.

a. Site and planting information, including town and field location, a map showing crop location and refuge configuration in relation to adjacent crops within 500 feet that may be susceptible to cross-pollination;

b. Total acres planted with the plant-incorporated protectant and seeding rate;

c. Total acres planted as refuge and seeding rate;

d. Detailed application information on any pesticide applied to the refuge as described in Section 1(A) of Chapter 50, "Record Keeping and Reporting Requirements"; and

e. Planting information for each distinct site including:

i. date and time of planting; and

ii. brand name of the plant-incorporated protectant used.

II. There are no annual reporting requirements for growers.

E. **Product-Specific Requirements**

I. Requirements for plant-incorporated protectant corn containing Bacillus thuringiensis (Bt) protein and the genetic material necessary for its production.

a. Prior to planting plant-incorporated protectant corn containing any Bacillus thuringiensis (Bt) protein and the genetic material necessary for its production, the grower must have completed a Board-approved training course and possess a valid product-specific training certificate.

b. Product-specific training certificates shall be issued following each Board-approved session. The certificates will remain valid until December 31 of the third year after issuance.

c. Non-Bt-corn growers whose crops are or will be located within 500 feet of a prospective Bt-corn planting site can request that the Bt-corn grower protect the non-Bt-corn crop from pollen drift.

i. the request must be made prior to planting of the Bt-corn crop;

ii. the request must identify the non-Bt-corn crop to be protected; and

iii. the growers may agree on any method for protection but, if an agreement cannot be reached,

1. the Bt-corn grower must plant any refuge required by the Bt-corn grower agreement, grower guide or product label in a configuration that provides maximum protection from pollen drift onto the adjacent non-Bt-corn crop; or

2. if no refuge is required, the Bt-corn grower shall maintain at least a 300-foot Bt-corn-free buffer to non-Bt-corn crops.

d. Bt-corn growers are encouraged to follow all best management practices developed by the Board or the Department of Agriculture, Conservation and Forestry.

II. Dealers distributing Bt-sweet corn shall only sell the seed in quantities large enough to plant one acre or more.

F. **Confidentiality**

Any person providing information to the Board in connection with the record-keeping and reporting requirements of Section 5 of this chapter may designate that information as confidential in accordance with 7 M.R.S.A. §20.

Section 6. NEONICOTINOIDS (DINOTEFURAN, CLOTHIANIDIN, IMIDACLOPRID, OR THIAMETHOXAM)

The registration of pesticides containing dinotefuran, clothianidin, imidacloprid, or thiamethoxam for which there is an outdoor ornamental plant or turf use on the product label shall be subject to the following limitations and conditions.

A. **Definitions**

I. “Invasive Invertebrate Pests” means any invertebrate species, including its eggs or other biological materials capable of propagating that species, that does or is likely to cause economic or environmental harm or harm to human health and meets one or more of the following criteria:

a. federally or state regulated;
b. non-native or not originating from this eco-region;
c. native or non-native vectors of plant diseases;
d. native pests that have become highly destructive due to climate change or ecosystem factors

II. “Ornamental Plants” means-shrubs, trees and related vegetation excluding turf and lawn, in and around residences.

B. **Board Publication of Product List**

The Board of Pesticides Control will publish by July 1, 2022 and by March 15th of each year thereafter a list of insecticide products containing dinotefuran, clothianidin, imidacloprid, or thiamethoxam registered in Maine for which the manufacturer has verified that there is an outdoor ornamental plant or turf use on the pesticide label. Based on available information, the Board may exempt from this list pesticides that it determines are not for use in the control of outdoor ornamental plants or turf. Pesticides labeled solely for use in preserving wood, managing indoor pests, managing structural pests within five (5) feet of a human dwelling, and treating pets are specifically exempt from this list.

C. **Licenses Required**

I. No person shall purchase, use, or supervise the use of any pesticides containing dinotefuran, clothianidin, imidacloprid, or thiamethoxam identified on the Board's annual listing unless they have obtained a private or commercial pesticide applicator's license from the Board.

II. Unless exempted under Chapter 41, Section 6 (C) (IV) no person shall purchase, use or supervise the use of any pesticides containing dinotefuran, clothianidin, imidacloprid, or thiamethoxam in outdoor residential landscapes to include ornamental plants and turf.

III. No person shall distribute any pesticides containing dinotefuran, clothianidin, imidacloprid, or thiamethoxam identified on the Board's annual listing without a restricted use pesticide dealer's license from the Board.

IV. Registered pesticides containing dinotefuran, clothianidin, imidacloprid, or thiamethoxam and identified on the Board's annual listing are exempt from the prohibition of use described in Chapter 41, Section 6 (C) (II) where used for management of an invasive invertebrate pest on ornamental plants.

V. No person shall use any pesticides containing dinotefuran, clothianidin, imidacloprid, or thiamethoxam identified on the Board’s annual listing for the purposes of managing turf and lawn in outdoor residential landscapes.

D. **Records and Reporting**

Dealers distributing any pesticides containing dinotefuran, clothianidin, imidacloprid or thiamethoxam identified on the Board's annual listing shall keep records of such sales and provide reports to the Board as described for restricted use pesticides in Chapter 50, "Record Keeping and Reporting Requirements."

This section becomes effective January 1, 2023.

Section 7. CHLORPYRIFOS (DURSBAN, LORSBAN)

The registration of chlorpyrifos (Dursban, Lorsban) is subject to the following limitations and conditions.

A. No person shall use or supervise the use of any pesticide containing the active ingredient chlorpyrifos unless they have obtained a private or commercial applicator's license from the Board, possess the pesticide in the State before January 1, 2022, and obtain a temporary use authorization permit from the Board.

B. Permit applications shall be made on such forms as the Board provides and shall include at least the following information:

I. The name, address and telephone number of the applicant;

II. The brand name of the pesticides to be applied;

III. The date on which the pesticides were purchased;

IV. The approximate quantity of the pesticides possessed;

V. The purpose for which the pesticide application(s) will be made; and

VI. The duration for which the applications will take place or until the product is gone.

C. Within 30 days after a complete application is submitted, the Board or its staff shall issue a permit if:

I. The permit application is received prior to December 31, 2022;

II. The applicant possesses a valid pesticide applicator license issued by the State;

III. The pesticides proposed for use were purchased prior to January 1, 2022;

The Board may place conditions on any such permit, and the applicant shall comply with such conditions. Except as required by the permit, the applicant shall undertake the application in accordance with all of the conditions described in their request and all other applicable legal standards. Permits issued by the Board under this section shall not be transferable or assignable except with further written approval of the Board and shall be valid only for the period specified in the permit.

STATUTORY AUTHORITY: 5 M.R.S.A. §§ 8051 *et seq*.
7 M.R.S.A. §§ 601-610
22 M.R.S.A. §§ 1471-A, 1471-B, 1471-C, 1471-D, 1471-M

EFFECTIVE DATE:
March 8, 1981 (Captan)

AMENDED:
May 7, 1981 (Trichlorfon)
January 2, 1984 (Aldicarb)
May 8, 1988 (Trichlorfon)
August 5, 1990 (Captan)
August 17, 1996 (Hexazinone)
October 2, 1996

EFFECTIVE DATE (ELECTRONIC CONVERSION):
March 1, 1997

AMENDED:
May 7, 1997 - Section 3(B)(II)

CONVERTED TO MS WORD:
March 11, 2003

AMENDED:
May 12, 2003 - Section 4 added

NON-SUBSTANTIVE CORRECTIONS:
June 24, 2003 - summary only

AMENDED:
February 2, 2004 - Section 4, 1st paragraph and sub-section A, filing 2004-31
April 30, 2007 – filing 2007-154
February 3, 2008 – filing 2008-36
July 16, 2009 – filing 2009-253 (final adoption, major substantive)
May 3, 2012 – filing 2012-99 (final adoption, major substantive)

CORRECTIONS:
February, 2014 – agency names, formatting

AMENDED:
December 9, 2014 – Section 3, filing 2014-283

STATE OF MAINE
DEPARTMENT OF AGRICULTURE, CONSERVATION AND FORESTRY
BOARD OF PESTICIDES CONTROL
28 STATE HOUSE STATION
AUGUSTA, MAINE 04333

JANET T. MILLS
GOVERNOR

AMANDA E. BEAL
COMMISSIONER

BOARD OF PESTICIDES CONTROL

November 19, 2021

9:00 AM Board Meeting

Video conference hosted in MS Teams

MINUTES

Adams, Bohlen, Flewelling, Granger, Jemison, Morrill, Waterman

1. Introductions of Board and Staff
   - The Board, Staff, and Assistant Attorney General Mark Randlett introduced themselves
   - Staff: Boyd, Bryer, Connors, Couture, Nelson, Patterson, Saucier, Tomlinson

2. Minutes of the October 8 Regular and August 16 Emergency Board Meetings

   Presentation By: Megan Patterson, Director

   Action Needed: Amend and/or approve

   - **Adams/Jemison: Moved and seconded approval of minutes as amended**
   - **In Favor: Unanimous**

3. Request to extend a Special Local Need [24(c)] Registration for Arsenal Herbicide with Applicators Concentrate for Increased Surfactant Rate When Used in Combination with Glyphosate for Jack Pine, Red Spruce and White Spruce Release

   The Board last approved a Section 24(c) registration for Arsenal Herbicide (EPA Reg. No. 241-299) in 2016 and initially approved it in 2004. This current EPA label specifies a maximum surfactant concentration of 0.25% (v/v) for conifer release. The current and proposed SLN allows the increased rate of surfactants for tank mixes of Arsenal and glyphosate which maximizes the effectiveness of glyphosate.

Presentation By: Mary Tomlinson, Pesticides Registrar and Water Quality Specialist

Action Needed: Approve/disapprove 24(c) registration request

- Tomlinson stated that this SLN requested authority to use extra surfactant when tank mixing imazapyr and glyphosate, to increase the efficacy of the glyphosate. She indicated that she asked the company to add this use to the label and they stated they intend to, but it may take a couple years due to existing stock. She added that this request was to bridge the gap to allow for the use until then.
- Ron Lemin stated that they have been using this SLN since 2004 and only about 1.5 oz per acre of Arsenal Herbicide is used during application. He added that he was glad BASF would finally be adding this language to the master label.
- Jemison asked if staff had found this combo in their water sampling.
- Tomlinson stated that they had detected imazapyr in surface water.
- Lemin said the current label rate was 6-12 ounces per acre for release of black spruce in Maine and they only use one ounce per acre.
- Jemison asked about how many people were currently using this mixture for a release program and that he was concerned the label rate was so high that it could hurt the plant while trying to protect it.
- Lemin responded that about five or six landowners used this prescription and that he hoped BASF would decrease the labeled rate per acre.

    - **Adams/Granger: Moved and seconded approval of the 24(c) request**
    - **In Favor: Unanimous**

4. <u>Staff Memo: Update on a Feasible Definition of PFAS in Pesticide Products</u>

At the October 8, 2021 meeting, staff presented a memo discussing the difficulty of identifying a PFAS definition for the implementation of the affidavits required by LD 264. Since that meeting, staff have met with staff at Maine DEP to discuss LD 1503. At that meeting, it became apparent that pesticides would be subject to the requirements of LD 1503 as well as LD 264. Staff will now present the outcome of that research.

Presentation By: Dr. Pam Bryer, Pesticides Toxicologist

Action Needed: Information only

- Bryer stated that Patterson, McBrady and she met with Maine DEP staff regarding LD 1503, which will prohibit, by 2030, distribution in Maine of all products with intentionally added PFAS. She added that in 2022 DEP must begin to record all products with intentionally added PFAS coming into Maine. Bryer told the Board that it should consider harmonizing their definition of PFAS with the definition in LD 1503 so that there would be clarity in compliance between DEP and BPC. She stated that DEP was open to input from DACF and indicated they would likely reach out at a later date but were currently in the process of hiring for a position to implement LD 1503.

- Morrill asked if they were waiting for DEP's definition of PFAS.
- Patterson responded that the definition was already laid out in LD 1503 to mean substances that included any member of the class of fluorinated organic chemicals containing at least one fully fluorinated carbon atom. She added that DEP would have the ability to prohibit distribution of pesticides in Maine if they included intentionally added PFAS, but they also would have the ability to provide exemptions for these products. Patterson told the Board that DEP indicated they would be interested in consulting with BPC.
- Patterson stated that the vast majority of products would not be prohibited until 2030 and said in the meantime staff could act on the affidavits in section one of LD 264. She stated that, to comply, registrants needed to know what they were attesting to when they made the claims that their product did or did not contain PFAS.
- Morrill thanked Bryer for all of her work on this subject.

5. <u>Continued Review of Potential Rulemaking Concepts Pertaining to LD 155 (neonicotinoids used in residential turf/landscape management) and Discussion of Next Steps for Proposed Rulemaking in Response to LD 264 (PFAS affidavits and registration of pesticide products) and LD 316 (prohibition on chlorpyrifos distribution)</u>

On June 10, 2021 LD 155, LD 264 and LD 316 were signed into Maine law. At its August 27, 2021 meeting, the Board held stakeholder information gathering sessions addressing these three bills. Following the August meeting, the Board directed staff to return with a review of rulemaking concepts. At the October 8, 2021 meeting of the Board, staff returned with proposed language and further discussion of rulemaking concepts. Following the October meeting, the Board directed staff to return with a draft rule for concepts related to LD 264 and additional information related to outstanding questions on LD 155—primarily related to the definition of "invasive vertebrate species". Staff will now present their findings.

Presentation By: Megan Patterson, Director
Karla Boyd, Policy & Regulations Specialist

Action Needed: Refine the rulemaking concepts and schedule a hearing

- Patterson directed the Board members to the staff memo included with this agenda item which detailed the actionable items, potential rulemaking concepts and steps that have been taken by staff to develop the current rule. She explained that the Board could not take public comment at this time for language in the rule, but the public comment period would open if the Board decided to go through with rulemaking.

- Boyd explained that Chapter 20 included a new definition of PFAS in which staff proposed adopting the State's definition.
- The Board decided to incorporate the State's definition for PFAS.
- Morrill requested that a public hearing be scheduled for the January Board meeting.
- The Board moved on to discuss Chapter 41 which dealt with LD 155 and LD 316.
- Boyd told the Board that staff proposed staying with the base definition of invasive invertebrate pests but also included criteria. She said that for ornamental plant, staff referred to the existing definition in Chapter 10.
- There was discussion about why turf and lawn had been excluded from the definition of ornamental plants.
- Patterson stated that staff had to exclude turf to accommodate the wording of LD 155 and that a pesticide license would be required to purchase any products with a label that allowed for use on outdoor ornamental and turf sites.
- Morrill and Jemison both expressed concern about the wording being understandable to applicators.
- Randlett commented that he thought what staff had done made sense if applicators read Section C carefully, and that it was the responsibility of the person using the product to read the rule and understand it.
- Tomlinson stated that on pesticide labels turf and lawn were always separate from ornamental plants and this suggested definition made it very clear that ornamental plants did not include turf and lawn.
- Randlett asked if the section listed under 6(C)IV should read Section 6(C)(II) rather than 6(C)(I).
- Patterson responded that it should.
- Morrill suggested that would it be clearer to strike out turf and lawn.
- Patterson responded that was not a bad point, however the definition already in place in Chapter 10 included turf and that was why staff attempted to provide clarification.
- The Board further discussed the original definition of ornamental plant in Chapter 10.
- Morrill pointed out that 'turf' was not defined in rule and suggested specifying that the listed exemption did not apply to turf and lawn applications.
- Jemison stated that they did not want people to think these four chemicals could be used on turf and suggested possibly defining 'turf' in Section 6(A).
- Adams commented that he tended to agree with Tomlinson and as a label reader he knew that turf and ornamental were separate, but they needed to make the public aware that 'T&O' do not stay together regarding these products.
- Patterson suggested retaining the original ornamental definition and adding that this exemption did not apply to turf.
- Tomlinson agreed with Jemison that maybe adding a definition for 'turf' and Patterson's idea about adding an additional statement in 6(C)(IV) that clarified it was not for turf. She added that Adams was correct in that the public often think of 'T&O' together.
- Morrill noted that the Board did provide separate licensing for turf and ornamental, and it may be easier to talk about applications being performed under category 3B to exclude turf. He suggested striking the word 'mown' from 6(A)(II) and have it just read 'turf and lawn' and add a new section 6(C)(V) to state that this prohibition extends to turf and lawn.
- Jemison agreed.
- Adams asked if the Board needed to consider commercial sod farmers.

- Patterson responded that they did not because commercial sod farmers were not residential, and agriculture was not addressed in LD 155.
- Morrill said to clarify in a new section 6(C)(V) that this was for residential areas only.
- Flewelling commented on the additional work this was going to be for the dealerships and asked if places like Lowes would no longer be able to sell these products.
- Patterson stated that was correct, that these products would only be able to be legally sold by restricted use pesticide dealers.
- Morrill commented on the large amount of on hand stock the large stores would have to use up. He asked if the Board normally referenced effective dates in rule.
- Patterson responded that staff would have to conduct a public education campaign for the general public, applicators, and dealers and it could take a couple of years to broadly communicate.
- Morrill suggested an effective date of January 1, 2023 to allow everyone to get rid of stock that was currently in the system. He added that this date may have to change after they hear from distributors and homeowners during the comment period.
- Jemison agreed that the Board should work towards January 2023 for no more sales of these products.
- Flewelling asked what would happen if someone sprayed their lawn after the rule went into effect.
- Patterson said that the application would be unlawful, but staff could, for a period of time exercise enforcement discretion and that the priority would be with commercial applicators and retailers and making sure they were aware of the regulatory changes.
- Tomlinson told the Board that she sent registrants letters in October regarding the new law so they had all been made aware that these products would become restricted use.
- Morrill commented that Section 7(C)(III) had a date that would essentially be retroactive.
- Patterson responded that was case because there would already be a prohibition on purchase by the time the rules were passed.
- Randlett responded that the retroactive date was not a problem.
- Jemison brought up the plant incorporated protectants, PIPs, referenced in Section 5. He said the Board originally created this section in 2012 and the reason the section was detailed was because it was thought at that time that specific education was required. Jemison said a lot things had changed since then, and he would like to consider changes to Section 5. He told the Board that in the past there were products that required a certain planting distribution where so much of a field required a buffer and it was confusing to growers, but after time industry decided they would put multiple PIPs in a seed and move to refuge in a bag and that was 99% of the current use seed corn. Jemison stated that he gave a talk annually to aid applicators with compliance and has wanted to raise this issue for the last three years. He added that most current use seed corn includes a PIP, which was unfortunate because it was not a good IPM approach to assume there was a problem a grower may or may not even have.
- Randlett commented that if the Board wished to make broader changes to the rule they would need to be proposed with these changes or rulemaking would need to be moved to a later date. He added that anything added to the rule regarding PIPs would make it major substantive.
- Jemison stated that maybe next time the Board did something major substantive to this rule then that would be the time to edit Section 5.
- Morrill said the Board should do that at a later date and Jemison could come back with suggestions for wording in the summer or fall.

- Patterson stated that regarding Section 7 federal law had passed that removed all tolerances for chlorpyrifos on food, including chlorpyrifos treated seed. She stated that staff needed clarification on the duration of permits issued under Section 7.
- Granger suggested letting the user define the permit length based on what they had on hand and how much they use. He said that he felt flexibility would be useful here for growers to find other products to use.
- Morrill suggested adding another section that talked about the duration of when the application would take place, depending on how much product the grower had on hand.
- Patterson stated that section 6(C)(III) essentially prohibited use of product purchased after January 1, 2022. She also asked when the Board would like to publish the initial list of neonicotinoid products under Section 6.
- It was decided that July 1, 2022 would be a good date as long as that would give staff enough time to compile a list.

6. Staff Report and Presentation of Sampling Results from the Ten Cities Surface Water Quality Study

On February 26, 2019, the Board approved funding for a staff proposed water quality monitoring effort referred to as the "Ten Cities Project". The primary objective of the study was to assess the occurrence of pesticides in surface water in urban waters along a population gradient of the ten largest Maine cities. Additional objectives including assessing the feasibility of passive sampling techniques and establishing a baseline for future trend studies of pesticide contamination in the sampled waters. Staff will present the findings of the study.

Presentation By: Dr. Pam Bryer, Toxicologist

Mary Tomlinson, Pesticide Registrar and Water Quality Specialist

Action Needed: Discuss and provide feedback on results

- Bryer presented the Board with a slideshow detailing the process and results of the 10 Cities Surface Water Study. She stated that the goals were to assess occurrence of pesticides in surface water and sediment along a population gradient of the ten largest Maine cities. She explained that staff collected grab and passive samples. Bryer explained that grab samples provided concentrations and only captured a snapshot in time, while passive samplers captured daily changes but did not give concentrations, only presence and absence of certain analytes. She told the Board it would have been expected to see the number of detections go up with population but there was no correlation. She noted that they did not find any glyphosate. Bryer said that all locations had pesticides in the water, and they did find that the variety of pesticides increased with population. She told the Board that bifenthrin in one location and imidacloprid in another were found to exceed the Aquatic Life Benchmark.
- Flewelling asked what bifenthrin was commonly used for.
- Bryer stated that it was usually used in urban areas for tick and mosquito treatment.
- Morrill asked about the spike in the stormwater drain.

- Bryer responded that it was a place that was draining a really small concentrated area.
- Bohlen stated that storm water concentrations tended to be much higher than once they got into the larger water bodies.
- Bohlen stated that generally any urban streams in the United States will contain a mix of pesticides and he did not see this as anything dramatically different than what was normally seen in an urban environment.
- Jemison asked if there had been a press release on what staff had found and that it might make some people think about being more careful when using products. He asked how this would be presented to the public.
- Patterson stated that it was on the website, and anyone on the Board mailing list would have been directed to the information. She added that staff planned to incorporate this into their recertification courses.
- Bohlen noted that since most of the data was from grab samples we likely were not seeing the moment of highest risk for the aquatic community and when staff presented this data to applicators they should be careful about how they talk about these low concentrations in the surface water.

7. <u>2021 Preliminary Water Quality Monitoring Related to Aerially Applied Herbicides in Forestry</u>

Executive Order 41 FY 20/21 directed the Board to develop a surface water quality monitoring effort to focus on aerial application of herbicides in forestry to be conducted in 2022. In an effort to be responsive to this request and to accommodate what was a changing timeline for completion of the EO request, staff conducted a small preliminary surface water quality monitoring pilot in 2021. Sampling was limited and all samples were collected in advance of planned 2021 aerial applications of herbicides for site preparation and conifer release.

Presentation By: Mary Tomlinson, Pesticide Registrar and Water Quality Specialist

Action Needed: Discuss and provide feedback on results

- Tomlinson stated that staff were tasked with conducting a baseline assessment of the occurrence of herbicides known to be applied via aerial application in forest management. Ron Lemin assisted staff with a list of commonly used active ingredients. There were 10 different sites selected that were likely to receive drainage from site preparation or conifer release preparation. A map was provided showing the location of those sites. Tomlinson credited inspectors for going out and collecting these samples in very remote areas. She added that they utilized the Montana Analytical Lab for the testing, and their general method tested 102 different pesticide active ingredients and metabolites. She told the Board that imazapyr and sulfometuron were found in water and sediment samples, but none exceeded benchmark levels. Tomlinson said that glyphosate, metsulfuron methyl, and triclopyr were not found. AMPA (a glyphosate metabolite) was also not detected.

- Bohlen asked if staff hoped to do some more sampling around areas of aerial spraying.
- Tomlinson stated that staff had a very limited window to do this and some places were not adjacent to spray areas but were as close as they could get to the area where there was also water.

8. <u>Consideration of a Consent Agreement with Mosquito Squad of Southern Maine, Scarborough, Maine</u>

The Board's Enforcement Protocol authorizes staff to work with the Attorney General and negotiate consent agreements in advance on matters not involving substantial threats to the environment or public health. This procedure was designed for cases where there is no dispute of material facts or law, and the violator admits to the violation and acknowledges a willingness to pay a fine to resolve the matter. This case involves multiple applications by unlicensed/unsupervised individuals, an unauthorized application, failure to notify an induvial on the Maine Pesticide Notification Registry, and noncompliant record keeping.

Presentation By: Raymond Connors, Manager of Enforcement

Action Needed: Approve/disapprove the consent agreement negotiated by staff

- Connors stated that this consent agreement was discussed at a previous meeting to get input from the Board because of the extent of some of the issues of the case which involved multiple years from 2018 to 2020. The first violation was an application to the wrong property and the company did not have a compliant method of positive identification. Connors stated there were also two months of unlicensed applications from July to September 2018. After reviewing the company records it was found that there were 170 unlicensed applications involving three applicators over that time period. The company indicated that the applicators alluded to be being licensed when they were not. The company made an application in June of 2020 in York and failed to provide sufficient advanced notification to a registry member. During the time frame from 2018 through 2020, Board inspectors, through inspections, also documented the company's commercial pesticide application records were missing the following required information: name of applicator, application method, size of area treated, site treated, application rate, record of sprayer calibration, target pest, sky conditions, active ingredient, and restricted entry interval. Connors stated that the proposed penalty of $20,000 was based on the variety and scope of violations. He added that it was negotiated down to $18,000 with $2,000 suspended if the company did not commit any violations in the following two years, beginning when the consent agreement was ratified.

    - **Adams/Jemison: Moved and seconded to approve the consent agreement**
    - **In Favor: Unanimous**

9. Other Old and New Business

a. Obsolete Pesticide Collection Results

b. LD 264 Final Report—January 15, 2022

- PFAS report

c. LD 519 Final Report—February 1, 2022

- The MAC has held two meetings.

d. LD 524 Final Report—January 1, 2022

e. Executive Order 41 Final Report—Due January 2, 2022

f. Medical Advisory Committee Update

- Waterman told the Board that MAC planned to prepare the requested report for the legislature's Agricultural, Conservation and Forestry Committee—as requested in LD 519 and regarding the potential impact of herbicides on human health. He added that the toxicologists were asked to review what had been applied to school grounds over the last two years. Waterman stated that there were 458 applications made over two years and the products used were mostly glyphosate and dicamba. He stated that the wording 'potential impact [of herbicides on human health]' was what they came up against during their discussion and that there was data suggesting both ways [both no and significant impact], but he had concerns especially for chronic exposures. Waterman said he felt that the MAC should recommend adding all herbicides to the 75' rule on school grounds. He told the Board that there were objections from the rest of the MAC that they felt that suggestion was too broad and wanted more specific data about what replacement herbicides might be, along with their toxicities. Waterman added that he would like to ask for an extension to gather more data and would ask the toxicologists to compile data of potential replacement products. He added that he thought the Board was supposed to be saying 'think first, spray last' and did not see a problem with preventing pesticides on school grounds.

- Patterson commented that she did not see an issue with asking for an extension.

- Waterman suggested each MAC member submit their own statement.

- Patterson suggested submitting the minutes from the meetings.

- Morrill stated that the MAC had always operated on a consensus basis in the past. He added that he thought the ask with a six-month deadline was a short turnaround time. Morrill said that if more guidance needed to be given to the MAC the Board could revisit this at the January Board meeting.

g. Other items?

10. Schedule of Future Meetings

The Board has added the following tentative meeting dates:

- January 14, 2022 12-4:00 PM with a 1-2:00 PM public hearing and 2-3:00 PM public listening session;
- February 18, 2022 and April 1, 2022

11. Adjourn
    - **Jemison/Waterman: Moved and seconded to adjourn 12:08 PM**
    - **In Favor: Unanimous**

MAINE MOBILE HEALTH PROGRAM

Improving the health status of Maine's seasonal workers and their families by providing culturally appropriate care and services.

December 20, 2021

Megan Patterson
Maine Board of Pesticides Control
28 State House Station
Augusta, ME 04333-0028

Dear Ms. Patterson,

I am contacting you on behalf of the Maine Mobile Health Program (MMHP) with a request for support from the Maine Board of Pesticides Control for a continued effort to deliver EPA Worker Protection Standard (WPS) education to Maine's farmworkers during the 2022 harvest season.

Throughout the 2021 season, the Maine Mobile Health Program worked to provide the Worker Protection Standard (PST) training to farmworkers across the state. The program recruited one returning PST trainer together with a new trainer who was multilingual with the capacity to speak in English, Spanish and Haitian Creole. One highlight from the season included training a crew of Haitian blueberry rakers in their native language. It was the first time ever that they had received the WPS content. Additionally, these two employees allowed the program to accommodate all trainings requested for the farmworkers across the state. While the trainers were able to utilize COVID-19 safety precautions developed in 2020, there were continued barriers to offering the training more extensively as many growers still sought to maintain quarantines for incoming workers and other crew sizes were small, especially in blueberries, due to the on-going pandemic.

Despite the challenges, our PST trainers were able to offer training in the WPS to 128 farmworkers across Maine in addition to curricula from the Association of Farmworker Opportunity Programs (AFOP) on occupational safety. The table included here breaks down, by education topic, important outcomes in 2021 completed by the staff members.

FWs trained in Worker Protection Standard	128
FWs trained in Take Home Exposure	10
Heat Stress Trainings	108

I also share an update that in 2021 the recipient of funding for the Farmworker Jobs Program shifted from the Eastern Maine Development Corporation to the Pathstone Corporation. In conversations with the Association of Farmworker Opportunity Programs, we learned that the Maine Mobile Health

Program would still be eligible as a recipient for funding to continue education efforts and has been awarded $2,870 to MMHP in support of on-going WPS training in 2022. MMHP plans to use these funds to support the staff time for multilingual WPS and occupational health trainings to farmworkers across the state. We request from the Maine Board of Pesticides Control a contribution of $6,432 which we would leverage with the funds from AFOP. The funding from the Board of Pesticides Control will be used to fund the staff person who provides WPS trainings; including both the hourly wage and the travel and lodging required to reach farmworkers, growers and partners along with the overhead of managing the grant and project. We request that the funding be made directly to MMHP.

We thank the Board for its past support and for considering this current proposal. To contact us about this request or our activities, please feel free to contact Liz Charles McGough (echarles@mainemobile.org, 207-441-1633).

Best Regards,

Elizabeth H Charles McG

Elizabeth Charles McGough
Director of Outreach and Deputy Director
Maine Mobile Health Program

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Board of Pesticides Control

Report to the 130th Maine State Legislature on LD 264 Resolve, Directing the Board of Pesticides Control to Gather Information Relating to Perfluoroalkyl and Polyfluoroalkyl Substances in the State

LEGISLATIVE REPORT
FISCAL YEAR 2021

MAINE DEPARTMENT OF
AGRICULTURE
CONSERVATION
& FORESTRY

Amanda E. Beal
Commissioner

Randy Charette
Deputy Commissioner

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Contents

I. Acronyms and Definitions

Adjuvant	A chemical added to a pesticide product to enhance or stabilize the product's performance.
BPC	Board of Pesticides Control
CIASA	Constituents ineffective as spray adjuvants; the portion of an adjuvant that is effectively equivalent to the inert/other constituents of registered pesticide
CSF	Confidential Statement of Formula
DACF	State of Maine Department of Agriculture, Conservation, and Forestry
DEP	State of Maine Department of Environmental Protection
DFAS	Defense Financial Accounting Service
EPA	U.S. Environmental Protection Agency
FFDCA	Federal Food Drug and Cosmetics Act
FIFRA	Federal Insecticide Fungicide and Rodenticide Act
HDPE	High Density Polyethylene
Inert	The constituents of a pesticide product that are not specifically acting to control the pest. Synonymous with 'other' ingredients.
LD	State of Maine Legislative Document
MEPRLS	Maine Pesticide Enforcement, Registration & Licensing System
OECD	Organization for Economic Co-operation and Development
OPP	EPA's Office of Pesticide Programs
OPPT	EPA's Office of Pollution Protection and Toxics
Other	The constituents of a pesticide product that are not specifically acting to control the pest. Synonymous with 'inert'.
PFA	Primary Functioning Agent. PFAs are the term of art used to identify the "active ingredient" in spray adjuvant products while simultaneously avoiding confusion with the term "active ingredient". PFAs are the portion of the spray adjuvant responsible for the effects of the spray adjuvant.
PFAS	Per and poly fluoroalkyl substances
Spray Adjuvant	A term used in this report to delineate the products sold separately from registered pesticide products which function to enhance or stabilize the performance of the pesticide. These products are frequently mixed with the registered pesticide product at the time of application.
TSCA	Toxic Substances Control Act

II. Introduction

In 2021, the Maine Legislature passed LD 264, Resolve, Directing the Board of Pesticides Control to Gather Information Relating to Perfluoroalkyl and Polyfluoroalkyl Substances in the State. One of the two major provisions of the bill directed the Board of Pesticides Control (BPC) to amend its rules relating to the registration of pesticides and require submission of two affidavits. The affidavits address 1) the use of fluorinated high-density polyethylene containers for storing, distributing and packaging pesticide products and 2) the inclusion of perfluoroalkyl or polyfluoroalkyl (PFAS) substances in the formulation of the pesticide product.

The second provision directed the Board to gather information relating to PFAS substances with a specific focus on developing 1) the framework necessary to regulate fluorinated adjuvants, 2) the framework necessary to prohibit the distribution and use of pesticides and adjuvants containing PFAS substances, and 3) a feasible definition of PFAS adulteration in a pesticide.

This report summarizes the BPC activities and findings. Specifically, the report summarizes the implementation of the required affidavits; findings on what is needed to regulate spray adjuvants (and thus fluorinated spray adjuvants); findings on how to prohibit distribution and use of pesticide and adjuvant products containing PFAS; and findings on how to define PFAS adulteration in pesticide products.

A. Constraints and Demands on Resources

LD 264 was passed with no additional funding to support BPC activities relating to its implementation. The Department of Agriculture, Conservation, and Forestry (DACF) and EPA have committed PFAS related funds and multipurpose grant funding, respectively, allowing the development of key components originating from this resolve. At the time of this writing, approximately $75,000 has been committed for web development for implementation of the required affidavits and collection and flagging of related product formulation information. An additional $4,800 has been used to support a part-time student assistant (approximately 320 hours). Within the BPC, work on this resolve has extensively included the Director and the Pesticides Toxicologist, and also involved the Pesticides Registrar, the Policy & Regulations Specialist, and the Certification & Licensing Specialist. Meetings with personnel outside of the BPC office involved staff from EPA Region 1, DACF, DEP, and the Office of the Maine Attorney General. Additionally, this topic has been discussed at each of the 2021 meetings of BPC’s public policy board.

B. Summary of Completed and Ongoing Activities

In response to LD 264, the BPC has performed the following activities further described in this report. Throughout the course of this project, staff have:

- developed affidavit language and consulted with the BPC's legal representation for appropriateness;
- researched, planned, and will now work with software programmers to add functionality to the existing registration platform to incorporate the PFAS affidavits starting with the 2022 registration year;
- added functionality of the existing registration platform to collect confidential statements of formula (CSF) for pesticide and, in the future, adjuvant products;
- collected information from other states on the registration of spray adjuvants;
- analyzed statutes, rules, and regulations from Maine and other states in order to identify mechanisms of gaining authority to regulate spray adjuvants;
- collected lists of registered spray adjuvants from those states that collect registrations on spray adjuvants;
- added/commissioned functionality of our existing registration platform to collect spray adjuvant registrations, fees, and CSF data;
- explored definitions of PFAS and PFAS adulteration;
- determined limits of BPC enforcement authority in cases of PFAS adulteration;
- communicated with pesticide repackaging entities in the state about repackaging activities related to the use of fluorinated HDPE containers in product distribution;
- communicated with DEP staff concerning overlap with LD 264 and LD 1503, An Act To Stop Perfluoroalkyl and Polyfluoroalkyl Substances Pollution;
- identified several currently registered pesticide active ingredients that meet the definition of PFAS established in LD 1503; and
- identified areas of concern for implementation of LD 264 due to ambiguity in interpreting the definition of PFAS.

C. PFAS and Pesticides

LD 264 focused on the potential nexus between pesticides and PFAS due to the detection of PFAS in one pesticide product utilized for mosquito control in Massachusetts.

Ultimately, it has been determined that the underlying pesticide formulation does not contain PFAS, nor does the HDPE container that it is packaged within. However, because the container underwent further fluorination treatment by a third party (to prevent container degradation), this process appears to be the source of PFAS compounds found in the sampled pesticide product. As a result, EPA is investigating container fluorination, possible leaching of PFAS, the conditions under which this is likely to occur, and the toxicological significance of the potential leachates.

The insecticide in question in Massachusetts is manufactured by Clarke Mosquito Control. The product is called Anvil 10+10 ULV. In 2018, BPC had one Clarke product registered under the name Anvil—Anvil 10+10 ULV. According to BPC distribution records this product appeared to have been purchased by an entity within Maine (Defense Finance and Accounting Service (DFAS) at Loring Air Force Base in Limestone, Maine), however following investigation, BPC staff have determined that the product invoice was paid by DFAS but shipped directly from Clarke to Altus Air Force Base in Altus, Oklahoma.

In 2021, BPC had two Clarke products registered—Duet Dual-Action Adulticide and Natular DT. Natular DT is a solid tablet packaged in a blister pack and is a ready-to-use larvicide applied directly to water. It is not to be applied via aerial application, and Clarke has indicated that it is not packaged in fluorinated HDPE containers. The sole purchase in Maine of Duet Dual-Action Adulticide was in 2019 by DFS at Loring Air Force Base, and the product was again shipped directly from Clarke to Altus Air Force Base.

Later in 2021, EPA was made aware of PFAS detected in another mosquito control product used in Maryland—Permanone 30+30—manufactured by Bayer. In response to this information, EPA applied its new 2021 internally validated oily matrix method to analyze three stored samples of mosquito control pesticide products (Permanone 30-30 and PermaSease 30-30) and determined that none of the tested samples contained PFAS at or above the Agency's method limit of detection.

It is important to stress that the initial and emerging studies of the Clarke Mosquito Control product links PFAS contamination to containers, not the pesticide formulation. The current science and testing around PFAS leaching due to fluorinated HDPE containers continues to evolve. The BPC staff are actively engaged on this broad topic with colleagues in state pesticide programs, EPA Region 1, and is routinely briefing the BPC board on developments at its monthly meetings.

PFAS detection in pesticide formulations is a whole new area of consideration, investigation, and response, beyond the current issues the Department has already been navigating related to PFAS impacted farms. Information will continue to emerge that will help shape and identify BPC's role related to PFAS. This report reflects BPC staff's current understanding of PFAS and pesticides, the applicability and limitations of current authority, and the applicability of parallel regulations.

III. Activities Related to Amending Rules

A. Affidavits

Section 1 of LD 264 directs the Board to conduct rulemaking to amend the requirements for pesticide product registration and collect affidavits relating to PFAS. These new affidavits will provide attestation to the following:

1) *whether a perfluoroalkyl or polyfluoroalkyl substance is in the formulation of the registered pesticide*
2) *whether the registered pesticide has ever been stored, distributed, or packaged in a fluorinated high-density polyethylene container*

BPC staff have worked with the web development company Stratosphere to allow incorporation of affidavits into the BPC's existing product registration software solution. Following completion of rulemaking and software development, these affidavits will be compulsory questions in the annual pesticide registration process required for lawful distribution of pesticide products in Maine. In addition, BPC staff are developing a new webpage that offers registrants information about these affidavits. Specifically, registrants are directed to the definition of PFAS established by LD 1503 and provided contact information for the Maine Department of Environmental Protection (DEP).

During the affidavit process pesticide registrants will answer the question, "is this product delivered in bulk to any vendors?" The MEPERLS database will flag affirmative entries for follow up by staff. Thus far, BPC staff have identified six vendors that may refill ("repackage") bulk pesticide containers in Maine. BPC staff are in the process of reaching out to these EPA registered Pesticide Producer Establishments in Maine to discuss this issue.

IV. Sale and Use of Fluorinated Adjuvants Used in Maine

The basic definition of an adjuvant is an ingredient that enhances the effectiveness of pesticide product ingredients or modifies the actions of those pesticide product ingredients. With pesticides, adjuvants are added to enhance the pesticide's performance. This report focuses on adjuvants sold separately from the registered pesticide products, those that are added to a tank mix prior to application. The term "fluorinated adjuvants" used in L.D. 264 is not defined, and it is not a term utilized in pesticide terminology. For the purposes of this report, staff have assumed fluorinated adjuvants to contain 1) primary functioning agents or 2) constituents ineffective as spray adjuvants (CIASAs) that could, under Maine's definition of PFAS (described in section VI below), be considered PFAS.

Adjuvant products are not currently regulated by any federal or State of Maine government entity. Determining if fluorinated adjuvants are definitively present in the state requires access to information to which the BPC is not currently lawfully entitled. Based on BPC staff research, the assumption is that fluorinated adjuvants are potentially available for sale and use in Maine. This assumption is based on the discovery that in some states adjuvants are registered and as many as 1,100 adjuvant products are registered annually. The EPA Master List of PFAS chemicals indicates approximately twenty of the inert/other chemicals known to occur in registered pesticide products may be available for use as ingredients in adjuvant products. BPC has not confirmed the presence of any specific fluorinated adjuvant products for sale or use in the State of Maine.

The BPC regulates pesticide products. Pesticide products must be registered by the EPA prior to being allowed on the market but only following an acceptable risk assessment. Pesticide products, as sold, are almost never composed of 100% pesticide active ingredient, most also include inert/other ingredients. The inert/other ingredients used as part of the pesticide product must also undergo a separate risk assessment prior to being allowed for use in registered pesticide products. This section does not apply to those adjuvants already assessed by EPA as part of pesticide products.

As stated, adjuvants are not currently regulated in Maine or in a majority of the states. Research indicates that nine states do regulate adjuvants and that two of those states require a statement of the complete ingredient list, otherwise known as a confidential statement of formula.

A. Identification of Fluorinated Spray Adjuvants

i. Definition of Spray Adjuvants

A spray adjuvant is added to a pesticide spray mixture to enhance the pesticide's performance and/or the physical properties of the spray mixture. Because spray adjuvants have no pesticidal properties (they do not control the pest), they are not required to be registered by the U.S. Environmental Protection Agency (EPA). However, if they are to be used on a food or feed crop, there must be an established tolerance or tolerance exemption for the adjuvant. Tolerances are the legal maximum amount of a chemical that are allowed to be on a food commodity at the point of sale. The process of establishing a tolerance involves understanding sufficient toxicology and chemical fate data in order to complete a risk assessment to demonstrate at what concentration exposure to the chemical would not cause undue harm to humans or the environment.

ii. Adjuvants Used on Food Crops

Spray adjuvant products to be used on food commodities are required to either have an established tolerance or be exempt from tolerance requirements as required by

Federal Food, Drug and Cosmetic Act (FFDCA), available as per Code of Federal Regulations (CFR) 40 CFR 180. Tolerances are searchable in the CFR at: https://www.ecfr.gov/current/title-40 by entering the chemical name into the search function. The majority of inert ingredients can be found in 40 CFR 180.910-180.960.

iii. Adjuvants Used on Application Sites Other Than Food Crops

Spray adjuvant products not used on consumable goods are regulated under Toxic Substances Control Act (TSCA). Approval under TSCA requires EPA to review chemicals ensure that chemicals do not present unreasonable risk of injury to health or the environment when used as proposed. Details on how chemicals are assessed under TSCA can be found at: https://www.epa.gov/reviewing-new-chemicals-under-toxic-substances-control-act-tsca/regulatory-determinations-made.

There is significant overlap between the ingredients used for inert/other chemicals used in registered pesticide products and spray adjuvant products. One state lead agency reported that during the process of registering spray adjuvant products they cross-check each product's ingredients against EPA's Inerts Finder tool. (Available at https://ordspub.epa.gov/ords/pesticides/f?p=INERTFINDER:1:0::NO:1::, the Inert Finder is EPA's clearinghouse for all inert/other ingredients used in registered pesticide products.) That state above does not allow registration of spray adjuvant products that include chemicals missing from the Inert Finder lists. EPA's Inert Finder can be sorted by food and non-food uses.

Appendix B contains the response provided by the Office of Pesticide Programs (OPP) at EPA to questions about adjuvants and required risk assessments. In the response, EPA indicates that during pesticide registration OPP includes all chemicals in the final product formulation and all chemicals mentioned on the product label into the registration risk assessment.

At present, the scope of the Board of Pesticides Control's regulatory authority is the distribution and use of pesticides.

B. Results from Survey of Other States

To better understand spray adjuvant regulation, BPC staff researched the regulatory authorities and processes in other states. States were contacted by direct email and asked a series of questions; additionally, states were queried with a survey distributed via the Association of American Pesticide Control Officials (AAPCO).

Several states responded and provided the following information. Arkansas provided an Excel spreadsheet of all adjuvants currently registered in the state of Arkansas. California was unable to provide any information due to a lack of resources to check the confidential statements of formula for all the adjuvant products to determine if the state had any adjuvants with PFAS, and additionally because the department is unsure if they would be able to provide this confidential business information. Idaho noted that their new database program requires actives/principle functioning agents to be listed when registering products; however, this is confidential information. They also stated that they would reach out again once they have devised a list of adjuvants registered in Idaho. Utah provided a way for BPC staff to find a list of registered adjuvants in the state of Utah on their state website. Appendix C contains the complete lists of spray adjuvant products registered in Arkansas, Tennessee, and Washington (these are the only states providing lists by the survey deadline).

Washington provided resources to determine a list of adjuvants registered in the state that have been added to the Washington State University website, Pesticide Information Center OnLine (PICOL). This is the official repository of pesticide labels registered in both Washington and Oregon. The list is not currently updated with a full list, but the internal database for Washington indicates there are about 870 adjuvants registered. Full text of how to navigate Washington's adjuvant registration page is provided as an excerpt of an email in Appendix D.

Requirements of each state's program is available in Table 1. These details include requirements and details for spray adjuvant registration including: registration fee per product, registration period, copy of product label, copy of confidential statement of formula, and a safety data sheet.

Table 1. Requirements from the nine states that regulate spray adjuvants as pesticides.
Note: States that require EPA confidential statement of formula (EPA Form #8570-4) for all pesticides (not spray adjuvants) are as follows: California, Colorado, Florida, Hawaii, and New York.

State	Application for Registered Pesticides	Registration Fee per product ($)	Registration Period (years)	Copy of Product Label	Copy of Spray Adjuvant Confidential Statement Formula (CSF)	Safety Data Sheet (SDS)
Arkansas	Yes	250	1	Required only upon request	Required only upon request	Required only upon request
California	Yes	1,150 for initial registration and annual renewal fee	1	6 copies, and copy of EPA approved label and letter unless product is exempt		
Idaho	Yes	160	1	Yes	Yes, along with efficacy data	Yes
Kentucky	Yes	250	1			

Mississippi	Yes	200	1	Yes (active ingredients & percentage)		
Tennessee	Yes	200	1			
Utah	Yes	195	1	Yes		
Washington	Yes	650	2	Yes	Yes	Yes
Wyoming	Yes		1			

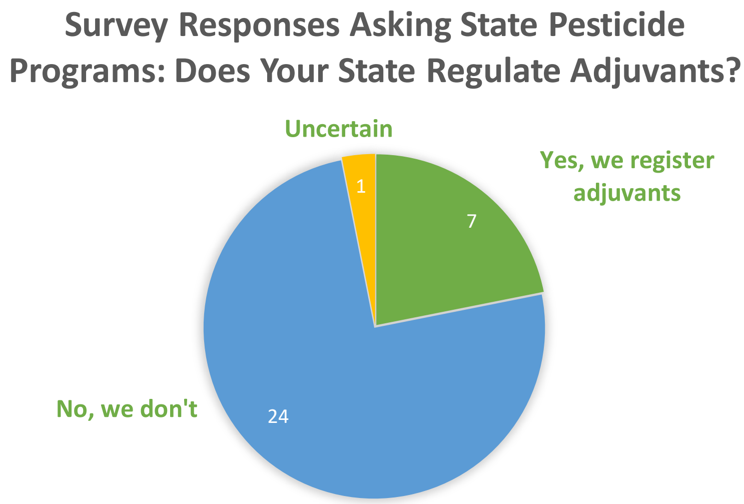
C. Methods for Identifying Specific Pesticide and Spray Adjuvant Ingredients as PFAS

BPC has not identified any specific spray adjuvants as containing PFAS for several reasons. First, what chemicals fit the state's definition of PFAS have yet to be finalized by the Department of Environmental Protection (DEP), and secondly, BPC is waiting for the release of a software add-on on EPA's CompTox Dashboard that will allow us to easily compare the compounds listed as adjuvant ingredients to the chemical structure established by DEP. Once there is additional guidance from DEP and a webpage update from EPA, BPC will be able to use qualifying chemical structures established by DEP as search criteria in the CompTox Dashboard and cross reference those chemicals to the potential ingredients in spray adjuvants identified by searching the relevant state and federal adjuvant databases. EPA estimates the CompTox Dashboard add-on to be available to the public starting around December 2021-January 2022.

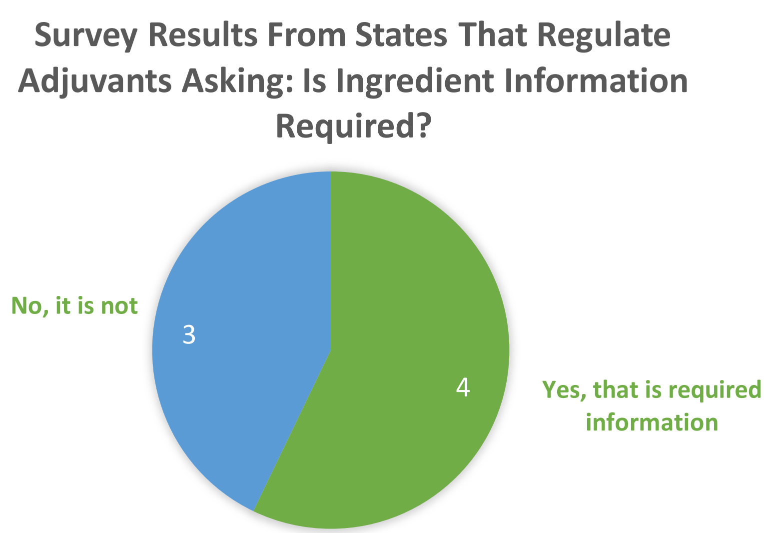
BPC has initiated the restructuring of the MEPRLS database to collect confidential statement of formula forms (CSF) for pesticides to be registered in the 2022 registration year. Should spray adjuvants become regulated by BPC, adding the functionality for collecting CSF information for spray adjuvants would not be a significant obstacle.

D. State Regulatory Agency Adjuvant Survey Results

Through the American Association of Pesticide Control Officials (AAPCO), a national organization representing state lead agencies responsible for pesticide regulation, BPC asked other states a series of questions about spray adjuvant registration. The survey yielded results from 32 states. Most of the responses indicated that spray adjuvants are not included in pesticide programs' responsibilities - see pie chart below.



Survey responses provided contact information from the state lead agencies that regulate adjuvants and, in some cases, lists of registered spray adjuvant products were also provided. For the states registering spray adjuvants, most do not perform risk assessments on the products. Several states indicated that they review the labeling of the product. The labeling review simply matches the product to the types of claims that can be made for that type of product and ensures no misleading statements are present.



The survey additionally asked states if ingredient information was collected. There are two aspects to this: states can collect 1) only "active ingredient" information and require it to be present on the label or 2) all product constituents CSF. To avoid confusion during registration, some states use differing terminology to differentiate between pesticides and spray adjuvants. Some spray adjuvant registrations use the term “primary functioning agents (PFA)” instead of “active ingredient.” The PFAs are required to appear on labels in some states, similar to how active ingredients are required on pesticide labels. In some states, ingredients are reviewed for accuracy, and the ingredients are compared to EPA’s Inert List. All compounds on EPA’s Inert List have been assessed for risk enabling manufacturers to include the compounds in pesticide product formulations. The Inert List is publicly available, but the specific inert ingredients found in a pesticide product are not. Two of the four states appear to collect the CSF. None of the states indicated that they prohibit certain adjuvants.

The purpose of the survey was to gather from states as much information on regulating spray adjuvants as possible. While much of the information ended up being redundant with the information gathered by directly emailing state lead agencies, confirming that most states do not register spray adjuvants was helpful.

V. What is Needed to Regulate Fluorinated Spray Adjuvants?

A. Authority

To determine what is needed to regulate spray adjuvants, the BPC researched authorities necessary for adding spray adjuvants to regulated products. This required an investigation into if other states regulate spray adjuvants and if those states require adjuvants to be registered as pesticides. The following nine states regulate spray adjuvants as pesticides: Arkansas, California, Idaho, Kentucky, Mississippi, Tennessee, Utah, Washington, and Wyoming. To determine how these states regulate spray adjuvants as pesticides, the BPC looked at each state’s statutory definitions (Table 2).

Table 2. State statutory definitions relating to pesticides and spray adjuvants.

State	Statute	Definition
Arkansas	2012 Arkansas Code Title 2 -Agriculture Subtitle 2 – Agronomy Chapter 16 – Plant Disease and Pest Control Subchapter 4 – --Pesticide Control 2-16-403 – Definitions	"Spray adjuvant" means any wetting agent, spreading agent, sticker, deposit builder, adhesive, emulsifying agent, deflocculating agent, water modifier, or similar agent intended to be used with any other pesticide as an aid to the application or to the effect thereof, and which is in a package or container separate from that of the pesticide with which it is to be used

	[AR Code § 2-16-403 (2012)]	"Active ingredient" means any ingredient which will prevent, destroy, repel, control, or mitigate pests or which will act as a plant regulator, defoliant, desiccant, or spray adjuvant "Pesticide" means any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pests; any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant; and any substance or mixture of substances intended to be used as a spray adjuvant.
Kentucky	KRS 217.544(26) KRS 217.544(31)	"Pesticide" means any substance or mixture of substances intended to prevent, destroy, control, repel, attract, or mitigate any pest; any substance or mixture of substances intended to be used as a plant regulator, defoliant, or desiccant; and any substance or mixture of substances intended to be used as a spray adjuvant. "Spray Adjuvant" means any wetting agent, spreading agent, sticker, deposit builder, adhesive, emulsifying agent, deflocculating agent, water modifier, or similar agent intended to be used with any other pesticide as an aid to the application or to the effect thereof, and which is in a package or container separate from that of the other pesticide with which it is to be used.
Wyoming	[WY Stat § 35-7-354 (2018)]	"Pesticide" means any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pests; any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant; and any substance or mixture of substances intended to be used as a spray adjuvant.
Maine	Title 22. Health and Welfare Subtitle 2: Health Part 3: Public Health Chapter 258-A: Board of Pesticides Control 1471-C. Definitions	"Pesticide" means any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest, and any substance or mixture of substances intended for use as a plant regulator, defoliant or desiccant. "Pesticide dealer" means any person who distributes limited or restricted use pesticides.

B. Budget Considerations

In a third query, BPC staff sent an email to states that regulate adjuvants to inquire about the staffing demands of spray adjuvant registrations. There is considerable variation in staffing between the states that handle spray adjuvant registrations. These differences parallel the thoroughness of review the spray adjuvants are given. For example, in Washington, each ingredient is verified against EPA's list of reviewed inert ingredients. The spray adjuvant program demands greater resources as compared to those states that simply collect registration fees and no other documentation. The state responses are summarized in Table 3.

Table 3. State programmatic costs for spray adjuvant registration administration from state programs registering spray adjuvants.

State	Program Cost Description Email Responses
Arkansas	….The Arkansas Department of Agriculture, Pesticide Section has 2 employees that handle registration reviews for Adjuvants. 1 Program Manager and 1 Program Coordinator.
Kentucky	….We have one staff member that works as our Product Registration Coordinator. Her supervisor is available for questions that may arise on label reviews and there are 3 of us that are involved in 24(c) and Section 18 requests.
Mississippi	….Currently, I [Branch Director, Bureau of Plant Industry] am the only person who reviews adjuvants in Mississippi. I have an assistant who helps with registrations, but she does not review adjuvants.
Utah	….We have one FTE in pesticide registration, which handles all that you mentioned in your email to me [adjuvant registration, regulation, review process, etc.]. Her job classification is Program Specialist. We don't review EPA registered products. Adjuvants and 25(b)'s get a review looking for key words/terms that I have given her. If she sees them, then I review the label. She also makes sure that 25(b)'s meet the EPA Label Review Manual's requirements.
Washington	….Entire registration staff currently consists of 7 people 2 pre-registration/helpdesk, 4 registration specialists 1 registration supervisor that also performs registrations Review/Registration Process: We currently have 15,500 pesticides registered, and of these 895 (5.8%) are spray adjuvants. Washington state regulates spray adjuvants as pesticides. (This same staff also maintains and registers fertilizers—we have about 10,000 registered currently.) Spray adjuvants are our most difficult and most time-consuming registration type. There is no federal oversight, so all the review is done within our program. We also require the complete formula to be submitted, which can be challenging if a registrant is using a 100% repack of someone else's "proprietary" formula. We also have difficulties getting an acceptable label that meets WA state laws and rules. You probably also know that there are only a few states that register spray adjuvants—and that WA and CA do the most intensive review. California review is data focused, and Washington state review is label focused. We do not allow any adjuvant to be used aquatically unless data is submitted. In this case, everything gets sent to our agency toxicologist for his review and approval. I have heard that most spray adjuvant registrants will get their product approved in WA and CA, and then will submit them to other states. The other states (knowing that they passed the test in WA and CA) will register without much review.

	Estimates of FTEs: .10 FTE for Pre-registration/help desk: time spent making sure application is complete (confidential statement of formula, safety data sheet.) Staff are Customer Service Specialists FTE for Registration: application review, proper labelling, verifying ingredients, chasing down the complete formula, corresponding with registrants, component suppliers, manufacturers. Staff are Senior Registration Specialists .05 FTE for Tox review. Staff is a Senior Toxicologist Total is about 1.15 FTE for us. I think it gives you a good flavor that spray adjuvants at 3.5% of our total (pesticide and fertilizer) registrations requires over 16% of our staff resources.
Wyoming	Department only has one person designated to product registration.

In sum, as modeled by states, spray adjuvants may be regulated by: 1) creation of a statutory and regulatory rubric that allows for adjuvants to be regulated by the controlling pesticide agency, including key definitions and collection of fees equivalent to pesticide registrations; 2) collecting spray adjuvant information in a manner similar to the pesticide registration process; and 3) requirement (by some states) of copies of confidential statements of formula. The degree to which states review pesticide product registration and adjuvant registration applications is directly dependent upon the availability of dedicated staff. Maine has dedicated 0.75 FTE to pesticide product registration, and the BPC is currently in the process of hiring an additional full-time FTE to better address existing registration and water quality monitoring responsibilities. Any additional staff time required for adjuvant registration application review will be additive to existing responsibilities and it should be noted that some states dedicate staffing for this purpose.

Should Maine require registration for the approximately 870 spray adjuvants registered in Washington State, implementation would likely require at least one FTE to process new applications. The increased staff demand depends on the extent of the review required. Registration of adjuvants will add to the inspection workload, referrals to the registration specialist, and follow up with companies.

If adjuvants will be registered and defined as pesticides, then registration will be subject to registration requirements for pesticides such as label review unless the statute specifically exempts spray adjuvants from label review. Review will require time and likely follow up with companies regarding label and CSF deficiencies.

VI. A Feasible Definition of PFAS Adulteration

For BPC to enforce regulations specific to PFAS adulteration, there first needs to be an established definition of PFAS. Further, established and efficacious methods must also be available to detect the presence of PFAS for enforcement purposes.

A. Variety of Possible PFAS Definitions

BPC staff explored a variety of different PFAS definitions. Appendix E contains a list of alternative definitions for PFAS categorization that were discovered in this process. However, the BPC public policy board has moved to adopt the PFAS definition established with LD 1503 (http://www.mainelegislature.org/legis/bills/getPDF.asp?paper=HP1113&item=5&snum=130), hereafter referred to as the "State's definition." The State defines PFAS as "one fully fluorinated carbon"; this definition is similar to several PFAS definitions from relevant authoritative bodies (e.g., EPA's Office of Pollution Prevention and Toxics and Organization for Economic Co-organization and Development (OECD), but it is not precisely the same. The state's definition includes a greater variety of compounds than the definition used by BPC's federal counterpart.

LD 1503 requires manufacturers of products with intentionally added PFAS to report the presence of those substances in those products to DEP beginning in 2023, and those products may not be sold after 2030, with limited exceptions. Adopting the definition established in LD 1503 will aid harmonization of State rules. In addition to being subject to LD 264, pesticide products are also subject to the reporting requirements of LD 1503. Given the broad reach of LD 1503, compliance will be aided by using a singular definition. To further assist compliance, BPC is communicating with pesticide registrants regarding their obligations under LD 1503.

i. Enforcement Limitations

Currently, there is not a suite of methods available that enables testing for all PFAS in pesticide products. The delegated enforcement authority granted by the cooperative agreement with EPA demands properly executed and repeatable sample testing methodologies. In the fall of 2021, EPA released approved test methodology suitable for PFAS in oily-based pesticide products. This new method, an adaptation of EPA method 537.1, identifies 28 unique PFAS and is available at: https://www.epa.gov/system/files/documents/2021-09/epa-pfas-method-in-oil.pdf. Hence, while BPC can collect affidavits regarding PFAS during the registration process, there currently exists only limited testing capabilities to detect the presence of the compounds in actual pesticide products.

There are somewhere between three to 190 constituents currently in pesticide products and adjuvants that may become classified as PFAS under the new definition referenced in LD 1503. Their presence is currently legal, but should they be become State prohibited, enforcing against them may prove to be difficult. One approach to establishing their presence could be following up on CSF records submitted to the BPC. The other approach, analytical testing, is more difficult for several reasons. Current analytical capabilities could only identify 28 of the 12,039 PFAS known to exist. Furthermore, even if it was possible to analytically identify all known PFAS, enforcement would be prevented due to a lack of regulatory allowable limits for each of the compounds. Given the background concentrations of PFAS found in many media, allowable thresholds need to be set before adulteration could be defined for enforcement purposes.

ii. Regulating PFAS As a Class

One approach to accommodate the uncertainty associated with this large class of chemicals has been to treat all PFAS as one class. While this is a simpler and seemingly easier approach, it is not consistent with current chemical regulations which are based on risk. Lumping PFAS into a single group ignores that they are likely to have differing effects in the body as well as differing movement through the environment. In Vermont, this approach was assessed but not endorsed because of the lack of toxicological data and lack of test methods for all the potentially regulated compounds, among other factors (https://dec.vermont.gov/sites/dec/files/PFAS/20180814-PFAS-as-a-Class.pdf).

Pesticide active ingredients are described in published literature at a level of detail not seen for thousands of PFAS chemicals, and many of the concerns surrounding PFAS are addressed as part of the pesticide registration review process. For pesticide registrations, there is publicly available information that describes toxicity and environmental fate in a way not seen for most PFAS. For example, a concern with PFAS is persistence in the environment--the amount of time it takes a pesticide to break down in the environment is required information for every pesticide registration. Of the federal laws that regulate chemicals, the Federal Insecticide Fungicide and Rodenticide Act (FIFRA) that regulates pesticides is more restrictive and transparent than the Toxic Substances Control Act (TSCA) that regulates general and industrial chemicals, like PFAS.

iii. Federal Approach to Adulteration in Pesticides

Currently, pesticide registrants are required (under FIFRA Section 6(a)(2)) to submit information to EPA when they discover or are made aware of PFAS in their products. This requirement under FIFRA stipulates manufacturers and registrants must report to EPA any known adulteration issues. PFAS are classified as adulterants because EPA has indicated 'any level of PFAS to be potentially toxicologically significant' in pesticide products. Therefore, when pesticides contain any amount of PFAS, reporting due to product adulteration is triggered under 40 CFR 159.179(b)(2). Adulteration by contaminants and impurities under FIFRA is set with the following criteria from 40 CFR 159.179(b):

(1) Quantities greater than 0.1 percent by weight (1,000 parts per million).

(2) Quantities that EPA considers, and so informs registrants, to be of toxicological significance.

(3) Quantities that the registrant considers to be of toxicological significance.

(4) Quantities above a level for which the registrant has information indicating that the presence of the contaminant or impurity may pose a risk to health or the environment.

(5) Quantities that a person described in § 159.158(a) has informed the registrant is likely to be of toxicological significance.

VII. What Is Necessary to Prohibit Distribution and Application of Pesticides & Adjuvants Containing PFAS?

A. Current state and federal laws

i. Pesticides

Current Maine law allows the BPC to collect CSF information for pesticide products as part of the annual registration process. Assessing each product against a list of prohibited PFAS could occur once the MEPERLS development work is completed. The newly enacted affidavits, in combination with the new CSF submission requirements, provide a mechanism to identify all pesticide products with intentionally added PFAS.

ii. Spray adjuvants

Currently, Maine does not regulate spray adjuvants. Authority to the state to regulate spray adjuvants would need to be established by the Legislature. A mechanism used in other states is to re-define pesticides in a manner that specifically brings in spray adjuvants. A clear statement of prohibition of PFAS chemicals in spray adjuvant products would further be required to create a prohibition of PFAS intentionally added to spray adjuvant products.

iii. Containers

Current state and federal law allows the use of HDPE containers that have been fluorinated in many applications, including for pesticide and spray adjuvant packaging. EPA has asked pesticide companies to voluntarily stop this practice and to seek alternative packaging. Certain products have been pulled from shelves and none of the products associated with PFAS adulteration from containerization are available on the market. The newly enacted affidavits identify pesticide products contained in fluorinated HDPE containers. A clear statement prohibiting the use of fluorinated HDPE containers at any stage of pesticide product storage would be required to prohibit the use of these containers.

B. Related State Laws

LD 1503 will prohibit PFAS chemicals as intentionally added components in pesticides starting in 2030. However, DEP may allow for a product with intentionally added PFAS to be sold if such product's use of PFAS is designated as "unavoidable" by DEP.

For registered pesticides, the prohibition of distribution of items containing intentionally added PFAS, as detailed in LD 1503, would also effectively ban use of the same in Maine unless DEP were to find their use "unavoidable." If sale is prohibited, however, pesticide registration could not occur, and under Maine State law, all pesticides must be registered in order to be lawfully used.

Helpful Resources:

Spray Adjuvants-

Winand Hock, PH.D., Pennsylvania State University https://extension.psu.edu/spray-adjuvants

PFAS Definitions-

Office of Pesticides Programs page on PFAS in pesticide packaging: https://www.epa.gov/pesticides/pfas-packaging

OECD recent publication: https://www.oecd.org/chemicalsafety/portal-perfluorinated-chemicals/terminology-per-and-polyfluoroalkyl-substances.pdf

PFAS General-

OECD Portal on Per- and Poly-fluorinated Chemicals https://www.oecd.org/chemicalsafety/portal-perfluorinated-chemicals/

Advance Notice On The Regulation Of Perfluoroalkyl, Polyfluoroalkyl Substances (Pfas) As A Class. Vermont Agency Of Natural Resources Department Of Environmental Conservation Drinking Water And Groundwater Protection Division. August 14, 2020. 11pp. https://dec.vermont.gov/sites/dec/files/PFAS/20180814-PFAS-as-a-Class.pdf

Bulk Pesticide Distribution-

EPA: A two-page brochure on refilling issues with the container and containment rule is available at: https://www.epa.gov/sites/default/files/2015-05/documents/ccrule-brochure.pdf

APPROVED	CHAPTER
JUNE 21, 2021	83
BY GOVERNOR	RESOLVES

STATE OF MAINE

IN THE YEAR OF OUR LORD

TWO THOUSAND TWENTY-ONE

H.P. 185 - L.D. 264

Resolve, Directing the Board of Pesticides Control To Gather Information Relating to Perfluoroalkyl and Polyfluoroalkyl Substances in the State

Sec. 1. Board of Pesticides Control to amend rules relating to registered pesticides. Resolved: That the Department of Agriculture, Conservation and Forestry, Board of Pesticides Control shall amend its rules governing the registration of pesticides in the State to require manufacturers and distributors to provide affidavits stating whether the registered pesticide has ever been stored, distributed or packaged in a fluorinated high-density polyethylene container and to require manufacturers to provide an affidavit stating whether a perfluoroalkyl or polyfluoroalkyl substance is in the formulation of the registered pesticide.

Sec. 2. Board of Pesticides Control to gather information relating to perfluoroalkyl and polyfluoroalkyl substances. Resolved: The Department of Agriculture, Conservation and Forestry, Board of Pesticides Control shall conduct a study to determine if fluorinated adjuvants are being used or sold in the State. The board shall explore what is needed to regulate fluorinated adjuvants in the State and shall explore what is necessary to impose a prohibition on the distribution or application of pesticides or adjuvants containing perfluoroalkyl or polyfluoroalkyl substances in the State. The board shall develop a feasible definition of perfluoroalkyl or polyfluoroalkyl adulteration in a pesticide. The board shall submit a report based on the study with findings and recommendations to the Joint Standing Committee on Agriculture, Conservation and Forestry no later than January 15, 2022. The joint standing committee may submit a bill to the 130th Legislature relating to the subject matter of the report.

Appendix B EPA Email Response Clarifying Risk Assessments For Adjuvants and Spray Adjuvants

Email Response from EPA:

<u>Spray adjuvants are not pesticides and not covered under FIFRA, right? Tolerances are set for those spray adjuvants to be used on ag commodities but that comes from FFDCA and FQPA, right?</u>

When evaluating a pesticide product for registration under FIFRA, EPA considers the proposed directions for use as well as widespread and commonly recognized practice of how it is used. That consideration may include how an adjuvant affects the use of the pesticide. Although adjuvants are not registered as pesticides, they are still regulated because adjuvants are chemicals added to a pesticide by users to improve the pesticide's efficacy. Such agents are often included in pesticide formulations as "other ingredients," in which case the ingredient is reviewed during registration and any necessary tolerances or exemptions from the requirement of a tolerance are established. Where a product label directs the user to add a particular adjuvant before use, the registering division will treat that adjuvant as if it were an "other ingredient" in making the registration decision, and will assure that any necessary tolerances or exemptions from the requirement of a tolerance are established. It also would be within the Agency's authority to treat any tank-mixed substance as part of the pesticide (and thus needing an FFDCA tolerance) in that it met the FIFRA definition of pesticide – i.e., a "mixture" of substances intended to kill a pest. See Chapter 1 of the Pesticide Registration Manual.

<u>I feel like inert/other ingredients are covered under FIFRA but registration is not required, is that true? and if so, is the same true for spray adjuvants? How can I find the requirements for tolerance setting on spray adjuvants and inert/other ingredients?</u>

EPA registers pesticide products, i.e., a product that includes a pesticidal active ingredient and any inert or other ingredients that make up the whole formulation. The registration of pesticide products under FIFRA include a determination that the pesticide product formulation meets the registration standard under FIFRA section 3 (including the lack of unreasonable adverse effects on the environment). The entire formulation, including the inert ingredients, must meet this standard. Inert ingredients themselves are not registered under FIFRA; the same applies to adjuvants. In addition, the Federal Food, Drug, and Cosmetic Act (FFDCA) requires that pesticide chemical residues, including any active ingredient and inert ingredients in pesticide products, used on food and feed crops, agricultural commodities, or livestock must have a tolerance or tolerance exemption under 40 CFR Part 180. See Chapter 8 of the Pesticide Registration Manual. Approved inert ingredient tolerances and tolerance exemptions are found in the Code of Federal Regulations (CFR) under 40 CFR Part 180. Links to inert ingredients approved for nonfood uses are listed on the Inert Ingredients Web page.

If the use of an adjuvant may result in detectable residues on food, the applicant should contact the EPA product manager or registration ombudsman (Chapter 21) prior to submitting the application to discuss the potential need for a tolerance. See Chapter 11 of the Pesticide Registration Manual; and Code of Federal Regulation, Title 21 Part 178 –Indirect Food Additives: Adjuvants, Production Aids, and Sanitizers

Continued… Email Response from EPA:

For spray adjuvants not intended for ag commodities what authorization are they regulated under?

If an adjuvant is listed on the product formulation, it would be evaluated by EPA as part of the overall formulation. If it is not listed as part of the product formulation, and there is no expectation of residues in or on food as a result of the use of the pesticide (e.g., because it is not intended to be used on food crops), then EPA would not regulate its use. Generally, it is likely that the adjuvant would be identified on the label, and so there might be some consideration of the adjuvant as part of the reviewing the label. This guidance on inert ingredient for non-food use may be helpful insight for an example of a process that could apply to an adjuvant. Inert ingredients guidance for new nonfood use (pdf)

Appendix C List of Registered Adjuvant Products in Other States (Arkansas, Tennessee, & Washington)

Arkansas

3M 6000 Copper Granules
3M 7000 Series Copper Granules
Water Bath Additive
c-series Water Bath Additive
Ultima Total Control Shock and Algaecide
Ultima Nix
Ultima Platinum Plus
Aqua Silk Algaecide
Ultima TKO
Ultima Swamp to Swim I
Ultima Yello-Free Algaecide
Salt Solutions by Ultima Algaecide
Aqua Silk Alage Control
Ultima Swamp To Swim (Kit)
AEM 5772 Antimicrobial
Bug Out Sticks
Stabrom 909 Biocide
Clarifect
Clor Mor Calcium Hypochlorite 3 Inch Tablets
Clor Mor Cal-Shock Cal Hypo Granules
E-Z Clor Quick Dissolve
E-Z Clor Mustard Algae Plus
Super Shockwave Shock Treatment
Re-Fresh+
E-Z Clor Algaecide Plus
Pool Logic Think Clear Solution 60
Regal Pool Care System Brom-A-Gard
Regal Pool Care System Algaezone Plus
Poolstyle Pool Products 3" Triple Action Tabs
Poolstyle Pool Products Bright Shock
Pool Season Brominating Tablets
Re-Fresh
Re-Fresh Dry Chlorinating Granular
Super Shock-It 73
Regal Pool Care System Algaecide 60
Regal Pool Care System Poly-Algaecide 30
Regal Pool Care System Algaecide 50
Regal Pool Care System Granular 90
Pool Season Algae Control 60
E-Z Clor Algaecide
Pool Season Algae Control 30
Pool Season Super Algae Destroyer
Pool Logic Think Clear Brominating Tablets
Pool Season Concentrated Algae Kill II
Alligare 8% Copper
Argos
AB Brand Copper Sulfate Crystals
Algimycin-PWF
Algaecide/Cyanobacteriocide
Black Algaetrine
Cutrine Ultra
CutrinePlus Algaecide/Herbicide
CutrinePlus Granular Algaecide
Algaetrine
Pooltrine 60
Swimtrine 7.4
Wintertrine
Applied Biochemists Phycomycin SCP Algaecide/Cyanobacteriocide
Super Algi-Gon
Clearigate EC9
Swintrine 90
Applied Biochemist Power Blast 70
Applied Biochemist Power Blast II
Cutrine Plus Algaecide
Silvertrine
Applied Biochemists 3" Tablets
Applied Biochemist Granular
Applied Biochemists Chlorinating Capsules
Applied Biochemists Triple Action Tablets
Phycomycin-SCP Algaecide & Oxidizer
Stocktrine II Algaecide
Swimtrine Plus
Algi-Cure Algaecide
YELLOWTRINE
Clearigate
Aquamira Water Treatment
Aquashade Aquatic Plant Growth Control
Baquacil Algicide
Baquacil Performance Algicide
Chlorine-Free Care Free Baquacil AD Auto Dosing System
Chlorine-free Care Free Baquacil AD Automated Dosing System
Com Chlor 3" Stabilized Chlorinating Tablets
Constant Chlor Plus Calcium Hypochlorite Briquettes
HTH Pool Care Liquid Chlorine
HTH Pool Care Algae Guard Advanced
HTH Pool Care Algae Guard 10
HTH 3" Chlor Tabs
HTH Pool Care Algae Guard 30
HTH Pool Care Algae Guard Granules
HTH Pool Care Algae Guard Ultra
Poolife Exclusive Pool Care Collection Complete Control Shock and Algaecide
90 Years of HTH Perfect Pools Ultimate 3" Chlorinating Tablets
90 Years of HTH Perfect Pools Ultimate Algae Guard
90 Years of HTH Perfect Pools Algae Guard 30
90 Years of HTH Perfect Pools 1" Chlorinating Tablets
Constant Chlor Plus Marathon Tablets
90 Years of HTH Perfect Pools Liquid Chlorinator
Chlorine-Free BaquaSpa Start-Up Kit
Poolife Exclusive Pool Care Collection NST Patrol
Poolife Exclusive Pool Care Collection NST Purge
Poolife Exclusive Pool Care Collective NST Prime
90 Years of HTH Perfect Pools Floater
90 Years of HTH Perfect Pools Shock! Treatment
90 Years of HTH Perfect Pools 3 Inch Chlorinating Tablets
90 Years of HTH Perfect Pools Pre-measured Water Soluble Pods Algae Guard
90 Years of HTH Perfect Pools Water Soluble Pods Shock!

90 Years of HTH Perfect Pools Ultimate Shock! Treatment
90 Years of HTH Perfect Pools Pool Care Kit for Opening/Closing
90 Years of HTH Perfect Pools Super Green to Blue Shock System
90 Years of HTH Perfect Pools Algae Guard Granules
90 Years of HTH Perfect Pools Super Algae Guard
90 Years of HTH Perfect Pools Super 3" Chlorinating Tablets
90 Years of HTH Perfect Pools Super Green to Blue I
90 Years of HTH Perfect Pools Super Shock! Treatment
90 Years of HTH Perfect Pools Ultimate Mineral Brilliance Chlorinating Granules
HTH Salt Pool Care Algaecide
Pool Breeze Pool Care System Defender
Pool Breeze Pool Care System Extra
Pool Breeze Pool Care System Opticide
90 Years of HTH Perfect Pools Algae Guard 10
90 Years of HTH Perfect Pools Chlorine Granules
HTH Super Green to Blue I
HTH Super Shock Treatment
HTH Ultimate Shock Treatment
HTH Ultimate Algae Guard
Pace Premier Shock Treatment
Poolife Exclusive Pool Care Collection Algaecide 90
HTH Pool Care Kit
HTH Algae Guard 10
HTH Algae Guard 30
HTH Shock Treatment
HTH Super 60 Shock Treatment
HTH Super Algae Guard 60
Pool Breeze Pool Care System Algae Clear
Pace 3" Chlor-Tabs
HTH Algae Guard Granules
Baquacil Select Algicide
Reputain D20 Preservative
Pond Oasis Algaecide
Poolife Exclusive Pool Care Collection Back to Blue 1
Pool Breeze Pool Care System Yellow Eliminate
HTH Super Algae Free
Densil ZOD Antimicrobial
Dry Tec Extra Shock
HTH Green to Blue Super Shock I
Poolife Exclusive Pool Care Collection Defend +
HTH Pool Shock
Reputain D20 Antimicrobial
HTH Clear Shock
HTH Super Shock Treatment
Reputain B30 Preservative
Poolife Exclusive Pool Care Collection AlgaePhos Algaecide
Baquacil Algidefense
Open/Close Algistat
HTH Super 3" Chlorinating Tablets
Outlast Mold-Buster Additive
Poolife Exclusive Pool Care Collection Brite Stix
Pool Breeze Pool Care System Start-up & Winterizing Algicide
HTH Algaeguard 3x Concentrate
Poolife Exclusive Pool Care Collection AlgaeBan II
Poolife Exclusive Pool Care Collection Mustard Algae Treatment
Pool Breeze Pool Care System Super AlgiKill
Poolife Exclusive Pool Care Collection AlgaeKill II
Poolife Exclusive Pool Care Collection Instant Clear Cleaning Granules
Poolife Exclusive Poolife Rapid Shock Shock Treatment
Poolife Exclusive Pool Care Collection Super AlgaeBomb 60 Algaecide
Poolife Exclusive Pool Care Collection Turboshock Shock Treatment
Poolife Exclusive Pool Care Collection Super Shock 'N Swim Shock Treatment
Pulsar Plus Calcium Hypochlorite Briquettes for Commercial Swim Pool Use
Reputain K50 Preservative
HTH Spa Shock
HTH Super Algae Guard
Poolife Exclusive Pool Care Collection Active Cleaning Granules Chlorinator
Poolife Exclusive Pool Care Collection AlgaeBomb 30 Algaecide
Poolife Exclusive Pool Care Collection Cleaning Sticks Stabilized Chlorinator
Poolbreeze Pool Care System Algicide 60
Proxel BD 20 Industrial Microbiostat
Proxel GXL Industrial Microbiostat
Pulsar Power Shock
Pool Breeze Pool Care System Granular Shock Treatment
Proxel AQ Preservative
Pool Breeze PCS 3" Chlorinating Tablets
Pool Breeze PCS Algicide
Pool Breeze PCS Chlorinating Granules
Pool Breeze PCS Chlorinating Sticks
Pool Breeze PCS Granular 68
Pool Breeze PCS Shock Treatment & Superchlorinator
DryTec Calcium Hypochlorite Briquettes
Dry Tec Calcium Hypochlorite Granular
HTH Liquid Chlorinator
HTH Shock 'N Swim
HTH Spa Brominating Tablets
HTH Spa Non-Foaming Algaecide
Omni Algae Terminator
Omni Multi-Purpose Algaecide 60
Synergy Tabs
Omni Algae Preventative 40
Winter Care Winter Algaecide 40
Omni Breakout 60
Myacide AS Plus
Myacide AS Technical
Myacide GA 50
Myacide GA 25
MasterLife AMA 100
Admiral WSP
Admiral Liquid
Green-Shield II Disinfectant & Algicide
Bellacide 350
Bellacide 355
Bellacide 325
Bellacide 301
Bellacide 300
Bellacide 355W
Bellacide 364
Bellacide 337
LiquiBrom 4300
LiquiBrom 4000
LiquiBrom 4600
Bellacide 300W
Bellacide 150
Bellacide 311
Magnacide B Microbiocide
X-Cide 102
X-Cide 137
X-Cide 302

X-Cide 105 Industrial Bactericide
X-Cide 120 Industrial Bactericide
Bayer Advanced 2-in-1 Moss & Algae Killer Ready-To-Spray
Algaecure Algaecide for Ponds and Fountains
Algaecure
Pro Guard 60% Algicide
Pro Guard Algae Predator
ProGuard Copper Algicide
SoftSwim Algicide A
SpaGuard Oxidizer Enhance Shock
BioGuard Inhibit Algae All 60
BioGuard Arctic Blue Winter Kit 12
BioGuard Arctic Blue Winter Kit 24
Pro Series Algaecide
Pro Series Dual-Action Algaecide
BioGuard Inhibit Back Up 2
BioGuard Maintain Brominating Tabs
BioLab T-0041
SoftSwim A
BioGuard Algae Complete
BioGuard Arctic Blue Algae Protector
Algae makes me mad! Angry Egg Algaecide
BioGuard Burnout 73
BioGuard CLC Classic
ProGuard Calcium Hypochlorite Granular
BioGuard Salt Scapes Saltwater Pool Care Algae Remover
BioGuard Remedy Banish
BioGuard Maintain Smart Shock
BioGuard Inhibit Algicide 28-40
BioGuard Off Season Winter Algicide
BioGuard Remedy Spot Kill
BioGuard Maintain Power Chlor
BioGuard Maintain Super Soluble
BioGuard Off Season Artic Blue Algae Protector
GreenClean Granular Algaecide
GreenClean FX Liquid Algaecide
GreenClean Pro
ZeroTol 2.0
SaniDate 12.0
GreenClean Liquid 5.0
ZeroTol HC
Spa Selections Algaecide
Spa Selections Maintenance Kit
Bonide MossMax RTS
Brandt T.A.C.
Liquid Copper Sulfate
KTND
WSCP
Busan 1215
Bulab 8861
Busan 1202
Busan 77
Busan 85
Bulab 6004
Coolacide
MB-1000
MB-60B Granules
Bacticide-45B
MB-1563B
MB-215
Check-Mark 40224
Copper Sulfate Crystals
SCI-62 Algicide/Bactericide
CB-3939
Chem-Aqua 42171
Chem-Aqua 40215
Chem-Aqua 42100
Chem-Aqua 40420
Chemical Treatment CL-2150
Chemical Treatment C-2185
ChemTreat C-2188
Chemical Treatment CL-206
ChemTreat CL-49
Chemical Treatment CL-215
Chemtreat CL2490
Chemtreat CL-2062
ChemTreat CL2065
ChemTreat CL 2250
ChemTreat CL497
ChemTreat CL-2206
ChemTreat CL-25
ChemTreat CL2155
ChemTreat C-2183T
Chemtreat CL-4907
ChemTreat CL-2030
ChemTreat C-206T
ChemTreat CL-2427
Chemtreat C2063T
BioTreat 8405
CDB Clearon Granular Industrial Water Biocide
ClearGold Tablets
Easy Pool Care Technology
Bio-Clear 1000
Bio-Clear 2000
Bioclear 2500 Antimicrobial
BioClear 2250 Antimicrobial
BioClear 1430 Antimicrobial
BioClear 2256 Antimicrobial
Bio Clear 5000
CYPHOS 3453W Phosphonium Salt
Plexcide P5S
TOLCIDE TP5
TOLCIDE TP50
Decco Ag PAA
Formula F-30 Algae Control
B.I.O. Blast 500
GAX-26
AquaVet Algae Control
AquaVet Copper Sulfate Algae Control
Ercopure 25
Ercocide CP
Ercopure 31
Pristine Blue
Agritec
Algae Shield
Cleanwater Blue
Earthtec
Aqua Balance Poly 60
Boost 3000
Oxxium 203
Surpass 100
Tsunami 100
WCS 102
Algaway 60
Microbe-lift Algaway 5.4
Microbe-Lift Algaway 5.4 (For Ponds)
Microbe-Lift Algaway 5.4 (For Aquariums)
BromMax 7.1
ENVIROBROM G
BromMax
Enviro-Brom Tabs
Peragreen 22
BCDMH Tabs
Bromide-Plus
Peragreen 22WW
Perasan OG
Peragreen WW
EnviroChlorite 15
ChlorCide
Peragreen 15%
Essick Air Humidifier Bacterostatic Treatment
B-Cap 35 Antimicrobial Agent
B-Cap 27 Antimicrobial Agent
B-Cap 34 Antimicrobial Agent
Vigorox SP-15 Antimicrobial Agent
VigorOx Oil & Gas
VigorOx 15/23 Antimicrobial Agent
VigorOx Oil & Gas1
VigorOx Oil & Gas Plus1
Quimag Quimicos Aguila Copper Sulfate Crystal
FQS 1.5 Microbicide
Spec-Aid 8Q704 (Stick)
Spectrus CT1300
Spectrus NX102
Spectrus NX1100
Spectrus NX1103
Spectrus NX1104

Spectrus OX103
Spectrus TD1100
iSolv Bio 2000
iSolv BIO1010
Spec-Aid 8Q704 (Stick)
Spectrus NX102
Spectrus OX101
Spectrus OX9200
Spectrus TD 1000
Biomate MBC 781
Biomate MBC 2881
Spec-Aid 8Q5700ULS
Spec-Aid 8Q703ULS
Spectrus NX1107
Spectrus OX103
Spectrus NX 1101
Spectrus NX 1102
Spectrus OX 1202
Spectrus OX101
Spectrus OX105
Spectrus OX1200
Spectrus OX909
Spectrus NX1106
Spectrus OX1201
SHOXIDIZER
Algimycin Winter
Super Charge II
GLB Triple Tab
Algae-X
Sirona Spa Care Bromine Start-Up Kit
GLB Dual Control Shock and Algaecide
GLB Nix
GLB Yello-Free Algaecide
GLB Aqua Silk Algaecide
GLB Swamp to Swim I
GLB Swamp to Swim Shock System
Bromine-Free Chlorine-Free Sirona Spa Care Simply Start-Up Kit
Algimycin 600
GLB 3 Part System Pool Closing kit
Spot Gone II
Super Charge
GLB Endura
Sirona Spa Care Spa Minerals
GLB Algimycin 3000
Rendezvous Spa Specialties Deluxe Chlorinating Spa Care Kit
GLB Sonic Blue Multipurpose Shock
Rendezvous Spa Specialties Deluxe Brominating Spa Care Kit
Algimycin 1000
Algimycin 2000
Formula 315
Formula 325
Formula 3051
Formula 318
Formula 3340
Formula 3230
BARDAC 2210
BE-6 Industrial Bactericide
Aldacide G
BE-9
BE-9W
Biobor JF
Sodium Hypochlorite Solution 10%
Sodium Hypochlorite 12.5%
Freestyle Calcium Hypochlorite 65
ProTeam Supreme
Proteam Mustard & Black Magic
Proteam Quick Shock
ProTeam Prevent
ProTeam Severest Algae Treatment
ProTeam Polyquat 60
Swim Clear Black Algaecide
Swim Clear Super Algaecide
Swim Clear Jumbo Tabs
ProTeam Power Magic AC+ Superoxidizer
Proteam Power 73
Proteam Polyquat 30
Aquamate Algaecide 30
Aquamate Algae Control
Proteam Mustard & Black Magic
Quick Shock
Spa Pure Brominating Tabs
Haviland Algae Kil 50
Haviland Algae Kil CB 7
Haviland Mustard Eliminator
ProTeam Poly Magic
Aqua Hawk CU
Spectrum RX9800
Biosperse 250
Spectrum XD8800 Microbiocide Agent
Spectrum RX3500 microbiocide agent
Biosperse 271 microbiocide
Biosperse XD9400 microbiocide
Spectrum RX9600 Microbiocide Agent
Biosperse CX1150 Microbiocide
Spectrum RX3101 Microbiocide Agent
Spectrum RX6800 Microbiocide Agent
Biosperse CX9071 Microbiocide
Biosperse 515 Microbiocide
Biosperse CN8109-NA Microbiocide
Spectrum RX3510 Microbiocide Agent
Biosperse CX9989 Microbiocide
Spectrum RX9500 Microbiocide Agent
Biosperse CX3400 Chlorine Stabilizer
Spectrum RX7845-NA Microbiocide Agent
Biosperse XD9411 Microbiocide
Spectrum RX6805 Microbiocide Agent
Biosperse CN6500 Microbiocide
Biosperse CN7539 Microbiocide
Biosperse CX7250 Microbiocide
Biosperse CN8450 Microbiocide
Biosperse CX3195 Chlorine Stabilizer
Spectrum XD1878 Chlorine Stabilizer
Biosperse CN2150 microbiocide
Biosperse CN4200 microbiocide
Biosperse CN5500 Microbiocide
Biosperse CN8059 microbiocide
Biosperse CN8109 microbiocide
Biosperse CX9969 Microbiocide
Biobrom C-103L
Fuzzicide Solution
Sodium Bromide-comp
Biobrom C-103
AR900 Series Algae Resistant Roof Granules
Copper Color Guard Algae-Resistant Roofing Granules
In The Swim Calcium Hypochlorite
In The Swim Algaecide
In The Swim Super Algaecide
In The Swim Algae Clear
In The Swim Super Pool Shock
In The Swim Pool Shock
In The Swim 1-Inch Tablets
In The Swim Sticks
In The Swim Algaecide 50
In The Swim Black Algaecide
In The Swim Winter Algaecide
In the Swim Di-Zap
Predator 5000
Ercopure BCD-25
Ercopure BCD-7.5
Micron CSC (Various Colors)
Interspeed 640 (Various Colors)
Regatta Baltoplace Racing Finish
VC-Offshore (Various Colors)
Fiberglass Bottomkote Racing Bronze Y999
Interspeed 340NA BQA357 Red
Aqua-One (Various Colors)
Micron WA (Various Colors)
Micron Navigator (Various Colors)
Micron Extra SPC (Various Colors)
Ultra (Various Colors)

Inerlux Micron CSC HS (Various Colors)
Super ProGuard (Various Colors)
ProGuard Ablative (Various Colors)
MicronCF (Various Colors)
MICRON OPTIMA (Various Colors)
Interspeed 5640 (Various Colors)
Trilux 33 (Various Colors)
Pacifica Plus (Various Colors)
ACT with SLIME FIGHTER (Various Colors)
Fiberglass Bottomkote NT (Various Colors)
Interspeed 6400NA (Various Colors)
Micro Extra (Various Colors)
Copper Powder V901
Copper Powder V900
VC17m Extra (YBA405 & 406)
VC17m Extra YBA407 Red
Trilux 33 (Various Colors)
Jack's Magic The Yellow Stuff
Jungle No More Algae Tank Buddies
Jungle Pond Algae Relief
Micropur MP 1
AMA-3725
AMA-424
AMA-350
Fennosurf 586
FennoSan Q-10
AMA-1750
New Water Cycler Pac
Frog Bam
Aqua Smarte Chamber
Frog Leap ALL-OUT
Aqua Smarte Plus Cannonball!
Oxi-King Brom Pac
FROG Pool Tender Chlorine Chamber
FROG Pool Tender Algaecide
FROG Pool Tender Mineral Chamber

Valvtet Marine Premium Diesel Additive with BioGuard Microbiocide
Valvtect Bioguard PLUS 6
Ultima SR-40 Ablative A/F Bottom Paint (various colors)
Pettit Hydrocoat Ablative Antifouling Paint (various colors)
Pettit Pontoon Pro Copper-Free Antifouling Paint-Black
Pettit Hydrocoat ECO Copper Fee Multi-Season Ablative (various colors)
Pettit Neptune 5 Hard Hybrid Ablative Antifouling Paint (various colors)
Pettit HRT Hybrid Reactive Technology ECO Antifouling Paint - Black
KR-153-SL
KR-148NL
Leslie's Swimming Pool Supplies Algae Control
Poolfresh 3" Tablets
Leslie's Swimming Pool Supplies Power Powder Plus 73
Leslie's Swimming Pool Supplies Copper Algaecide
Leslie's Swimming Pool Supplies Black Algae Killer
Leslie's Swimming Pool Supplies Power Powder Granular 70
In the Swim 3-Inch Tablets
In The Swim Algaecide 60 Plus
In The Swim Chlorinating Granules
Leslie's Pool Supplies Service & Repair Power Powder Pro 73
Tektamer 38 A.D.
N-2000 Antimicrobial
Antimicrobial N20
Veriguard 3003
N-922 Antimicrobial
N-5033 Antimicrobial

Leisure Time Spa Algaecide
Dantochlor RW
Dantobrom RW
Dantogard Preservatives
Dantogard XL-1000
Dantogard Plus Industrial Preservative
Isocil
Densil FZ Antimicrobial
Triadine 20 - Lonza Industrial Microbiostat
Lonza Reputain D20 Bactericide
Lonza Reputain B30 Preservative
Isocil IG-C
Dantoin BCDMH RW Tablets
Bardac 2250M
Lonza Microbiocide 50
Barquat Low Foam Additive
Bardac 2250 Microbiocide
Isocil RW
Dantogard Plus Liquid
Bardac LF 18-50 WT
Bardac LF 1880
Bardac LF 1850
Barquat Low Foam Algaecide
Direx 4L 24(c)
Algae Destroyer Advanced
AlgaeFix
Pond Care Algae Destroyed Advanced
Pond Care Algae Fix
Microbial Algae Clean
Top Fin AlgaeGone
API Pond Algaefix
API Marine Algaefix
AquaTrol 12601
MC B-8802
MC B-8805
MC B-8807
MC B-8520
MC B-8501
MC B-8904
BC-2545

MC B-8614A
MC B-8625A
MC B-8626A
MC B-8642A
MC B-8650A
MC B-8910
MC B-8901
MC B-8626
BC-40
BC-118
BC-215
NAVA Quick Dissolving Shock
NAVA Yellow Algae Remover
Member's Mark Quality Guaranteed Algaecide 40
Member's Mark Quality Guaranteed Chlorinating Granules
Member's Mark Quality Guaranteed Chlorinating Tablets
Star Plus 3" Jumbo Tabs
Poolbrand Quick Dissolving Shock
Star Plus 8-Ounce Sticks
Star Plus Dichlor Granular
Star Plus Yellow Algaecide
Great Value Pool Shock
Great Value 3" Chlorinating Pool Tablets
Poolbrand 3" Chlorinating Tablets
NALCO 60510
Acti-Brom 1318
Nalco 2838
Nalco 2877
EC5114A
Nalco EC6110A
EC5122A
Purate DW
NALCO 73002
NALCO 7639S
NALCO 73650S
Stabrex ST70CAN
LegionGuard LG25
NALCON 7614
Nalco 2840

Solid Bionox
H150M
CoilClear
NALCO 60505S
EVAC Biocide
HYG-25
NALCON 60505
NALCON 7637
NALCO 60615
NALCON 240
Nalco 7634
Nalco 77352
B015
Nalcon 7639
PermaCare PC-12
VeliGon TL-M
Nalco 77352NA
ControlBrom CB70
NALCO 7341
Nalcon 7649
Nalco EC6110A
NALCO 60620
H-130 Microbiocide
STABREX ST70
TOWERBROM 960
TOWERBROM 991
PermaClean PC-11
Nalcon 10WB
Nalco 7320
Nalco 7330
Nalcon 7647
Nalcon 7648
Nalcon 7678
Nalco 90005
MBC 211-P
MBC 215-P
MBC 214
MBC 175
Spa Bromine Tablets
One Step Brominating Concentrate
Algae Break 90
Seaklear 90 Day Algae Prevention & Remover for Pools
Seaklear Yellow Klear Algaecide
Seaklear Problem Klear Algaecide
SeaKlear Pool Opening & Winterizing Kit
No. 85 Algaecide
Pan Pads
Towerbrom 60M Granules
Towerbrom 90M Tablets
Technical Sodium Chlorite
Technical Sodium Chlorite 31.25
31% Active Sodium Chlorite Solution
Towerchlor 56 Granules
Old Bridge Copper Sulfate Fine
Olin Chlorine Liquified Gas Under Pressure
Gordon's Pondmaster Copper Sulfate Crystals
Gordon's PondMaster SeClear Algaecide & Water Quality Enhancer Ready-To-Use
Mildew Check
HP AM27
PPG MZD 7330
PPG MZD 7340
PPG MZD 7360J
PPG MZD 7340A
PPG MZD 7330US
X3
EZPool PRO
Premium 60 Algaecide
Quash!
Quantum Algigon 30 Algaecide
Quantum Algigon C
Terminator II
Quantum Q-Shock II
Aqua Chem keeps water clean 1" chlorinating tabs
Aqua Chem keeps water clean 3" Chlorinating Tabs
Aqua Chem shocks water clear
Shock Plus
Aqua Chem keeps water clean
Optimum Chlorinating Granules
Pool Essentials Shock
Aqua Chem Algae Eliminator
Pool Time MaxBlue Algicide
Pool Time All-in-One MaxBlue Chlorinating Granules
Pool Essentials Chlorinating Tablets
Pool Time Shock MaxBlue2
Pool Time MaxBlue Pre-Filled Chlorinating Floater
T-0034
Pool Time Algicide + Clarifier
Pool Time Chlorinating Tabs
Pool Time MaxBlue All-In-One Chlorinating Granules
Pool Time Algicide 50
Aqua Chem Algae Eliminator Max
Pool Time Algicide 50%
Pool Time MaxBlue 3" Tablets
Pool Time Shock MaxBlue
Pool Time Algicide MaxBlue
Pool Time MaxBlue 1" Tablets
Tolcide PS75LT
Pool Specialties BLACK ROBACIDE
Robarb Pool Specialties Power Blast II
Kathon 886 MW Biocide
Kathon 893 MW
Kathon FP 1.5 Biocide
Kathon WT 1.5% Biocide
Aqucar DC 4P25 Water Treatment Microbicide
Kathon CF 150 Biocide
Kathon 725 BF Antimicrobial
Klarix 4000 Microbicide
Kathon Fuel 15 Biocide
Rust-Oleum Marine Coatings Boat Bottom Antifouling Paint (Various Colors)
Safer Brand Moss & Algae Killer & Surface Cleaner RTS II
Safer Brand Moss & Algae Killer & Surface Cleaner RTU II
Pond Champs Algae X Algaecide/Herbicide
Crystal Plex Algae Control
Crystal Blue Copper Sulfate Smart Crystals
Stock Plex Stock Tank Algae Control
Decorative Fountain Algae Control
Green X Concentrated Granular Algaecide
Captain Liquid Copper Algaecide
K-Tea Aquatic Algaecide
Captain XTR
SeClear Algaecide
PAK 27
SeClear Algaecide & Water Quality Enhancer Ready-to-Use
SeClear G
SePRO Total Pond-Clear
SePRO Total Pond- Clear G
Proxitane WW-12 Microbiocide
Pak 27 Algaecide
BIO/TEC 15
Bio/Tec 081
Bio/Tec 14
Ultra-Kleen Solution 1
Pool Mate Jumbo Tabs
Pool Mate Black Algaecide
Pool Mate Non-Foaming Algae Rid
Pool Mate All-In-1 Swimming Pool 3" Chlorinating Tabs
Pool Mate Algaecide 50
Pool Mate Algaecide 50
Marineland Algae Eliminator
Tetra Algae Control
Tetra Pond Algae Control
Tetra Pond Pond Block
Tetra Pond Fountain Block
Tetra No More Algae-Tablets
Sump Buddy MWF Antimicrobial Time Release Tablets

Amical 48
Bioban BP-Plus Preservative
Bioban BP-10 Preservative
Ucarcide 25 Antimicrobial
Ucarcide 50 Antimicrobial
AQUCAR 7140 LT Water Treatment Microbiocide
Aqucar GA 50 MUP Water Treatment Microbiocide
Aqucar PS 20 Water Treatment Microbiocide
Aqucar TA 64 Water Treatment Microbiocide
AQUCAR BP 40 Water Treatment Microbiocide
Kathon 7G Antimicrobial
AQUCAR TN 250 LT Water Treatment Microbiocide
AQUCAR GA 4PO Water Treatment Microbiocide
AQUCAR PS 75 Water Treatment Microbiocide
AQUCAR PS 75 MUP Water Treatment Microbiocide
Tris Nitro
Aqucar Sump Buddy DB 40 TL Water Treatment Microbiocide
Aqucar TN 25 Water Treatment Microbiocide
AQUCAR A 78 Water Treatment Microbiocide
AQUCAR TN 50 Water Treatment Microbiocide
AQUCAR BP 10 Water Treatment Microbiocide
AQUCAR BP 30 Water Treatment Microbiocide
AQUCAR 714 Water Treatment Microbiocide
AQUCAR 742 Water Treatment Microbiocide
AQUCAR BP 100 Water Treatment Microbiocide
AQUCAR 720 Water Treatment Microbiocide
AQUCAR DB100 Water Treatment Microbiocide
AQUCAR DB20 Water Treatment Microbiocide
AQUCAR DB 5 Water Treatment Microbiocide
AQUCAR DB100 MUP Water Treatment Microbiocide
Bioban BP-M Preservative
Aqucar GA 50 Water Treatment Microbiocide
AQUCAR GA 25 Water Treatment Microbiocide
AQUCAR GA 30 LT Water Treatment Microbiocide
AQUCAR GA 45 Water Treatment Microbiocide
AQUCAR GA 15 Water Treatment Microbiocde
Algae Defense
Algae-Off
Algae D-Solv
Scotts 3-In-1 Moss Control Ready-Spray
Scotts Moss EX 3-In-1 Ready-Spray
S-W Seaguard Copper Bottom AF #45-Various Colors
Acticide CT
Acticide B20
Acticide BW20
Acticide 14-CF
Acticide 45-CF
Acticide WP
ACTICIDE OTW 45
ACTICIDE SPX
Acticide LA 1205M
Acticide MKS 1U
Acticide OTW
Acticide LA 1016
Acticide MKW2
Acticides MBS
Acticide RS
Acticide L 30
ACTICIDE DBU 20
ACTICIDE IPW 40
Acticide M10S
Acticide LA
Acticide LA 1206
Acticide LA 1209
Acticide IMS
Acticide MBS 2550
Acticide MV 14
Acticide 45
Acticide PA
Acticide GA
Acticide OTW
Acticide MBL
Aquamate DB20
Pink Treat Algicide
Yellow Treat Algicide
Green Treat Algicide
No Mor Problems Prevent Algicide
Swamp Treat
Yellow Treat 2
Hydrothol 191 Aquatic
Hydrothol Granular
Symmetry NXG
Mold Armor Concrete Driveway and Sidewalk Cleaner
Protech Algaecide 60 Plus
Protech Copper Algaecide
Protech Maintenance Algaecide
Protech ProShock Cal Hypo Granules
JT-1 Starch Preservative
PacifiClear 3 Month Algaecide
Focus Algaecide 10
Focus 3 Month Algaecide
Focus Algaecide 60 Plus
O-ACE-sis 3 Month Algaecide
O-ACE-sis Algaecide 60 Plus
Swim Best Maintenance Algaecide
Swim Best Alagecide 60
Swim Best Copper Algaecide
Swim Best Black Out Granular 90
O-ACE-sis Multishock
PacifiClear Multishock
PacifiClear Algaecide 10
PacifiClear Algaecide 30
PacifiClear Algaecide 60 Plus
Swim Best Cal-Shock Cal Hypo Granules
FreshWater Spa Care Kit
FreshWater Spa Care Kit (Free-Oxidizer)
Wet & Forget
Biocide 10
Zep Biofilm Drain Purge A
Jandy TruGuard
Jandy TruGuard Cartridge
Aqua Pure Algaecide
SKILL-IT Swimming Pool Algaecide
Aquamate Shock
Divergard 42960
MicroClear
Pro-Treat 151
Pro-Treat-151 Pan Treatment
Asurity Pro-Treat-151
AquaPrime NeoKlor
AquaPrime Peraside 15
Algea Clean Out
TopFin Algae Remover Algicide
Clearview Quat Power
Clearview Algaecure
ClearView Poly Power 60
ClearView Copper Strike
ClearView Poly Power 30
Clearview Shimmer N'Shock
Clearview Insta-Chlor Super 73
Zinc Pyrion 48% Aqueous Dispersion Industrial Microbiostat
Zinc Pyrion 48% MPF
Irgarol 1051
Irgaguard D 1071
ConBlock MIC

Smartpond Green Stop Liquid Algaecide
Pond Boss Algaesolv
Pond Boss Pro
RoCide IS-2
Bell Performance-Bellicide
Durobrom
DuroCide C100-G
DuroKlor 56
KEM-TEK Pool & Spa Care Power 99 3" Chlorinating Tablets
KEM-TEK Pool & Spa Care All-In-One Algaecide
KEM-TEK Pool & Spa Care Spa Brominator Tablets
KEM-TEK Pool & Spa Care 60% Algaecide Concentrate
KEM-TEK Pool & Spa Care Shock Quick 10
Aqua Guard Green Algaecide
Pro Side 3" Chlorinating Tablets
HDX Chlorinating Liquid
Aqua Guard 5-Step Pool Care System Pool Start Up Kit
Aqua Guard All-In-One Chorinating Granules
Aqua Guard Black Algae Treatment
Aqua Guard Chlorinating Sticks
Aqua Guard Power 99 3" Chlorinating Tablets
Pro Guard Chlorinating Liquid
Pool Essentials Chlorinating Liquid
Aqua Guard Swimming Pool Winterizing Kit
Aqua Guard Mustard Algaecide
Aqua Guard Algaecide 60% Concentrated
Aqua Guard 1" Chlorinating Tablets
Aqua Guard 3" Chlorinating Tablets
Aqua Guard Algaecide & Clarifier
IonGen Probe
Algaecide
EcoBlast Contact Granular Algaecide
Aqueon Algae Remover
K-Bac 1020
K-Brom 40
K-Brom-T
K-BAC 1005
K-BROM G
K-BAC 1000
K-BAC 7015
K-BAC 4020
K-BAC 4075
CMB-6
K-BAC 2050
Mizzen Algaecide
Cape Furl
PoolRx
PoolRx+
5-in-1 Multi-Purpose Tabs
Avancid 75
Avancid DB20
Avancid DB98
AVANCID GL 15
AVANCID GL 25
AVANCID GL 45
AVANCID GL 45M
AVANCID GL 50
AVANCID GL 50M
Algaecide
Power Powder Plus
Induclor 70
Zappit
Accu-Tab Blue Calcium Hypochlorite Tablets
Induclor
Super Zappit
Power Powder Pro
Incredipool
Zappit 73
Accu-Tab Wastewater Tablets
Indutabs Induclor Calcium Hypochlorite Tablets
Americhlor Calcium Hypochlorite Granules
Power Pro Tabs
VersaChlor System Chlorinating Tablets
Clorox Pool&Spa Algaecide + Clarifier
Clorox Pool & Spa Active 99 3" Chlorinating Tablets
Clorox Pool & Spa Algaecide Xtra Blue
Clorox Pool & Spa Green Algae Eliminator
Clorox Pool & Spa Shock Xtra Blue
Clorox Pool & Spa Xtra Blue 3" Long-Lasting Chlorinating Tablets
Clorox Pool & Spa All-In-One Xtra Blue Chlorinating Granules
XtraBlue Chlorinating Tablets
Chlorinating Tablets
Clorox Pool & Spa Shock XtraBlue2
Clorox Pool & Spa Awesome Alagecide
Clorox Pool & Spa Active 99 1" Tablets
Clorox Pool & Spa Green Algae End for Small Pools
Clorox Pool & Spa Texas Blue 3" Chlorinating Tablets
Clorox Pool & Spa Goodbye Green Algaecide
Clorox Pool & Spa Green Algae Eliminator2
Clorox Pool & Spa XtraBlue Algaecide
Borax 10 Mol FG
Justeq07
TMB-471C
TBM-25 - Sodium Chlorite
Champion Pool Shock
The Bug Bomb
Biotrol 536
Biotrol 550
Biotrol BT
Biotrol 102
Biotrol 250
Biotrol 114
Biotrol 150
Biotrol 407
Biotrol 509
Biotrol 515
Super Shock- Rx Clear
50% Algaecide- Rx Clear
Mega Shock-Rx Clear
Rx Clear 7% Copper Algaecide
Rx Clear Chlorinating Tablets
Rx Clear 60% Poly Algaecide
BioRCK 2512W
BioRCK 1036W
BioRCK 1036
BioRCK 1037
BioRCK 1038
BioRCK 1029
BioRCK 1032
BioRCK 1015
BioRCK 1016A
BioRCK 1017A
BioRCK 1018A
BioRCK 1021
Tolcide 4Frac 20A
Plexcide T20
Tolcide PS50AS Industrial Antimicrobial
Plexcide 15G
Plexcide 24L
Plexcide P5
Tolcide TP5W
Plexcide P5W
Plexcide G15
Plexcide 20BR
Plexcide 5BR
AS-521
AS-592
AS-790
AS-521
CWT-Cooling Water Treatment

Payzone 8102BCD
Payzone 814BCD
Payzone 815GLUT
Payzone 820THPS
Payzone 865BCD-W
Payzone 802BCD
Payzone 875THPS-A
Payzone 8102BCD
Payzone 825GLUT
Payzone 845BCD
Payzone 845BCD-W
Payzone 850THPS
Payzone 855GLUT
Payzone 865BCD
Dutrion Tablet
BIOC16779A
BIOC12031A
BIOC16388A
BIOC11139W
BIOC16779A
Aquatabs InLine
BIO-909
BIO-909
Compass THPS
Compass THPS 50
Compass THPS 35
Biocide 3725
Biocide 1410
Biocide 1400
Brom Tabs No. 2500
Br-Plus
CRBiocide 15
pHin Mineral Purifier for Pools & Hot Tubs
Coastal Cal Jet Algaecide
Shock X-Tra
Chlorine X-Tra Stabilized Chlorinating Granules
Coastal Long-Lasting 1" Chlorinating Tablets
Utikem Mini Slow Dissolving Chlorinating Tablets
Coastal Concentrate 50 Algaecide
Coastal Long-Lasting 3" Chlorinating Tablets
Guardian Chlorinating Tablets
Algae X-Tra 90-Day Algaeacide
Algae X-Tra 90-Day Liquid Algaecide
Dry Chlorinator Granular
BioAdvanced Science-Based Solutions 2-in-1 Moss & Algae Killer & Cleaner Ready-To-Spray
MossBuster RTU
Imagitarium Algae Reducer
Blue Micro-B-Gone
Bromiguard Tablets
Hot Tub Serum Total Maintenance
Algae Guard
Austin's Pool Tech Algaecide
Pondmaster Algaecide
IGL 25 Antimicrobial
AlgaeBlaster
BCS 3024CF
Kuriverter IK-110
Promex CMT1.5
Promex CM14
Hydrex 7958
Hydrex 7611 MQ
Chem Copp HP III
Purple Copp
LoLo Tint
Aqua Clear Pool Products 1" Chlorinating Tablets
Aqua Clear Pool Products 3" Chlorinating Tablets
Aqua Clear Pool Products Pool Algaecide
Aqua Clear Pool Products Pool Shock
BioBrom BT
Ultimate Defense High Copper AntiFouling Paint (Various Colors)
Yacht Shield Premium Multi Season Ablative (Various Colors)
Ablative Plus Premium Antifouling Paint (Various Colors)
Main Stream 635 Algaecide/Bactericide
Bionix BP10
Bionix ISO2A
30 SECONDS Spray & Walk Away
PAACT 22
MAV AquaDoc Chlorinating Granules
Lake Guard Blue
Chlor No More Orb
Old Man Winter Orb
Grotamar 71 (CNA)

Washington

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POWER-LINE CROP OIL [1
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X-CELERATE [1
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Tennessee

Actamaster Soluble Crystal Spray Adjuvant
Lesco Rain-ject (091130)
Prefer 90
Lescoflo Ultra Granular Superior Non-ionic Wetting Agent For T&o (088600)
Pool Style Pool Products Ph Decreaser
Poolife Pods Ph Minus
Fieldgoal
Surfix
Hth Pre-measured Water Soluble Pods Ph Down
Kem-tek Pool & Spa Care Spa Ph Plus
Lock-in
Wcs Crop Oil
Strikelock
Farm General Defoamer
Hth Pre-measured Water Soluble Pods Stabilizer
Nu-film-ir
Frontpage
Cerium Elite
Salient 372 Fs Seed Treatment Fungicide
Exit
Accudrop
Leaf Life Organic Water Conditioner
Profoam Platinum
Mso Concentrate
Fast Break
Jacuzzi Spa Shock Oxidizer
Sedate Max
Hth Alkalinity Increaser
Phase
Phin Orange Striped Pods Ph Up For Hot Tubs
Pathfinder Blue
Brandt Super 7
Contain Max
Ps 804 Select (1 Gallon And 2.5 Gallon)
90 Years Of Hth Perfect Pools Pre-measured Open & Pour Pouch Ph Down
Methsoyoil
Precinct
Amigo
Bioamp Aa
Break Thru T & O
Agrisolutions Level 7
Cohere
Class Act Ridion
Kristol
Foaminator Dry

Seaklear Chlorine Free Shock Oxidizer
Dyne-a-pak Spray Adjuvant And Deposition Aid
Cni Defoamer
Airtech
Tactic
Cni Agri-oil
Pointblank Wm
Hth Pre-measured Water Soluble Pods Alkalinity Up
Aqua Guard Muriatic Acid 1
Maximizer
Aircover
90 Years Of Hth Perfect Pools Pre-measured Water Soluble Pods Ph Down
Tuff Trax
Venturi
Cognitive 1
Buckhorn Total
Oroboost
Scrimmage
Spa Selections Ph Decreaser
Choice Weather Master (lpi)
Flame
Hth Pre-measured Water Soluble Pods Ph Up
Wick
Amspread
Equinox Stabilizer-15
Drexel Mes-100 Modified Vegetable Oil Concentrate
Zaar
Hydrate Plus Nf
Jacuzzi Ph Up
Penetron
Fast Rate
Oculus
Kem-tek Pool & Spa Care Stabilizer Conditioner
Phin Yellow Striped Pods Ph Down For Hot Tubs

Topside
Pool Style Pool Products Stabilizer
Polyan
Diligence-EA
Harrells Spraymax Herbicide Activator
Spa Ph Decreaser Pods
Jacuzzi Alkalinity Up
Trapline Pro
Emulate
Resilience
Purely Hydro
Spa Ph Increaser Pods
Agrisolutions Interlock
Liberate
Activator 90
Thatch Buster
Fact-or
Drexel AMS-XTRA

Accuquest Wm
90 Years Of Hth Perfect Pools Pre-measured Water Soluble Pods Stabilizer
KINETIC
Shake Down
Instinct HL
Herbicide Helper
Surfate Spray Adjuvant
Invade
Drexel Fome-kil
Microsolve Activator Solution

Lesco Ecosential Moisture Manager #084855
Hook Zero
Audible 90
Mso Surfactant
W-box
Conquer Spray Adjuvant
E-z Clor Ph Down
Smoke
Intact

41-a Dry-flowable Drift Control Additive
Desikote
Farm General 80/20 Surfactant
Green To Clean
Lescoflo Ultra Wetting Agent Tablet (184900)
E-z Clor Alkalinity Up
Voyager 90/10
Nzone
Farmworks Defoamer
Sustain
Phuse
Atmos
Kem-tek Pool & Spa Care Spa Non-chlorine Shock Oxidizer
Pool Essentials Muriatic Acid
Pro Side Muriatic Acid
Sequel
OnTarget
Vixen Ac-l
Audible 80
Hand Off
Anchor
Drexel Sil-fact Surfactant
Gulfstream
Promark
Spa Alkalinity Increaser Pods
Yellow Gone
Fire-zone
Clear Spa 104 Spa Solutions Ph Plus
Last Chance
Harrells Spraymax Crop Oil Concentrate
Request
Verimax Ams
Iconic
Clidox-s Activator
Rawwar
Farmworks 80/20 Surfactant
Li 700
CIDE WINDER
Flame Spray Adjuvant

Oro-hsmoc
Kammo Plus
Kem-tek Pool & Spa Care Muriatic Acid
Cense Simple Rituals
E-z Clor pH Up
E-z Clor O2 Shock
Completion
Spa Selections Brom Start
Alligare Mso 1
Fs Crop Oil Plus Sulfactant
Poly Film-r
Drexel Hot Mes
Harrells Spraymax Defoamer
Adigor Adjuvant
Bark Oil Blue
Scoria X Dry
Drexel Pas-800
Lesco Hawkeye #069404
GLB pH Up
Actamaster Spray Adjuvant
Lesco Recade Liquid Antifoam #069386
Instant Pool Water Conditioner
Fireball
Veracity Elite Ii
90 Years Of Hth Perfect Pools Pre-measured Water Soluble Pods Alkalinity Up
Ag 14039
Alligare Buphr
Compadre
Soiltrate
E-z Mix
Envelop
Tyrant
Hydra-hume A
Harrells Spraymax Activator
Pentrol
Hel-fire
Strike Zone LC
Axon
Upland Mso

Hth Ph Decreaser
Mso Concentrate With Leci-tech
Nzone Gl
Pristiva Liquid Rapid Action Stabilizer
Drop Ph
Alligare Drift Control
Verifact
Protyx
Poolife Pods Stabilizer And Conditioner
Alligare 7
Kem-tek Pool & Spa Care Swimming Pool Muriatic Acid

Stake
Invade Rst
Plex Mate Surfactant
Lesco 90/10 Nonionic Surfactant
Clearsurf 90
Poolife Pods Alkalinity Plus
Response
Aqua Guard Stabilizer Conditioner
Leaf Life Slingshot
Back Field
Reign
Tpq89
Hth Salt Pool Care Ph Decreaser
Pool Style Pool Products Alkalinity Increaser
Induce Ph
Aqua Guard Alkalinity Booster
Nanoboost
Jackhammer Elite
Sms 200 Soil Surfactant
Pht Latron B-1956
Kem-tek Pool & Spa Care Ph Plus
Bark Oil Lt
Hydro-pak Command
Drexel Pinene II Extender And Sticker
Clear Spa 104 Spa Solutions Ph Minus

Levesol Defoamer
Ams 4xl
Pool Season Non-chlorine Shock
Gundown Max
Harrells Siloxane Surfactant
Rendur Defoamer
Amp Activator
Warraw
Fixate Pro
Poolife Pods Ph Plus
Emulsifier Blend
Green Aid
Water Conditioner + Surfactant
Blendex VHC
Hi-yield Spreader Sticker
Harrells Spraymax Nonionic Penetrant
Microsolve Soft Metal Activator Solution
Trio
Ag 13063
Du Pont TPQ89 Adjuvant
Cense Island Pleasure
Infuse
Offside
Cense Divine Secrets
Sure Fire Crop Oil Plus
Peradigm
Partition
Cni 80-20
Wheelhouse Pro
Drexel Haf-pynt
Alligare Mvo Plus 1

Fortify
Contain
Seaklear Shock Oxidizer Pods For Spas
38-f Liquid Drift Control Additive
Wetcit
90 Years Of Hth Perfect Pools Pre-measured Water Soluble Pods Ph Up
Dc-4

Clearview Chlor Free Shock & Swim 15
Pool Season Alkalinity Up
Lesco Flo Ultra #084570
Navigator Hc
Drexel Lox
Alligare Trace
Phase Ii
Hth Stabilizer
Drexel Mix
Weather Gard Complete
Mso Ultra
Silenergy
Linkage
Boost 3201 Sm
Harrells Ph Buffer
Velomax
Exuro
Oro-rz
Spa Selections Non-chlorine Shock Oxidizer
Jagge
Synurgize
Phin Orange Pods Ph Up For Pools
Jackhammer
Rendur Compatibility Agent
800 Plus
Alligare Forestry Oil

Pentra-bark
Ex Plus
Purge
Aqua Guard Ph Down
V-drift Control
Civitas Harmonizer
Soydex Plus
Raider Tg
Hy-stop
Wheelhouse
Clear Spa 104 Spa Solutions Crystal Shock Oxidizer
Spa Selections Ph Increaser

Drexel Surf-ac 910 Non-ionic Surfactant
H-45
Aqua Guard Non-chlorine Shock Oxidizer
Spa Oxidizing Shock Pods
Airlink
Nzone Max
Sms 400 Soil Surfactant
Woodside
Mediate Plus
Combust
16098
Ad-spray 90 Nis
Permeate
Drexel Vegetoil Emulsifier
Alligare Water Conditioner 1
Lesco Spreader-sticker #019255
Gunsmoke
Drexel Ams-supreme
Aqua-king Plus
Attach Non-ionic Spreader Sticker
Vincero 90
Yellow Out
Suffusion Tablets
Alligare Coc Crop Oil Concentrate
Aqua Chem Balanced For Clean Pools Muriatic Acid

Foliar Nutrient 3
Hth Spa Non-chlorine Shock Oxidizer
Breeze
Triple Play
Impel Red
Fixate
Reverse
Navigator Crop Oil Concentrate
Chem-stik
Harrells Spraymax Nonionic Spreader Sticker
Ultra Pro
Nvincible

Mystic Hc Spray Pattern Indicator
Ivc Defoamer
Sms 700 Soil Surfactant
Voyager 80/20
Succeed Ultra
Bioguard Muriatic Acid Contractor Strength
Hyper-Active
Blastoff
Between
Lesco Wet Plus #069383
Aqua Guard Muriatic Acid
Yardage
Poolife Pods Non Chlorine Oxidizer
Choice Trio
Nvincible Plus
Bark Oil
Foambuster 10
Harrells Spraymax Nonionic
Penetrant Plus
Brewer Ta-39
Comp-aide
Trapline Pro Ii
Fbs Harmony
Hydro-pak Matador
Chemsurf 90
Brandt Indicate 5
Agri-dex
Velomax Drt
Aquicare
90/10 Surfactant
Veracity
Dyne Amic
Noble
Kem-tek Pool & Spa Care Spa Ph Minus
Spredde 90/10
High Load Mso
Ultra Soft Metal Activator
Spread Coat
Herbimax
Aqua Guard Ph Up
Boost 3201
Hi-wett
Clasp
Citrisan
Efficax
Cynder
Persist® Ultra
Hth Salt Pool Care Stabilizer
Cense Quiet Escape
Brilliance For Spas Oxidizing Tablets
Traverse D
Justified
Nemasan
Bark Oil Blue Lt
Valcheck
Turbulence
Coact+
Sitka
Seaklear Balanced Shock Oxidizer For Spas
Droplex Xtra
Jette 80/20
Green Gone
Agrisolutions Powerlock
Spreader 90
Turfvantage Nanoboost
Bark Oil Red Lt
Hook
Agrisolutions Class Act Flex
Mediate
Velocity Elite
Hypertonic
Savvy
Winfield Droplex
Agrisolutions Superb Hc
Harrells Spraymax Methylated Seed Oil
E-z Clor Clor Save
Level Best
Liquid Ams
Freeway
Lesco Methylated Seed Oil
Aqufact
Mon-10
Drexel Bean

Appendix D Email From Washington State Registrar On Adjuvant Registration

Email excerpt from Washington state's pesticide registrar:

….You will note that the ingredients column for all the adjuvants contains "no active ingredients." This is because adjuvants technically contain only inert ingredients. We use the phrase are functioning like an active ingredient. State law requires that the top three PFAs be listed on the label in descending order of concentration, and the TOTAL percentage of all the PFAs be listed as well. If you click on one of the red WA hyperlinks you will be able to view that product's label. If you look at a label you will see that the ingredient statement uses "constituents ineffective as spray adjuvants" (CIASA) instead of "inert ingredients."

Unfortunately, I cannot share information on the composition of any of the spray adjuvants. We track the PFA ingredients that are listed on the label and are publicly accessible via PICOL. The CIASAs are not tracked or recorded by us; they appear on the Confidential Statement of Formula only. And as you mention below, we cannot share confidential information.

There is, however, a kind of work-around to getting this data. We use EPA's InertFinder website when we review an adjuvant. ALL spray adjuvant ingredients must be verified as being an inert. If we cannot find them on the website, we will contact the Inerts Branch to have them verify if it is an inert (I've been told they have an internal database that contains more inerts.) The EPA InertFinder website is located here: https://ordspub.epa.gov/ords/pesticides/f?p=INERTFINDER:1:135638543692::NO:1. You could enter the CAS numbers on the spreadsheet you sent me into the CAS reg. No. field and see if they come up as a recognized inert….

Appendix E Lists of PFAS Definitions

Table 4. List of PFAS definitions and validated test methods for PFAs substances

Origin of Definition	Number of Chemicals	Definition	Notes on the Used Definition
Buck et al. 2011	268	Detailed in Buck et al. 2011 Perfluoroalkyl and Polyfluoroalkyl Substances in theEnvironment: Terminology, Classification, and Origins. Integrated Environmental Assessment and Management Vol 7 Num 4pp 513-541.	This is the original modern understanding of PFAS structure.
EPA's PFAS Master List	9,252	A List of Lists: Per- and polyfluorinated alkyl substances (PFAS) represent a growing, increasingly diverse inventory of chemicals of interest to the general public, scientific researchers, and regulatory agencies world-wide.	US EPA "PFAS Master List of PFAS Substances (Version 2)"; serves as consolidated list of substances spanning and bounded by the lists, defining a practical boundary of PFAS chemical space (within DSSTox) of current interest to researchers and regulators worldwide.
EPA Drinking Water Test Method	18	Compounds positively identified by Method 537.1. Method 537.1 is one of the standard tests used for drinking water throughout the US.	Method 537.1: Determination of Per- and Polyfluoroalkyl Substances in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS) (2018/2020)
EPA Oily Matrix Test Method	28	Compounds positively identified by methods detailed in 'Analysis of PFAS in Oily Matrix'. This method is a modification of 537.1.	Released Fall 2021, available at: https://www.epa.gov/system/files/documents/2021-09/epa-pfas-method-in-oil.pdf
EPA with National Toxicology Program	75	Individual chemicals prioritized for future toxicity testing based on underlying risk.	Per- and Polyfluoroalkyl Substances (PFAS) list corresponds to 75 samples (Set 1) submitted for the initial testing screens conducted by EPA researchers in collaboration with researchers at the National Toxicology Program.

Origin of Definition	Number of Chemicals	Definition	Notes on the Used Definition
State of Maine: "Sum of 6 PFAS" / "regulated PFAS contaminants"	6	"Perfluoroalkyl and polyfluoroalkyl substances" or "PFAS" means a perfluoroalkyl substance or polyfluoroalkyl substance that is detectable in drinking water using standard analytical methods established by the United States Environmental Protection Agency, including regulated PFAS contaminants.	Resolve 2021, Ch.82 - LD129: To Protect Consumers of Public Drinking Water by Establishing Maximum Contaminant Levels for Certain Substances and Contaminants
State of Maine Definition per LD 1503	Unknown	"Perfluoroalkyl and polyfluoroalkyl substances" or "PFAS" means substances that include any member of the class of fluorinated organic chemicals containing at least one fully fluorinated carbon atom.	H.P. 1113 - L.D. 1503 An Act To Stop Perfluoroalkyl and Polyfluoroalkyl Substances Pollution of 2021
OECD	4,730	PFASs are defined as fluorinated substances that contain at least one **fully fluorinated methyl or ethylene carbon atom (without any H/Cl/Br/I atom attached to it)**, i.e. with a few noted exceptions, any chemical with at least a perfluorinated methyl group (–CF3) or a perfluorinated methylene group (–CF2–) is a PFAS.	Issued Fall 2021, OECD attempts to harmonize the chemical structures while explicitly stating that structures alone should not dictate policy.
EPA OPPT	Approximately two pesticide a.i.s	"…a structure that contains the unit R-CF2-CF(R')(R"), where R, R', and R" do not equal "H" and the carbon-carbon bond is saturated (note: branching, heteroatoms, and cyclic structures are included)…."	EPA Office of Pollution Prevention and Toxics "working definition" for PFAS.
Found in Pesticide Container Testing	8 (clearly not a definition but it sets a potential expectation)	Testing done at EPA's Ft Mead in 2020 using a Modified Method 537.1	PFAS compounds detected on/in the containers

Board of Pesticides Control

Report to the 130th Maine State Legislature on LD 524 Resolve, Directing the Board of Pesticides Control to Research Workable Methods to Collect Pesticide Sales and Use Records for the Purpose of Providing Information to the Public

LEGISLATIVE REPORT

FISCAL YEAR 2021

MAINE DEPARTMENT OF AGRICULTURE CONSERVATION & FORESTRY

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Contents

I. Acronyms and Definitions

BPC	Board of Pesticides Control
GUP	General Use Pesticide Dealer
IPM	Integrated Pest Management
LD	Legislative Document
RUP	Restricted Use Pesticide Dealer
SCF	Spray Contracting Firm
MePERLS	Maine Pesticide Enforcement, Registration and Licensing System

II. Introduction

In 2021, the Maine Legislature passed LD 524, Resolve, Directing the Board of Pesticides Control to Research Workable Methods to Collect Pesticide Sales and Use Records for the Purpose of Providing Information to the Public. One of the two major provisions of the bill directed the Board to research the best methods for collecting pesticide use information from K-12 schools, private applicators, and commercial applicators. Private applicators of general use pesticides as defined by 22 MRSA § 1471-C (22-A) have been excluded from the requirements of LD 524.

The second provision directed the Board to research the best methods for collecting information on pesticides sales in the state.

The Board was further directed to prepare a report with findings and recommendations for submission no later than January 1, 2022.

III. Background

The Board is keenly aware of longstanding legislative interest (Appendix E) in pesticide sales and use reporting and related topics and has focused on methods to accurately collect and report this information. Historically, the Board produced reports of the 1997, 1998, and 2000 pesticide sales and use data, as well as several informal summaries of sales and use data (Appendix G). Currently, the BPC does track annual pesticide sales and use data, which is submitted by a variety of means (hard copy or email) on forms supplied by the BPC by relevant parties such as commercial pesticide applicators and general and restricted use pesticide dealers. The data is then filed by BPC staff into the relevant commercial applicator, spray contracting firm, or pesticide distributor physical files located at the BPC's offices.

In 2019, the Board committed funding to the development of electronic reporting of annual use summary reports from commercial applicators and sales and distribution reports from both general and restricted use pesticide dealers. Development of this new functionality began in 2020, and in 2021, staff began testing this new approach to reporting using the Board software solution MePERLS, to tabulate this data. This report describes the type of sales and use data collected, provides summaries of 2019 commercial use data, describes a possible approach for collecting information on commercial pesticide use on school grounds, and provides a summary of considerations for private applicator use reporting.

IV. Existing Board Authorities

The Board has authority under 22 MRSA § 1471-G and W to establish regulations requiring the annual collection of general use pesticide dealer sales, restricted use pesticide dealer sales, and commercial pesticide applicator use reports. The Board has authority to require private applicators and schools to maintain detailed records of pesticide use and to provide those records for inspection by representatives of the Board at reasonable times, upon request. Presently, the Board does not have the authority to require routine submission of private applicator and school records.

Before reviewing what is collected, however, the below table provides a brief synopsis of the types of pesticide dealers and applicators referenced in this report.

Table 1. Licensure Categories for Pesticide Businesses in Maine

General Use Pesticide Distributor	"General use pesticide" means any pesticide which has been registered by the US EPA as evidenced by a registration number on the label and which is not a restricted use or limited use pesticide
Restricted Use Pesticide Distributor	"Restricted use pesticide" means any pesticide or pesticide use classified for use only by or under the direct supervision of a certified applicator by the Administrator of the US EPA or by the Commissioner of DACF
Agricultural Basic Applicator	For growers who annually sell more than $1,000 of plants or plant products intended for human consumption and who use only general-use (over-the-counter) pesticides on property owned or leased by them. These include: • Growers of fruits, vegetables, herbs, and grains for human consumption; • Growers of the above crops who make bread, jam, french fries, wine, cider, juice, etc., or who sell produce to be processed into these products; and • Greenhouse growers selling fruit, vegetable, and herb seedlings. • Medical marijuana growers

Private Applicator	For those wishing to purchase and use restricted-use, as well as general-use, pesticides in the production of agricultural commodities on property owned or leased by them. These typically include: • Farmers • Greenhouse and nursery operators • Orchardists • Christmas tree growers • Foresters
Commercial Applicator	For professionals using any pesticide in a variety of occupations, a commercial license is required in all of the following situations: • Application of any restricted-use pesticide for purposes other than producing an agricultural commodity; • Use of any pesticide as a service for which compensation is received. Examples include lawn and landscape care; tree and shrub care; and home pest control; • Use of any pesticide in a licensed food or eating establishment; • Use of any pesticide in connection with duties as an official or employee of federal, state or local government; • Use of any pesticide on non-agricultural sites open to public use. Examples include office and apartment buildings and grounds; golf course, campgrounds, and other outdoor recreation facilities; hospitals and nursing homes; and retail and commercial spaces.

A. General Use Pesticide Dealers

The Board derives authority to regulate general use pesticide dealers from 22 MRSA § 1471-W. In Maine, general use pesticide dealers who sell pesticides that the general public may purchase, are required, under 22 MRSA § 1471-W(3), to annually report sales to the BPC when they sell products to other general use pesticide dealers to the BPC. Reports (Appendix A) must include the contact information for all companies from which pesticides were purchased and companies to which pesticides were distributed, and for each brand of pesticide any wholesale dealer sells, they must report annually the:

- trade name,
- EPA registration number,
- total number of units sold, and
- weight/volume per unit

Pesticide dealers are exempted from licensure and sales reporting requirements for the following types of pesticides as detailed in 22 MRSA § 1471-W(5):

- household use pesticide products with no more than 3% active ingredients;
- Dichlorvos (DDVP) impregnated strips with concentrations not more than 25% in resin strips and pet collars;
- pet supplies such as shampoos, tick and flea collars and dusts;
- disinfectants, germicides, bactericides, and virucides;
- insect repellents;
- indoor and outdoor animal repellents;
- moth flakes, crystals, cakes, and nuggets;
- indoor aquarium supplies;
- swimming pool supplies;
- aerosol products; and
- general use paints, stains, and wood preservatives and sealants.

B. Restricted Use Pesticide Dealers

Restricted use pesticide dealers are individuals licensed to sell any pesticide classified for use only by or under the direct supervision of a certified applicator by the United States Environmental Protection Agency (EPA) or the Maine Department of Agriculture, Conservation and Forestry (DACF). Individuals licensed as restricted use pesticide dealers must pass a certification exam before becoming licensed (CMR 01-026 Chapter 34), must complete continuing education, and are subject to annual restricted and limited use pesticide sales reporting requirements (CMR 01-026 Chapter 50).

Required reports (Appendix B and C) must include the contact information for all companies from which they purchase pesticides and separate listings for companies versus consumers to which they distribute; and, for each brand of pesticide any dealer sells, they must report annually the:

- trade name,
- EPA registration number,
- total number of units sold, and
- weight/volume per unit

C. Spray Contracting Firms and Commercial Pesticide Applicators

Spray Contracting Firms and Commercial Master Applicators working as sole proprietors must keep detailed records of each application they make and are required (CMR 01-026 Chapter 50) to report the supervisory master applicator's name and license number as well as the following summary (Appendix D) of use data annually:

- site of application,
- pesticide name brand,
- EPA registration number,
- total pounds or gallons undiluted formulation used, and
- total area treated

D. Private Pesticide Applicators and Private Pesticide Applicators of General Use Pesticides (Ag Basic Applicators)

The Private Pesticide Applicator (22 MRSA § 1471-C (22)) license is for agricultural producers who wish to purchase and use restricted-use, as well as general-use, pesticides in the production of agricultural commodities on property that they own or lease. Individuals interested in this type of licensure typically include farmers, greenhouse and nursery operators, orchardists, Christmas tree growers, and foresters.

The Private Applicator of General Use Pesticides (or Ag Basic Applicator) (22 MRSA § 1471-C (22-A)) license is for growers who annually sell more than $1,000 of plants or plant products intended for human consumption and who use only general-use (over-the-counter) pesticides on property owned or leased by them. Individuals interested in this type of license typically include growers of fruits, vegetables, herbs, and grains for human consumption; growers of these crops who make value-added products or sell produce to be processed; greenhouse growers selling fruit, vegetable and herb seedlings; and cannabis growers.

Private and Ag Basic Applicators are not required to submit annual reports to the BPC, but they are required to keep a detailed record (CMR 01-026 Chapter 50) of each application they make as well as a sprayer calibration log (Appendix F). The BPC employs five pesticide inspectors who review these records when conducting inspections. Each application, even those exempt from licensure requirements, such as the application of general use sanitizers and disinfectants in produce wash water, must be documented with the following recorded details :

- date,
- start time,
- finish time,
- address, town/field location
- size of treated area,
- any nearby sensitive areas,
- site or crop,
- target pest,
- wind speed and direction,
- temperature/cloud cover, and time noted,

- pesticide(s) and diluent applied,
- undiluted amount, mix, mix ratio,
- application method

Additionally, maintenance of complete pesticide application records requires inclusion of data relevant to the:

- Routine Calibration Log (calibration date, sprayer type, nozzle type, nozzle spacing, boom height, pressure, speed, calculated volume/acre, calibration method, etc.)
- Pesticide Key (brand name, active ingredients, EPA Registration Number, Restricted Entry Interval and/or Air Concentration Level)

At present, this information must be maintained at the agricultural establishment for two years and made available to representatives of the Board upon request, but the Board does not have the authority to require submission of these records.

LD 524 specifically addresses pesticide use reporting for Private Pesticide Applicators and doesn't appear to contemplate further data gathering from Ag Basic Applicators. All pesticides present risk and most pesticides used by agricultural producers are general use pesticides. Given these two points, there is little reason to not include Ag Basic Applicators in a proposed use reporting requirement for agricultural producers.

E. Pesticide Applications on School Grounds

The vast majority of pesticide applications on school grounds must be made by outsourced licensed Commercial Applicators (CMR 01-026 Chapter 31). The two exceptions to this licensure requirement are the emergency application of ready-to-use aerosol insecticides for stinging insects and the hand/non-powered application of general use antimicrobial pesticides for routine cleaning. These and all other applications must be approved and documented by an Integrated Pest Management (IPM) Coordinator.

Maine K-12 schools and affiliated nursery schools are required to appoint a trained IPM Coordinator who must authorize and document pesticide applications made on school grounds (CMR 01-026 Chapter 27). IPM Coordinators are required to complete an initial pesticide safety course within one month of appointment and a three-hour comprehensive course within one year of appointment. Information for any applications made on school grounds must be kept in a "Pest Management Log" for at least two years and must include justification for why the application was necessary. Justification of necessity requires documentation of monitoring efforts for the pest and/or conditions conducive to a pest outbreak; pest identification; pest population exceedance of a safety, economic, or aesthetic threshold; and demonstrated use of practicable, effective, and affordable non-pesticide control measures. Schools are currently not required to submit Pest Management Logs annually, but these documents are reviewed by Board inspectors while conducting onsite school inspections. All Pest Management Logs must also be made available for review by school staff, parents, and guardians upon request, and schools must comply with notification requirements that are outlined in CMR 01-26 Chapter 27—Standards for Pesticide Applications and Public Notification in Schools.

The Board does not currently have the authority to require submission of school Pest Management Logs. However, all pesticide applications made by Commercial Applicators on school grounds are also documented in the applicator's or Spray Contracting Firm's pesticide application log and reported to the Board via the Commercial Applicator/Spray Contracting Firm annual use summary report.

V. Current and Potential Reporting Practices

A. Pesticide Dealer and Commercial Applicator Use Reporting

All required sales and use reports are submitted annually to Board staff—typically via paper or PDF on standardized forms (Appendix A, B, C, & D). These records are kept on file at the Board offices and made available to the public upon request for in-person review. In 2021, Board staff began entering 2019 commercial applicator use summary reports and then 2019 pesticide dealer sales summary reports into the newly developed MePERLS use reporting functionality. A preliminary summary of the 2019 commercial applicator annual use data is presented in Section VI of this report.

The time required for report quality control and data entry has, historically, been prohibitive to routine sales and use reporting. This remains the primary obstacle to electronic entry of sales and use records. While some applicators and dealers have begun voluntarily using MePERLS for report submission, the Board does not currently have the authority to require use of electronic records reporting. Temporary staff have made possible the compilation of 2019 use and sales information. Requiring most commercial applicators and pesticide dealers to use electronic data entry may make annual use and sales reporting possible. Instructions designed for use by applicators and dealers explaining how to use the MePERLS software provide some insight into the process of data collection and are available on the Board's website:

> Commercial Use Reporting:
> https://www.maine.gov/dacf/php/pesticides/documents2/pega/External_Portal-Commercial-Use-Reporting-Directions.pdf
>
> General Use Dealer Reporting:
> https://www.maine.gov/dacf/php/pesticides/documents2/pega/External_Portal-GPD-Sales-Reporting-Directions.pdf
>
> Restricted Use Dealer Reporting:
> https://www.maine.gov/dacf/php/pesticides/documents2/pega/External_Portal-RPD-Reporting-Directions.pdf

B. Private Applicators and Private Applicators of General Use Pesticides (Ag Basic)

In the past, Board staff have conducted on-farm surveys of agricultural pesticide use. These surveys were anonymous and were typically conducted at the same time as a routine enforcement inspection—collecting information similar to those collected during a records and operations inspection. Agricultural producers generally consented to this data collection because while the cropping type was recorded, the farm size was documented as an acreage range, and no other identifying features such as applicator name or farm name were recorded (Appendix H). These surveys provided the Board with useful information on agricultural pesticide use. The most recent agricultural use surveys were conducted in 2014.

While preparing this report and considering workable methods of agricultural use reporting, Board staff recognized a need to reach out to Maine's agricultural community. Staff hosted a stakeholder meeting on December 20, 2021 with the purpose of gaining input from agricultural producers regarding use reporting. As stated, agricultural producers who use pesticides must keep records of those applications and make them available to Board staff for routine auditing; however, they are not required to submit any records documentation to the BPC. Participants invited represented specific aspects of the agricultural and forest industries in the state.

Growers were asked to reflect on a series of questions that focused on their thoughts about required agricultural pesticide use reporting; frequency of required reporting; and reported records content. The overall sentiment of the meeting was that growers were not supportive of an annual or more frequent requirement to submit pesticide use information to the Board. Growers cited several considerations about new requirements, including:

- concerns about lack of time for additional record keeping/reporting requirements;
- the added pressure of the current labor shortage and its impact on existing or additional work;
- the difficulty of electronic reporting in the absence of reliable broadband access;
- concerns about data use, including that the records may be used for defamation on social media;
- concerns about public access to CBI (confidential business information);
- the Board is already collecting pesticides sales data from restricted-use pesticide retailers and general-use pesticide wholesalers that could provide amounts of pesticides used in agriculture in the state.

C. Schools Use Reporting

While schools are required to maintain Pest Management Logs to document pesticide applications made on school grounds, all pesticide applications requiring a pesticide license must be made by Commercial Applicators. All commercial pesticide applications made on school grounds are recorded in the relevant commercial applicator's application log and will be reported as a part of the commercial applicator annual use summary report (Appendix D). As mentioned in Section V(A) of this report, these reports can now be submitted electronically by commercial applicators. At present, applications on school grounds are not necessarily specifically identified but could be identified in the description for the site of application—a required reporting field.

VI. Current Reporting Results—Use Summary

In 2021, BPC hired a temporary part-time staff member whose primary role was to enter 2019 Sales and Use Reports into the newly created functionality of the MePERLS database. To date, over 500 hours of staff time has been committed to this effort. Data entry for 2019 Sales Reports is ongoing and expected to be finished early in 2022. The following is a brief and preliminary summary of the 2019 use data displaying types of information and patterns that can be described with existing collection efforts.

Use of 359 conventional pesticide active ingredients, plus approximately 25 Minimum Risk (Section 25(b)) pesticide products were reported in 2019. The total for solid products tallied by weight in 2019 was 394,378 lbs. The total for liquid products tallied by volume was 24,291 gallons. The totals presented represent the weight and volume of the active ingredients as determined by multiplying the total amount of product used by the product's percent active ingredient. Tables 2 and 3 present the most commonly reported pesticides applied by commercial applicators. Commercial applicator use summary data includes some agricultural applications, but only those applications for which an agricultural producer hired a commercial applicator to apply pesticides. Applications made by individuals with private applicator licenses and agricultural basic licenses are not included. Many of the solid pesticide products reported as most commonly used or used in the largest quantities are primarily used for industrial applications. The industrial use of pesticides includes applications in paper mills and cooling towers largely to control microorganisms in slurries and these applications occur at higher volumes, comparatively.

Table 2. Use Summary for Commonly Used Pesticide Active Ingredients for 2019 (Reported by Weight). List includes only products where the total used was in excess of 100 lbs.

Active Ingredient (AI)	Use Type	AI Lbs
Dazomet	Soil fumigant	138,561.8
Ammonium sulfate	Industrial Antimicrobial	88,027.6
Ammonia	Industrial Antimicrobial	51,107.3
Chloropicrin	Soil fumigant	44,886.5
Chlorpropham	Herbicide	20,831.5
Sodium bromide	Industrial Antimicrobial	13,098.8
Sodium hypochlorite	Disinfectant	9,291.6
Boric acid	Insecticide	3,449.0
Phosmet	Insecticide	2,791.4
Trichloro-s-triazinetrione	Industrial Antimicrobial	2,647.7
Mancozeb	Fungicide	1,523.0
5-Chloro-2-methyl-3(2H)-isothiazolone	Industrial Antimicrobial	1,512.2
Sulfometuron	Herbicide	1,419.2
Chlorothalonil	Fungicide	1,344.9
2,4-D	Herbicide	1,329.0
Glutaraldehyde	Disinfectant	1,212.5
Terbacil	Herbicide	1,211.1
Fosetyl-Al	Fungicide	1,127.1
Imidacloprid	Insecticide	1,052.7
Dithiopyr	Herbicide	707.4
Atrazine	Herbicide	656.2
Prodiamine	Herbicide	595.8
Trichlorfon	Insecticide	576.5
2-Methyl-3(2H)-isothiazolone	Industrial Antimicrobial	510.5
Bifenthrin	Insecticide	500.5
Acetamiprid	Insecticide	428.0
Quinclorac	Herbicide	364.8
Chlorantraniliprole	Insecticide	347.2
1,3-Dichloro-5,5-dimethylhydantoin	Industrial Antimicrobial	289.0
Pentachloronitrobenzene	Fungicide	285.7
Acephate	Insecticide	227.1
Bronopol	Industrial Antimicrobial	220.5
Captan	Fungicide	220.0
Glyphosate	Herbicide	180.3
1,3-Dichloro-5-ethyl-5-methylhydantoin	Industrial Antimicrobial	159.0
Thiophanate-methyl	Fungicide	156.4
Hexazinone	Herbicide	117.0
Dicamba	Herbicide	106.2

Table 3. Use Summary for Commonly Used Pesticide Active Ingredients for 2019 (Reported by Volume). List includes only products where the total used was in excess of 50 gallons.

Active Ingredient (AI)	Use Type	AI Gals
Glyphosate	Herbicide	9,828.9
Chlorothalonil	Fungicide	2,887.9
2,4-D	Herbicide	978.3
Malathion	Insecticide	952.1
Bifenthrin	Insecticide	804.5
Dithiopyr	Herbicide	744.6
lambda-Cyhalothrin	Insecticide	691.6
Permethrin	Insecticide	451.4
MCPA	Herbicide	428.4
Mineral oil - includes paraffin oil	Insecticide	392.8
Imazapyr	Herbicide	369.8
Piperonyl butoxide	Insecticide	358.4
Iprodione	Fungicide	342.9
Diuron	Herbicide	288.1
Propiconazole	Fungicide	277.5
Hexazinone	Herbicide	273.3
Prothioconazole	Fungicide	257.0
Triclopyr	Herbicide	243.1
Methomyl	Insecticide	226.1
Sethoxydim	Herbicide	218.7
Mecoprop-p	Herbicide	188.6
Garlic	Insecticide	184.7
Aminopyralid	Herbicide	166.4
Tebuconazole	Fungicide	142.2
Alpha-cypermethrin	Insecticide	127.1
Dicamba	Herbicide	124.3
Potassium salts of phosphorus acid	Fungicide	118.7
Mesotrione	Herbicide	111.5
Naphthalene	Insecticide	95.0
Imidacloprid	Insecticide	93.9
Rosemary oil	Insecticide	88.6
Fipronil	Insecticide	88.4
S-Metolachlor	Herbicide	87.0
Sodium hypochlorite	Disinfectant	86.1
Methoxyfenozide	Insecticide	74.7
Thiophanate-methyl	Fungicide	72.7
Clethodim	Herbicide	72.3
Quinclorac	Herbicide	71.5
Pyrethrins	Insecticide	70.7
Pendimethalin	Herbicide	68.7
Spinosad	Insecticide	57.3

Sodium bromide	Industrial Antimicrobial	55.0
Diquat	Herbicide	54.8
Cedarwood oil	Insecticide	50.5

A further breakdown of the reported active ingredients by use type are presented in Tables 2 and 3. These use types are categories created to describe various types of pesticide application scenarios. The Built Structures category is very broad but includes all the applications geared toward keeping human-constructed facilities in working order. This category includes applications for managing bedbugs, sidewalks, foundations, cooling towers, biocide treatment as well as roofing, ant infestations, the areas around homes, fences, and similar. These categories do not correspond to licensure categories; instead, they are based on popular topics in pesticide discussions and were selected to help better understand use patterns. For example, the Rodents category is a subset of Built Structures but relevant to the ongoing discussions around rodenticides.

These data can also be explored on an active ingredient by active ingredient basis, as seen as examples in Figures 1 and 2, for glyphosate and imidacloprid respectively. The data from Tables 4 and 5 show how certain active ingredients appear under multiple use categories. Conversations about regulating the use of these active ingredients can be aided by better understanding which sectors use the largest quantities. Over time, graphs like these could provide a perspective on use pattern changes over time.

Table 4. Pesticide Active Ingredient Use Reported in Pounds by Commercial Applicators in 2019. The table is organized from greatest to least weight, in pounds. Note: In addition, there were 57,656 lbs of active ingredient recorded but general application categories could not be easily summarized from the data.

Broad Application Category	Active Ingredient Weight (lbs)	Top Three Most Common Active Ingredients (highest to lesser)
Built structures	235,743	Dazomet, ammonium sulfate, sodium bromide
Ag	71,039	Chloropicrin, Chlorpropham, Phosmet
Water	19,460	Ammonium sulfate, *Bacillus thuringiensis* israelensis, Diquat dibromide
Turf	7,311	Fosetyl-Al, Imidacloprid, Chlorothalonil
Ornamental	2,030	Boric acid, Acephate, Dithiopyr
Right of way	982	Sulfometuron, Glyphosate, Metsulfuron
Forestry	136	*Bacillus sphaericus*, Sulfometuron, Metsulfuron
Biting flies, ticks, & allies	14	Bifenthrin, S-Methoprene, Indoxacarb
Rodents	3	Carbon monoxide, Bromadiolone, Brodifacoum
Bare ground	2	Diuron, Sulfometuron, Chlorsulfuron
Invasives and habitat management	1	Imidacloprid, Metsulfuron, Triclopyr
Grand Total (of 1,456 records)	336,721	

Table 5. Pesticide Active Ingredient Use Reported in Gallons by Commercial Applicators in 2019. The table is organized from greatest to least volume, in gallons. Note: In addition, there were 9,808 gals of active ingredient recorded but general application categories could not be easily summarized from the data.

Broad Application Category	**Active Ingredient Volume (gal)**	**Top Three Most Common Active Ingredients (highest to lesser)**
Turf	4,129	2,4-D, Dithiopyr, Chlorothalonil
Ag	3,794	Malathion, Chlorothalonil, Glyphosate
Right of way	2,672	Glyphosate, Aminopyralid, Hexazinone
Ornamental	2,144	Bifenthrin, Permethrin, Piperonyl butoxide
Built structures	1,479	Lambda-Cyhalothrin, Garlic, Bifenthrin
Bare ground	110	Glyphosate, Nonanoic acid, Aminocyclopyrachlor
Forestry	52	Glyphosate, Triclopyr, Imazapyr
Biting flies, ticks, & allies	49	Bifenthrin, Cedarwood oil, 2-phenyl ethyl propionate
Water	32	Diquat dibromide, Cuprous oxide, Glyphosate
Invasives and habitat management	20	Glyphosate, Triclopyr, Imazapyr
Rodents	< 1	Fipronil, Borax, Bromadiolone
Grand Total (of 3,143 records)	14,482	

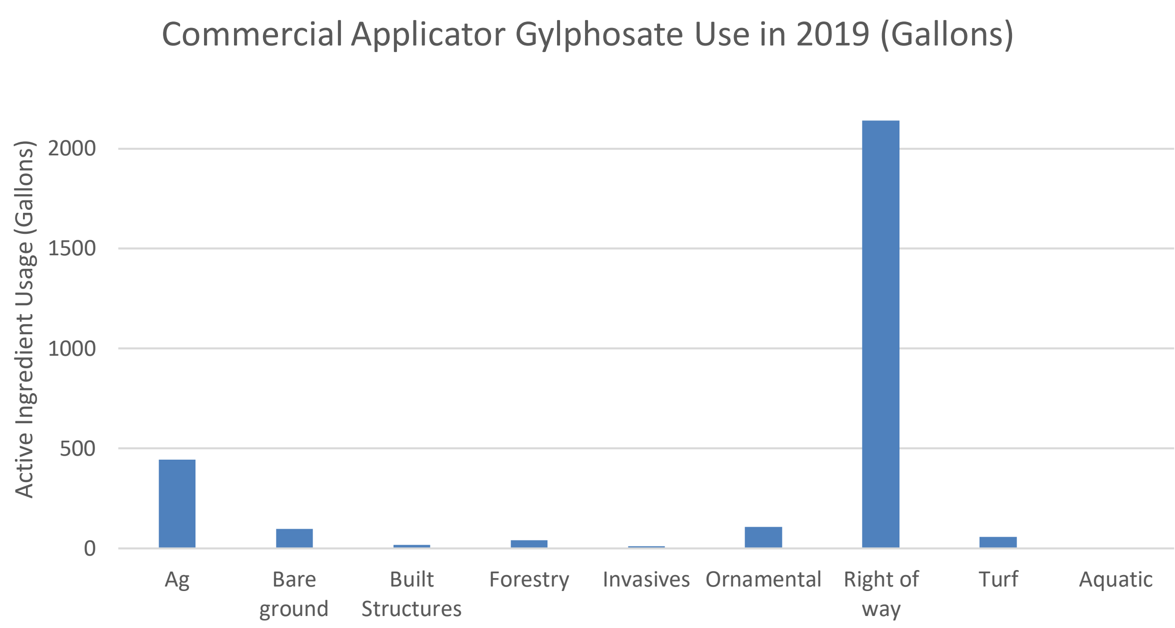

Figure 1. Liquid Glyphosate Use by Maine Commercial Applicators in 2019.

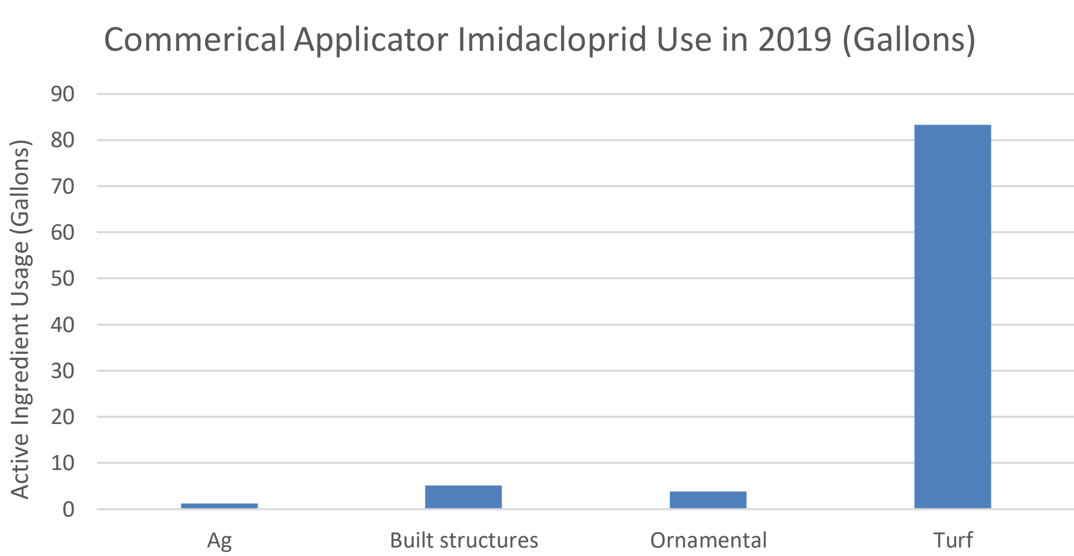

Figure 2. Liquid Imidacloprid Use by Maine Commercial Applicators in 2019.

VII. Use and Sales Reporting in Other States

BPC staff queried other state pesticide programs for information on sales and use reporting activities. In addition to mining state websites for information, a survey was sent via the American Association of Pesticide Control Officials (AAPCO). Twenty-four states and one territory responded to the survey. Summarized answers from the survey of pesticide use reporting and pesticide sales are presented in Table 5. Staff have combined survey results with prior experience and knowledge of other pesticide programs to produce this summary. For example, California, New York, and New Jersey did not respond to the survey, but their programs are known to staff and included below.

Table 6. Summarized Results Pesticide Use and Reporting Survey Sent to State Pesticide Programs. Survey was sent electronically to all state and territories with AAPCO membership. Twenty-four states and one territory responded to the survey. Fifteen states indicated that they did not collect or report on pesticide sales and use information.

State	Collect Use Data?	Report Use Data to Public?	Collect Sales Data?	Report Sales Data to Public?
Arizona	Yes	Yes		
Georgia	Yes			
Hawaii	Yes	Yes	Yes	
Maryland		Yes	Yes	
Massachusetts			Yes	
Minnesota			Yes	Yes
New Hampshire	Yes		Yes	
Oklahoma			Yes	
Puerto Rico	Yes		Yes	
Washington	Yes		Yes	

Ten states collect application data outside of typical enforcement action activities (the states listed in Table 5 plus California, New York, New Jersey, & Vermont). In those states there is a mix of reporting requirements, with annual reporting as the most common.

A. States with pre-notification

In three states/territories, notification of a proposed pesticide application is required prior the actual application taking place. The states/territories with pre-notification for certain types of applications are California, Georgia, and Puerto Rico. In California, County Commissioners accept application plans within the week of a proposed application. As part of the notification, certain agricultural applications in California must show approval of the application details from certified crop advisors. County Commissioner offices are also responsible for data clean-up and often reach out to the applicators for clarifications prior to submission of the data to California's Department of Pesticide Registration. Puerto Rico requires pre-notification of certain pesticide applications within the week of the application. Georgia has a heightened focus on termite applications and consumer protection issues. In advance of structural pesticide treatments for termite control, applicators are required to submit fumigation plans that detail the location, name, and contact information for the operator in charge, active ingredient, volume to be treated, pest, and time of releasement.

B. States with post-application use records collection

Many states collect post-application records; however, each program is unique in the details of what is collected. In Maine and Vermont, annual summaries (Appendix D) based on application records (Appendix F) are collected from commercial applicators (private applicators are excluded from this requirement). In New Hampshire, annual summaries based on application records are submitted, similar to Maine and Vermont; however, in New Hampshire, all applicators (commercial and private) are required to submit records. In New York, commercial applicators, but not private applicators, are required to submit an annual summary report. Applicators report every application on an application-by-application basis. The New York annual summary report includes product information, application location, date, dosage, method of application, target pest, site, and total product used. In Hawaii, recent legislation required annual use reporting for restricted use pesticide applications by certified applicators. The reporting form and collected details in Hawaii are not substantially different from Maine's annual reporting (Appendix A). Washington collects details associated with usage on a voluntary basis at pesticide credit training conferences. Since credit meetings tend to be focused around applicator categories or specific commodities, these meetings work well for asking focused groupings of applicators what methods and active ingredients they have been using.

C. States that report data from use records or summaries to the public

The data reported is not in the format most useful to the public. Pesticides are managed by the State Brand Name and EPA Registration Number, not the active ingredient. Some states present the data received as lists of products (like Hawaii), while others process the information and convert the data into pounds of active ingredient. Even the task of determining the amount to report differs among reporting states. The weight of the product as purchased includes the active ingredient and the inert/other ingredients together. By using percent active ingredient information from the label, the total weight can be converted into active ingredient alone. Some states (like Vermont) additionally convert liquid products from gallons into their solid weights using formulas based on the density of active ingredient.

Other states (like New York) report the results separately in pounds and in gallons. The New York results are available as summarized report documents and as an interactive web application hosted by Cornell University/Cooperative Extension. The most recent validated annual report covers 2013 data; however, data up to 2018 can be found on the interactive web application.

In Arizona, most reporting focuses on specific topics rather than simply all of the annually submitted data. Reports are the product of Cooperative Extension under direction and collaboration of the Arizona Pesticide Management Committee (APMC), a stakeholder group for IPM in Arizona. Pesticide use data requested by third-party groups in Arizona is handled by a Data Request subcommittee to ensure that identifying features are removed prior to release.

Maryland does not annually collect use data. However, every few years, as budget permits, they work with the National Agricultural Statistical Service (NASS) to estimate pesticide usage in the state. NASS performs in-depth surveys of agricultural producers (generating greater than $1,000 annually) as part of their Census of Agriculture. After identifying growers, private applicators, and commercial spray firms associated with agriculture in Maryland NASS and Maryland Department of Agriculture sends surveys to all growers and applicators. The surveys are voluntary, and between 34% and 55% of the surveys are returned. The data are privacy protected as data management is handled completely by NASS personnel, and privacy is extended by federal law under Title 7 US Code § 2276.

D. States with sales records collection

As seen in Table 6, eight states participating in our survey reported the collection of sales data from pesticide dealers. Of those eight respondents, only one state, Minnesota, also publishes sales data for the public. New York state also apparently collects and represents sales data to the public, similar to their use data as discussed in the previous section.

VIII. Past Board Use and Sales Reporting Efforts

In 2002, the BPC released findings relevant to LD 1726, An Act to Minimize Reliance on Pesticides, where the BPC was to study ways to improve the usefulness of report information and to publish an annual report on pesticides sales and sector of use wherever possible. The full report discusses 2000 sales and use data but also includes discussion of 1995, 1997, 1998 and 1999 data and can be found here:
https://www.maine.gov/dacf/php/pesticides/documents2/technical_resources/Pesticide-sales-and-use-report-2020.pdf

The 2002 report acknowledged that the legislature did not provide any new money to accomplish the proposed task of annual use reporting and data sorting by active ingredient and use sector. Staff identified several major hurdles to accomplish the effort, the first of which was density conversion factors to translate gallons of liquid products into pounds of active ingredients contained in each liquid product sold in the state. The necessary data to calculate conversions was and is not readily available from any one source. In 2002, a staff decision was made to divert the staff person in charge of water quality and worker safety from those responsibilities to focus on searching and compiling density data for each of over 500 active ingredients. The ensuing process consumed hundreds of staff hours.

The second major hurdle involved checking the veracity of hundreds of use and sales summary reports, entering thousands of lines of data, and developing a database.

In addition to these significant challenges, the 2002 report noted that while sales and use data was reported, additional work was necessary to improve the poor quality of reports, ensure required reports are received from all distributors, and continue efforts to sort the data by sector of use.

The 2002 report also provided a series of recommendations that are described in further detail below.

IX. Considerations

The Board's staff has attempted to identify considerations relevant to successful implementation of comprehensive use and sales reporting as has been requested by LD 524. Following review of the 2002 Sales and Use Report (Appendix G), staff determined that the recommendations of this report remain relevant and are listed below. Additionally, staff have identified relevant necessary resources, barriers to success, and recommendations that are also provided below.

Recommendation from the 2002 Sales and Use Report:

- Consider revisions to 22 M.R.S.A § 1471-W (3) that would require any person who distributes pesticides into the state to report the amounts of the sales, regardless of to whom those sales are made. Such an approach should eliminate many of the reporting loopholes and the potential for double reporting.
- Consider revisions to 7 M.R.S.A. § 607 (2) to require pesticide registrants to submit additional useful information about the pesticide products at the time of registration, similar to New York State. Examples of other useful information may include: 1) pounds of active ingredients per gallon of liquid formulations; 2) type of pesticide such as insecticide, herbicide, etc.; 3) probable use sector such as agriculture, turf, structures, aquatic, industrial, etc.; and 40 label signal word or other toxicity data.
- Identify funding and provide necessary positions to administer the state pesticide sales and use information program. Other states charged with compiling pesticide sales and use data have come to recognize the complexity of the task and allocated resources accordingly. For instance, in New York State, this program is contracted to Cornell University, which had, in 2002, eight staff members working on the program.
- Consider requiring commercial agricultural producers to submit annual pesticide use reports in addition to the commercial applicator reports the Board currently receives.

- Modify the Board’s rules requiring reporting by commercial pesticide applicators (Chapter 50) to tailor the reports to correspond to the type of information that is of interest to the legislature.

Additional Necessary Resources/Transitions and Barriers to Success

As previously mentioned, the Board has new electronic reporting functionality and has compiled 2019 commercial data with this new software and the help of temporary staff. Temporary staff will continue to be necessary for successful compilation of 2020 and 2021 data. In order to effectively receive annual sales and use data from reporting parties in the future, it will be necessary for pesticide applicators and distributors to input their own data. The Attorney General’s Office has indicated that making electronic submittals mandatory would require rulemaking.

It is important to note that even with applicator and dealer input of the data, additional staff will be necessary to respond to the increased volume of support requests for entering sales and use reports and for data quality control. Without some idea of the type and frequency of the records reported and expectations for data publishing, it is impossible for staff to precisely predict the number of staff and the cost of software improvements necessary for response.

Given concerns about the cost of employing the necessary number of staff to adequately address the demands of comprehensive reporting, Board staff have reached out to the Maine Office of Information Technology and the currently contracted programmers who built and maintain MePERLS. Staff have asked for recommendations of technological solutions to staffing, specifically asking about the application of artificial intelligence (a.i.) and optical character recognition (OCR). Following these discussions, staff anticipate incorporating a rudimentary version of OCR into the existing sales and use reporting framework; however, use of a.i. appears unrealistic given the absence of a searchable pesticide label language database.

Additional Recommendations

Staff have identified some potential additional suggestions to aid in fulfillment of the sales and use reporting request and to improve the quality of the annual pesticide sales and use reports:

- Consider modifying the Commercial Use Summary report (CMR 01-026 Chapter 50) to require identification of pesticide applications on school grounds through use of the existing reporting field “site.”
- Consider revisions to CMR 01-026 Chapter 50 to require electronic submittal of commercial applicator use annual summary and restricted-use pesticide dealer sales annual summary reports.
- Consider revisions to 22 MRSA § 1471-W(3) to require electronic submittal of general-use pesticide dealer annual sales summary reports.

- Consider hosting a series of stakeholder meetings with parties required to submit sales and use reports and entities interested in sales and use data to better understand the types of questions to which the data might be applied. Without a clear understanding of the types of information of interest, it is difficult to impossible to effectively tailor responsive reports.
- At present, all pesticides sales and use data collected by the Board is subject to FOAA. Consider revisions to Maine law to provide protection for information identified as CBI by agricultural producers.
- Consider the potential issues of data security for all collected information and identify ways by which sales and use data could be collected and protected.

X. Appendices

Appendix A—General Use Pesticide Dealer Annual Sales Summary Report Form

Annual Pesticide Dealer Sales Report

Company Name

Directions to upload Sales Report to Board of Pesticides Control online portal:

- log onto BPC portal. (If you do not already have a login please got to www.maine.gov/bpc to create one)
- click on 'my profiles' in the top right corner; then click on your company name
- on left side of screen select 'upload documents/reports'
- select document 'category' and 'year' from dropdown menus, then click 'upload document'
- select annual report document file from your computer and click submit
- file will appear on screen- to finish attaching to profile click submit and you will see statement that your document has been sent for review.

Please list ALL companies from which you receive pesticides (Name, Address, Phone Number)

Please list ALL companies to which you distribute pesticides (Name, Address, Phone Number)

*use a second form if more room is required.

General Use Pesticide Dealer Sales Report for 2021 Distribution

Company Name	
Company Address	
Company Contact & Telephone Number	

Sales Report Status: ☐ No Pesticides Sold or Offered for Sale
Required: Check One ☐ No Reportable Sales

Plant Incorporated Protectant Status: Applicant intends to distribute plant-incorporated protectants, e.g., Bt Field Corn
Required: Check One ☐ Yes ☐ No

Pesticide Trade Name	EPA Registration Number	Total Number Units Sold	Weight/Volume per Unit

Page ____ of ____

Appendix B—Restricted Use Pesticide Dealer Annual Sales Summary Report Form—Sales to Distributors

Restricted, Limited and General Use Pesticide Dealer Sales Report for 2021 Sales TO OTHER DISTRIBUTORS

Federal Tax ID Number:	
Company Name:	
Company Address:	
Company Contact and Telephone #	

Name

Pesticide Trade Name	EPA Registration Number	Total Number of Units Sold	Weight/Volume per Unit

Page____of____

Appendix C—Restricted Use Dealer Report Annual Sales Summary Report Form—Sales to Consumers

Restricted, Limited and General Use Pesticide Dealer Sales Report for 2021 Sales TO CONSUMERS

Federal Tax ID Number:	
Company Name:	
Company Address:	
Company Contact and Telephone #	

Name ____________________

Pesticide Trade Name	EPA Registration Number	Total Number of Units Sold	Weight/Volume per Unit

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Commercial Applicator Annual Summary Report

Report Year 2021

Master Applicator's License #	
Master Applicator's Name	
Company Name	
Company Email	
Address	
Telephone #	

If this report covers applications performed by all company licensees, please check here ☐

If no applications performed, please check box and return to the Board. ☐

Please convert all application data to pounds or gallons of 'undiluted'

Target site	Pesticide Brand Name	EPA Registration Number	Total Pounds Undiluted Formulation	Total Gallons Undiluted formulation	Total Area Treated (Ac, Sq Ft, #trees, homes, pets)
Golf greens	Scott's fungicide 6	538-159	373.75		183,931 Sq. Ft.
Brocolli	Phosdrin 4EC	5481-412		7.1	57 Ac.
Wall Void	Empire 20	6217-145		0.16	20 homes
Dogs	Fleas-No-More	624-467		3	1378 dogs

Examples

Page ____ of ____

Appendix E—Summary of Maine Legislation Addressing Use/Sales Reporting, Notification, and Drift

Notification				
Legislature	**LD #**	**Title of Bill**	**Description**	**Final Disposition**
110th	941	An Act Requiring the Notification of the Specific Location of All Aerial Application of Pesticides Including Herbicides.	Requires notice to the BPC and newspapers in the area before aerial spraying of pesticides	Leave to Withdraw (died) 1983
111th	1249	An Act Relating to the Notification of Intent to Apply Pesticides	Requires notification of intent to apply pesticides & establishes fee of retail sale of pesticides to provide funds to monitor notification and application	Unanimous Leave to Withdraw (died) 1984
111th	2335	An Act to Provide for Public Notifications of the Intent to Apply Pesticides and for Monitoring Certain Pesticide Application Projects	Establishes a system for public notification provisions prior to pesticide application.	Unanimous Leave to Withdraw (died) 1984
113th	2441	An Act to Require Farms to Post Notice of Pesticides Used	Requires owners of farms to notify both agricultural workers and persons who enter the farm to pick their own produce of the pesticides used on the farm.	Majority ONTP (died) 1988
118th	447	An Act Regarding Disclosure of Pesticide Use to a Buyer of Blueberry Land	Requires seller of blueberry land to disclose to the prospective buyer any use of pesticides on the land prior to purchase.	ONTP (died) 1997
119th	1535	An Act to Require Notice to Abutters Prior to Commercial Applications of Pesticides	Requires commercial applicators to provide a one-week advance notice of applications to residences on abutting property.	Unanimous ONTP (died) 1999
122nd	1256	An Act To Ensure Public Awareness of Pesticide Applications	This bill requires persons certified to apply pesticides to provide written notice of pesticide application to the Board of Pesticides Control concerning the type and amount of pesticide and the time and place of application. The Board must then make that information easily available to the public.	ONTP (died) 2005

123rd	1698	An Act To Provide for Public Notification of Indoor Pesticide Applications	Voids the current rules of the BPC for notification in Ch 26, requires institutions to post for a period of 6 months after the application a notice that pesticide application took place. Also implements specific notification rules for childcare facilities and notice to tenants.	ONTP (died) 2007
123rd	2194	Resolve, Regarding Legislative Review of Portions of Chapter 26: Standards for Indoor Pesticide Applications and Notification for All Occupied Buildings Except K-12 Schools, a Major Substantive Rule of the Department of Agriculture, Food and Rural Resources, Board of Pesticides Control. (Submitted by the Department of Agriculture, Food and Rural Resources, Board of Pesticides Control	This resolve provides for legislative review of portions of Chapter 26: Standards for Indoor Pesticide Applications and Notification for All Occupied Buildings Except K-12 Schools, a major substantive rule.	Emergency Passed. Resolve, Chapter 153. 2008
124th	972	Resolve, Regarding Legislative Review of Portions of Chapter 28: Notification Provisions for Outdoor Pesticide Applications, a Major Substantive Rule of the Board of Pesticides Control	This resolve provides for legislative review of portions of Chapter 28: Notification Provisions for Outdoor Pesticide Applications, a major substantive rule of the Department of Agriculture, Food and Rural Resources, Board of Pesticides Control.	Emergency Passed. Resolve, Chapter 115. 2009
124th	1293	An Act To Require Citizen Notification of Pesticide Applications Using Aerial Spray or Air carrier Application Equipment	Requires land managers to notify neighbors prior to the application of pesticides using an aircraft or air-carrier equipment. Establishes the notification registry of citizens that desire additional information when pesticides are applied using aircraft within 1,320 feet of land owned, leased, or resided upon.	Enacted, PL Chapter 378. 2009
124th	1294	An Act To Amend the Laws Governing the Referred to Jt. Standing Comm. On Agriculture, Conservation and Forestry. Public Hearing Process for the Board of Pesticides Control	Requires the BPC to hold public hearings on registration applications of certain pesticides (toxicity category I, 40 Code of Federal Regulations, 5 Section 156.62, 2008) or for an application for registration of a product that contains a plant-incorporated protectant.	ONTP, Joint Rule 310. (died) 2009

124th	1547	An Act To Revise Notification Requirements for Pesticides Applications Using Aircraft or Air-carrier Equipment	Excludes backpack sprayers as air-carrier equipment, adds definition for “sensitive area likely to be occupied”, requires notification be sent by March 15th, removes obligation to update notification information more than 3 years, allows information for participants in the pesticide registry to be provided any time of day before application rather than minimum of 24 hours prior, specifies brand names rather than commercial and scientific names of pesticides provided to registry participants, request for MSDS from landowner will not postpone treatments, land managers must use registrant’s preferred form of communication, revises information required from registrants, establishes a deadline of March 15 for registrants who want to receive information, and authorizes waivers of notification requirements when public health or natural resources are threatened.	Emergency enacted, PL Chapter 584. 2010
125th	16	An Act To Revise Notification Requirements for Pesticides Applications Using Aircraft or Air-carrier Equipment.	Changes the distance requirements for the pesticide notification registry from within 1,320 feet of a property to within 100 feet of a property.	ONTP (died) 2011
125th	228	An Act To Revise Notification Requirements for Pesticide Application	Repeals laws that govern the development and maintenance of a registry of the properties of residents, lessees, and property owners who request that their properties be placed on an advanced notification registry for outdoor pesticide applications.	Enacted, PL Chapter 332. 2011
125th	1041	An Act To Simplify and Enhance Pest Control Notification	This bill amends the notification process for pesticides applications. The bill directs that the registry established by the Department of Agriculture, Food and Rural Resources, Board of Pesticides Control is the only mandatory notification system for outdoor applications. It requires all registrants to update or confirm their contact information annually. The bill amends notification requirements that currently apply to applications made using aircraft or air-carrier equipment to provide that the requirements apply to outdoor applications generally. It requires that the board determine the distances between properties and applications within which a land manager is required to notify a person whose property is on the registry of an application based on the type of equipment used to make the application.	ONTP (died) 2011

126th	1391	An Act To Provide a Pesticide Spraying Notification Process	This resolve directs the DACF to create a publicly accessible website where persons may enter their information on a registry for notification of pesticide applications by aircraft or air carrier equipment in a given county. This bill also allows persons to be on more than one county registry. Applicators must enter application date, time and location and the types of pesticides to be applied and other information as determined by the department into the publicly accessible website at least one week before the application. The website must then generate e-mail messages to those listed on the appropriate county registry notifying them of the application of pesticides	ONTP (died) 2013
126th	33	Resolve, Regarding Legislative Review of Portions of Chapter 27: Standards for Pesticide Applications and Public Notification in Schools, a Major Substantive Rule of the Board of Pesticides Control. New Title: Resolve, Regarding Pesticide Applications and Public Notification in Schools	This resolve provides for legislative review of portions of Chapter 27: Standards for Pesticide Applications and Public Notification in Schools, a major substantive rule of the Department of Agriculture, Conservation and Forestry, Board of Pesticides Control.	Emergency Passed, Resolve. Chapter 63. 2013
126th	1569	Resolve, Regarding Legislative Review of Portions of Chapter 51: Notice of Aerial Pesticide Application, a Late-filed Major Substantive Rule of the Department of Agriculture, Conservation and Forestry. (Submitted by the Department of Agriculture, Conservation and Forestry	This resolve provides for legislative review of portions of Chapter 51: Notice of Aerial Pesticide Application, a major substantive rule of the Department of Agriculture, Conservation and Forestry that was filed outside the legislative rule acceptance period.	Passed, Resolve. Chapter 86. 2014

127th	203	Resolve, Regarding Legislative Review of Portions of Chapter 28: Notification Provisions for Outdoor Pesticide Applications, a Major Substantive Rule of the Department of Agriculture, Conservation and Forestry, Board of Pesticides Control	This resolve provides for legislative review of portions of Chapter 28: Notification Provisions for Outdoor Pesticide Applications, a major substantive rule of the Department of Agriculture, Conservation and Forestry, Board of Pesticides Control.	Emergency Passed, Resolve. Chapter 6. 2015
129th	101	An Act To Reestablish the Pesticide Notification Registry	This bill reestablishes the law, which was repealed by Public Law 2011, chapter 332, governing the development and maintenance of a registry of the properties of residents, lessees and property owners who request that their properties be placed on a registry in order that they receive advance notification of the outdoor application of pesticides near their properties.	Leave to Withdraw. 2019
Sales & Use				
110th	738	Resolve, Authorizing and Directing the Board of Pesticides Control to Study and Report on Urban Pesticide Usage.	Requires the Board of Pesticides Control to study the use of pesticides in urban areas and report back to the first regular session of the 111th Legislature.	Leave to Withdraw, Report Read and Accepted. 1981
114th	179	An Act Concerning the Regulation of General Use Pesticides	Requires annual sale reports from persons who are licensed to distribute general use pesticides.	Enacted, PL Chapter 93. 1989
114th	466	An Act to Study the Use of Pesticides in the State's Forests	This bill requires the Department of Conservation to review the issues relating to pesticide use in the tate's forests on an ongoing basis. The department is required to review the use of pesticides and the issues surrounding their use by December 1990.	Majority ONTP (died) 1989
115th	577	An Act Regarding the Use of Pesticides and Placing the Board of Pesticides Control under the Authority of the Department of Environmental Protection	Moves the BPC from DACF to DEP and prohibits sale of certain produce treated with pesticides. Requires research into agricultural, forestry, and right-of-way alternatives to pesticide use, repeal the exemption for pesticide dealer reporting of pesticides sold in smaller containers.	Majority ONTP – resolve from LD 1838, 1989 to study herbicide use

115th	72	An Act Regarding the Forestry, Natural Habitat, Water Quality and Environmental Impacts of Pesticide Use	Same bill as above but removes the change of jurisdiction of the BPC from DACF to DEP.	ONTP (died) 1991
118th	420	An Act to Improve the Reporting of General Use Pesticide Sales	Shifts reporting requirements primarily to wholesalers and a few large distributors. Computerized sales data on all pesticides regardless of package size. Removes burden from smaller retailers.	Enacted, PL Chapter 139. 1997
118th	447	An Act Regarding Disclosure of Pesticide Use to a Buyer of Blueberry Land BY REQUEST	This bill requires a seller of blueberry land to disclose to the prospective buyer any use of pesticides on the land of which the seller has knowledge. This includes knowledge the seller may have about pesticide use that occurred before the seller bought the land. Disclosure may be delivered orally or written in the contract, but may not be hidden in fine-print contract language. The bill gives the buyer the right to rescind the land sale contract, or after delivery of the deed, to recover damages.	ONTP (died) 1997.
118th	1726	An Act to Minimize Reliance on Pesticides	This bill directs the agencies of the State to promote integrated pest management and to work with private interests to determine other appropriate actions. It directs the State Board of Pesticides Control to study ways to improve the usefulness of report information and to publish an annual report on pesticides sales and sector of use wherever possible.	Enacted, PL, Chapter 251. 1997
119th	2435	An Act to Implement the State Policy to Minimize Reliance on Pesticides	This bill appropriates $150,000 to the Board of Pesticides Control to be used to establish an Integrated Pest Management Research Fund.	ONTP (died) 2000
120th	1540	An Act to Ensure that the State Board of Pesticides Control has Sufficient Resources to Provide Accurate Information About the Use of Pesticides in the State	Amends the annual reporting requirements of the BPC to require that report to Legislature each January 15th. Contents expanded to include review of all commercial and noncommercial uses of pesticide products in the state and ID of purpose for use, environmental and economic impacts, and benefits of those uses.	Enacted, PL Chapter 335 2001
127th	708	An Act To Limit the Use of Pesticides on School Grounds	Defines lawn care pesticide, pesticide, school, and school grounds and stipulates that lawn care pesticides can only be used for stinging or biting insects, in response to a public health nuisance, or on an agricultural field in accordance with manufacturer's instructions. This rule also designates the Department of Education to adopt landscaping designs that minimize use of pesticides.	ONTP – introduced in 128th as LD 174

128th	174	An Act To Limit the Use of Pesticides on School Grounds	See above	Died on Adjournment 2018
129th	908	An Act To Require Schools To Submit Pest Management Activity Logs and Inspection Results to the Board of Pesticides Control for the Purpose of Providing Information to the Public	This bill establishes in law certain requirements of the Department of Agriculture, Conservation and Forestry, Board of Pesticides Control related to pest management on school property. It requires a school to maintain a pest management activity log related to the application of pesticides. It requires this information to be provided annually to the board and requires the board to post the information on its publicly accessible website. It also requires that the board post on its publicly accessible website a list of all board inspections of a school's use of pesticides and the results of those inspections.	Died on Adjournment 2020
129th	2083	An Act To Require the Board of Pesticides Control To Annually Publish Certain Information Regarding Pesticides and To Prohibit Certain Uses of Neonicotinoids	This bill has two requirements. First, The Department of Agriculture, Conservation and Forestry, Board of Pesticides Control to annually publish a summary of the reports received during the previous calendar year from commercial applicators of pesticides. For each pesticide reported to the board, the board's annual summary must include information on the total quantity of pesticide applied and the total area treated in each county in the State. Second, the bill requires The Board of Pesticides Control to prohibit the use of any product containing neonicotinoids for landscape gardening by certified applicators or limit the use of any product containing neonicotinoids if the board determines that use is necessary to protect the State. The bill also requires the board to adopt rules establishing restrictions for the use of products containing neonicotinoids.	Died on Adjournment 2020
130th	524	Resolve, Directing the Board of Pesticides Control To Research Workable Methods To Collect Pesticide Sales and Use Records for the Purpose of Providing Information to the Public	This bill directs the Board of Pesticides Control to research workable methods to collect pesticides sales and use records from schools. The board shall explore the best methods for collecting information on pesticide sales in the State. Results of this research must be provided in a report to the Joint Sanding Committee on Agriculture, Conservation, and Forestry.	Passed, PL Chapter 54. 2021

130th	1599	An Act To Establish A Maine Pesticide Sales and Use Registry	This bill directs the Department of Agriculture, Conservation and Forestry, Board of Pesticides Control, in collaboration with the Department of Administrative and Financial Services, Office of Information Technology, to create a publicly accessible online registry of pesticide dealers and applicators reporting pesticides sold, distributed or applied in the State and including the quantity, location and purpose of the use of pesticides in indoor and outdoor applications. This bill also requires the Board of Pesticides Control to report annually to the Legislature on the developments and progress made in carrying out the state policy of minimizing the use of pesticides.	Died on Adjournment 2021
		Drift		
111th	1022	An Act to Protect the Public from Unsafe Pesticide Use.	Enhances the Board of Pesticides Control Act to strengthen Board investigative, rulemaking, and enforcement powers. This includes residues, droplet size, buffer zones, and new registration periods.	Enacted, PL Chapter 558. 1983
111th	2306	An Act to Amend the Act to Protect the Public from Unsafe Pesticide Use	Repeals a prohibition on all application of pesticides which may result in any off-target residue and substitutes a requirement that the board may issue regulations to minimize drift.	Enacted, PL Chapter 761. 1983
122nd	1657	An Act To Minimize the Risk to Maine's Marine Waters and Organisms Posed by the Application of Pesticides	Limits the application of pesticides near the normal high tide mark for the control of browntail moths. This includes prohibiting the use of mist blower and hydraulic rig within 500 and 50 feet of a high tide mark, respectively.	Enacted, PL Chapter 553. 2005
123rd	406	An Act To Prohibit Aerial Spraying of Pesticides near Buildings, Roads and Bodies of Water	This bill establishes buffers where aerial spraying of pesticides is prohibited.	ONTP 2007 – became LD 182 in 124th
124th	182	An Act To Prohibit Aerial Spraying of Pesticides near Buildings, Roads and Bodies of Water	See above	ONTP (died) 2009

124th	494	Resolve, Regarding Legislative Review of Portions of Chapter 22: Standards for Outdoor Application of Pesticides by Powered Equipment in Order To Minimize Off-target Deposition, a Major Substantive Rule of the Department of Agriculture, Food and Rural Resources, Board of Pesticides Control	Revises portions of Chapter 22 to minimize off-target deposition, major substantive rule.	Emergency Passed, Enacted. Resolve Laws. Chapter 114. 2009
125th	591	An Act To Prohibit the Use of Pesticides in Certain Circumstances	Prohibits application of pesticides from aircraft. Also prohibits use of pesticides for aesthetic purposes, removing roadside vegetation, and removing vegetation in parks. Also directs the board to prohibit synthetic pesticides when less toxic, naturally occurring pesticides are present as an alternative.	Leave to Withdraw. (died) 2011
126th	1567	Resolve, Regarding Legislative Review of Portions of Chapter 22: Standards for Outdoor Application of Pesticides by Powered Equipment in Order To Minimize Off-Target Deposition, a Late filed Major Substantive Rule of the Department of Agriculture, Conservation and Forestry	This resolve provides for legislative review of portions of Chapter 22: Standards for Outdoor Application of Pesticides by Powered Equipment in Order to Minimize Off Target Deposition, a major substantive rule of the Department of Agriculture, Conservation and Forestry that was filed outside the legislative rule acceptance period.	Passed, Resolve PL. Chapter 88. 2014

SPRAYER CALIBRATION LOG

Date calibrated:				
Sprayer brand:				
Spayer type:				
Sprayer model:				
Nozzle type:				
Nozzle spacing:				
Nozzle orientation[1]:				
Nozzle condition[2]:				
Boom height[3]:				
Pressure:				
Speed (mph):				
Throttle (rpm):				
Tractor model:				
Tractor gear:				
Calculated volume/acre[4]:				
Calibration method:				

1 - Nozzle orientation is the nozzle angle with reference to the airstream (for aerial and air-blast) or with the ground (for boom sprayers). For aerial and airblast 0^0 = with the airstream; for boom sprayers, 0^0 = straight down.

2 - Do all nozzles match (size and number) and does output of each nozzle vary by less than ± 10% from the average nozzle output?

PESTICIDE KEY

Brand Name	Active Ingredients(s)	Epa Reigistration No.	Restricted Entry Interval and/or Air Concentration Level

PESTICIDE APPLICATOR LOG

Company Name:

Date	Start Time	Finish Time	Address, Town/ Field Location[1]	Size of Treated Area[2]	Sensitive Area[3] Yes/No	Site or Crop

1 - Be specific, street address, etc. Use abbreviations if needed.
2 - Acres or other unit of measure you normally use, eg. 1000 sq ft, tree-volume, acre-ft., linear miles, etc.
3 - If sensitive areas are present, a description or map is required.

NOTES:

Applicator Name(s):

License Number (s):

2.

Target Pest	Wind	Weather Conditions			Pesticide(s) and Diluent Applied[5]	Rate Description			Application Method
	Speed & Direction	Temp	Cloud Cover	Time Noted[4]		Undiluted	Mix	Mix Ratio	

4 - Note weather conditions every two hours, more often if conditions change.

5 - Use the pesticide key at the front of this Logbook to record pesticide brand name, active ingredient, EPA registration number and restricted entry interval or air concentration interval.

If you make an incorrect entry - DO NOT ERASE - cross out the error and write in the correction

REPORT OF PESTICIDE SALES AND COMMERCIAL USE FOR CALENDAR YEAR 2000

PREPARED BY

MAINE BOARD OF PESTICIDES CONTROL
MAINE DEPARTMENT OF AGRICULTURE, FOOD & RURAL RESOURCES
28 STATE HOUSE STATION
AUGUSTA, MAINE 04333-0028

PUBLISHED IN ACCORDANCE WITH P.L. 1997, CHAPTER 389
AND P.L. 2001, CHAPTER 355

MARCH 29, 2002

REVISED JUNE 27, 2002

REVISED SEPTEMBER 6, 2002

REVISION NOTES

The revisions of June 27th result from information prepared for a presentation to the Joint Standing Committee on Agriculture, Conservation and Forestry on June 4, 2002. They include a new section titled Interpretation of Reports plus three new tables that (1) sort the pesticides by major use classification, (2) sort the homeowner products by quantity but list the type of product, and (3) compare retail sales for 2000, 1997 and 1995.

The revisions of September 6th correct errors in Appendices I-A and I-B that resulted from an error in the original query that incorrectly multiplied the quantities when there was more than one federal or state registration number.

REPORT DISCUSSION

Introduction

In 1997, the Maine Legislature passed LD 1726, An Act to Minimize Reliance on Pesticides. One of the two major provisions of the bill created a state policy for finding ways to use the minimum amount of pesticides needed to effectively control targeted pests in all areas of application.

The second provision directed the Board to implement a system of record keeping, reporting, data collection and analysis that provides information on the quantity of products and brand names of pesticides sold. In addition, the Board was directed to apply this system to compile, by October 1st of each year, an annual report containing the quantity of product sold in the previous year, sorted by the trade name and United States Environmental Protection Agency registration numbers. Further, the report was to be sorted by sector of use, wherever possible. The Board was also directed to build cooperation with the University of Maine Cooperative Extension to improve these pesticide information databases and to optimize reporting analyses.

The Board produced reports of the 1998 and 1999 sales and use data before there was general agreement that sorting by product name and EPA registration number did not produce a useable report that allowed evaluation of the relative levels of pesticide use by principle use sectors within the state. Legislation passed in 2000 released the Board from reporting in 2000 and 2001, directing it instead to study ways to improve the quality of the data collection and sorting. In 2001, legislators pointed to small, focused reports produced previously by the Board that summarized sales of agricultural pesticides by pounds of active ingredient. Subsequently, legislation was passed directing the Board to sort the data by active ingredient and prepare a new report by April 1, 2002.

Constraints on Staff Resources

Because the 2001 legislation did not provide any new money to accomplish these tasks, production of the newly required reports presented some major hurdles for the Board's staff. First, density conversion factors to translate gallons of liquid products into pounds of active ingredients had to be acquired and entered into a database for all active ingredients contained in each liquid product sold in the state. This data is not readily available from any one source. Consequently, the staff person in charge of water quality and worker safety who is knowledgeable in databases and pesticide formulations was diverted from her job responsibilities. A labor intensive process of searching for density data for each of over 500 active ingredients ensued that consumed hundreds of staff hours. Second, this staff person was assigned to check the veracity of the hundreds of reports, enter the thousands of lines of data, and develop a database system capable of summarizing sales and use amounts and converting them to pounds of active ingredients. It required over two months of staff time to develop the report to this point. Significant additional man hours will be needed in the future to improve the poor quality of submitted reports, ensure that required reports are received from all distributors and continue efforts to sort the data by sector of use.

Limitations of the Data

In addition to some of the obstacles discussed above, the Board is still confronted with a fundamental problem that limits the usefulness of the attached reports. The statutory reporting requirements as currently constructed do not capture all the pesticide sales in the state and have a potential for some double reporting.

In 1997, legislation was passed with the hope it would improve the reporting for the vast majority of pesticide (the general use or over the counter pesticides) sales in the state. Prior to that time, all licensed retailers of general use pesticides, including department and hardware stores, had to report their annual pesticide sales, but products sold in less than one quart or five pound sizes were exempt from the reporting requirement. When the Board pointed out difficulties encountered trying to obtain accurate reports from these retailers and that large quantities of smaller sized products were not being reported, the legislature decided to remove the container size exemption but take the burden off the smaller stores by identifying a smaller group to do the reporting. The actual language in the revised statute, 22 M.R.S.A. § 1471-W (3), reads, "Any person who distributes general use pesticides to licensed general use pesticide dealers in the State shall keep and maintain records of these sales for reporting purposes." While it seemed like a good idea at the time, we now realize it creates a system where sales of the same products could be reported more than once, and it ignores some fairly substantial amounts of sales that go directly from out-of-state to large in-state end-users and licensed restricted use pesticide dealers. Examples of high volume sales directly to end-users include the following:

- Exterminators
- Lawn care companies
- Golf courses
- Right-of-way maintenance companies
- Forest management companies
- Internet sales to any end-user
- Catalogue sales to any end-user
- Chlorine to many industrial/municipal sites
- Biocides to many industrial/municipal sites
- Wood preservatives to pressure treatment facilities

Sales Reports

There are three sets of calendar year 2000 Maine pesticide sales reports attached, tallied by total volume of active ingredient sold. Each set is sorted both alphabetically and then by volume of sale. These sets are comprised of:

- Wholesale sales,
- Retail sales, and
- Sales of homeowner products.

Wholesale Reports (Appendices I-A & I-B)

The wholesale reports were compiled from reports submitted by distributors who sell pesticides to licensed Maine general use pesticides dealers. Therefore, this information represents sales of pesticides to retailers such as department stores, hardware stores, farm & garden supply stores and other retailers that distribute over the counter pesticides. Several types of pesticides are exempt from the general use pesticide dealer licensing requirements, and those products are not covered by these reports:

- Household use pesticide products containing no more than 3% active ingredients:
- DDVP impregnated strips containing no more than 25% active ingredient;
- Pest supplies, such as shampoos, tick and flea collars and dusts;
- Disinfectants, germicides, bactericides and virucides;
- Insect repellents;
- Indoor and outdoor animal repellents;
- Moth flakes, crystals, cakes and nuggets;
- Indoor aquarium supplies;
- Swimming pool supplies;
- Aerosol products; and general use paints, stains and wood preservatives and sealants.

Aside from those products that are exempted from licensing and sales reporting as described above, there are a number of types of general use pesticide sales that are not subject to the reporting requirements as described earlier in this report, including the following:

- Sales from out-of-state distributors to large in state end-users; and
- Sales from out-of-state distributors to licensed in state restricted use pesticide dealers.

In addition, some sales of general use pesticides may be reported more than once where products are distributed between licensed general use pesticide dealers in the state.

Retail Reports (Appendices II-A & II-B)

The attached retail pesticide sales reports are derived from reports submitted by licensed restricted use pesticide dealers distributing products in Maine. This includes both in-state and out-of-state licensed dealers. These distributors tend to cater primarily to commercial agriculture, forestry, exterminators and golf courses.

Homeowner Reports (Appendices III-A & III-B)

The attached homeowner pesticide sales reports represent a subset of the wholesale reports and are based on product data obtained from New York State intended to identify products most likely marketed primarily to homeowners. At the time of product registration, New York's Product Registration Section asks registrants to specify the major use of each product. Household or home garden are two of their categories and their staff adds a code for either use to the product's EPA registration number in their database. At the Board's request, New York officials provided a listing of all their EPA registration numbers with the two homeowner codes. This information was then used to check the Maine database to identify products most likely marketed primarily to homeowners.

Use Reports (Appendices IV-A & IV-B)

The pesticide use reports are compiled from annual pesticide use summary reports submitted by licensed commercial pesticide applicators. Commercial applicators are those individuals who:

- Apply any pesticide as a service for compensation;
- Apply any pesticide in connection with their duties as an employee of a local, state or federal government;
- Apply any pesticide in an area open to the public; or
- Apply restricted use pesticides on sites other than their own agricultural land.

Examples of the most prevalent types of commercial pesticide applications include:

- Exterminating,
- Lawn care applications,
- Right-of-way applications,
- For hire agricultural applications, and
- Forestry applications.

Use Reports from Other Sources

The 2001 revisions to the Board's reporting statute directs the Board to include summaries of pesticide survey results conducted by the University of Maine Cooperative Extension (UMCE) or the United States Department of Agriculture (USDA). The Board's director wrote both agencies requesting pesticide use information for Maine. Their responses are enclosed as Appendices V-A and V-B and they point out that they have no sector of use information available at this time.

Interpretation of Reports

The preceding sections of this report detail a number of hurdles and statutory limitations to acquiring quality pesticide sales and use data and translating that data into useful reports. Although the Board's staff would prefer not to make any tallies due to the illogical and incomplete reporting system, it does recognize the public's interest in an interpretation of the information that was reported. Accordingly, Table 1was created to present a side by side comparison of the information contained in the appendices for Wholesale, Retail and Commercial Use. First, the reported quantities of each active ingredient were rounded off to thousands of pounds. All of the active ingredients that had more than 500 pounds of sales in one of the appendices were included in this table. The information was first arranged alphabetically by the type of pesticide, and then within type, the active ingredients were arranged alphabetically by common name. Please note the results have been aggregated for herbicides such as 2,4-D, dicamba, endothall, picloram and triclopyr that are active as acids but marketed as salts or esters. The table also contains columns to show how many products containing that active ingredient were registered in Maine in 2001.

The Board's staff added the quantities within the three columns of sales and use records and obtained the following totals:

Wholesale Sales	= 3,867 Thousands of Pounds of Active Ingredients
Retail Sales	= 3,519 Thousands of Pounds of Active Ingredients
Commercial Use	= 2,530 Thousands of Pounds of Active Ingredients

Unfortunately, the many deficiencies in the reporting system do not allow the Board's staff to calculate even an estimate of total sales or usage from the above figures. In addition to sales and use that are not reported, some sales data may represent duplication of reporting. Then there is the simple fact sales reports cannot be converted to use reports.

The side by side comparisons in Table 1 provide an excellent opportunity to point out some gaps in the current reporting system. Diquat dibromide is the most widely used potato vine desiccant but it is a general use pesticide that is primarily sold by restricted use pesticide dealers serving the agricultural community. Thus, persons distributing the product into the state are not delivering it to a general use dealer and are therefore not required to report those wholesale sales. In addition, a high percentage of this product is applied by potato farmers who are not required to report use data. Two other good examples include the slimicides and wood preservatives where no quantities are reported being sold at either level but significant quantities are clearly being used by commercial applicators in industrial settings.

Table 2 was similarly prepared from the homeowner sales reports in Appendix III-A rounded off to thousands of pounds, and the active ingredients arranged by highest to lowest pounds of sales. Diazinon, a widely used insecticide, had the highest level of sales while the popular herbicides glyphosate and 2,4-D were ranked second and third respectively. It is interesting to note that sales of diazonon products labeled for indoor home uses will be discontinued after December 31, 2002 while products labeled for outdoor use must cease by December 31, 2004.

At least one distributor reported on sales of DEET that is an active ingredient in many insect repellants. However, these types of products are exempt from licensing and reporting so actual sales are no doubt much higher than the reported amount.

Table 3 presents a comparison of the active ingredients rounded off to the nearest 1,000 pounds from the retail sales in Appendix II-A with two previous tallies of agricultural and forestry sales from the years 1995 and 1997. The Board's staff cautions readers that the 2000 figures were received from more dealers than were included in the previous two tallies. In addition, some of the agricultural dealers are now carrying more ornamental and turf care products so this may be another reason some of the numbers are hither in 2000 than in 1995 or 1997. The best value from this table lies in the Registration Notes that indicate the status of EPA's review of the active ingredient.

Recommendations

Detailed below, the Board's staff has attempted to identify some potential revisions to Maine law intended to improve the quality of the annual pesticide sales and use reports.

- Consider revisions to 22 M.R.S.A. § 1471-W (3) that would require any person who distributes pesticides into the state to report the amounts of the sales, regardless to whom those sales are made. Such an approach should eliminate many of the reporting loopholes and the potential for double reporting.

- Consider revisions to 7 M.R.S.A. § 607 (2) to require pesticide registrants to submit additional useful information about the pesticide products at the time of registration similar to New York State. Examples of other useful information may include: 1) pounds of active ingredients per gallon of liquid formulation; 2) type of pesticide such as insecticide, herbicide etc.; 3) probable use sector such as agriculture, turf, structures, aquatic, industrial etc.; and 4) label signal word or other toxicity data.

- NOTE: The Board has surveyed a number of states and found that many already routinely ask for additional data from registrants at the time of registration renewal. On May 3, 2002 the Board voted to direct the staff to request additional information on all future registration applications including but not limited to primary intended use of the product and the pounds of active ingredient per liquid volume.

- Identify funding and provide a position to administer the state pesticide sales and use information program. Other states charged with compiling pesticide sales and use data have come to recognize the complexity of the task and allocated resources accordingly. For instance, in New York State this program is contracted to Cornell University which has eight staff members working on the program.

- Consider requiring commercial agricultural producers to submit annual pesticide use reports in addition to the commercial applicator reports the Board currently receives.
- Modify the Board's rule requiring reporting by commercial pesticide applicators (Chapter 50) to tailor the reports to correspond to the type of information that is of interest to the legislature.

NOTE: The Board's staff is currently redesigning the report form with standardized target codes so future, annual applicator reports may be clearly categorized by sector of use.

Table 1. 2000 Wholesale and Retail Pesticide Sales and Commercial Use Information; Sorted by Major Use Classification and Alphabetically by Common Name; June 27, 2002

Common name	**Thousands of pounds Active**			**# Products registered in Maine 2001**
	Wholesale sales	**Retail sales**	**Commercial use**	
Disinfectants				
Alkyl* dimethyl benzyl ammonium chloride (60% C14, 30%C16, 5%C18, 5%C)	0	2	0	**197**
Alkyl* dimethyl ethylbenzyl ammonium chloride (68% C12, 32% C14, 5%C18, 5%C)	0	2	0	**149**
Bromo-3-chloro-5,5-dimethylhydantoin	0	0	3	**20**
Dichloro-5,5-dimethylhydantoin	0	0	2	**12**
Hydrogen peroxide	2	1	0	**21**
Nitrobutyl)morpholine	0	0.7	0	**3**
Poly(oxyethylene(dimethylimino) ethylene(diemthylimino) ethylene dichloride	0	0	1	**38**
Sodium bromide	0	0	283	**18**
Sodium chlorite	222	0	0	**15**
Sodium hypochlorite	0	0	8	**79**
Sodium-o-phenylphenate	4	0	0	**5**

Table 1. 2000 Wholesale and Retail Pesticide Sales and Commercial Use Information; Sorted by Major Use Classification and Alphabetically by Common Name; June 27, 2002

Common name	Thousands of pounds Active			# Products registered in Maine 2001
	Wholesale sales	Retail sales	Commercial use	
Trichloro-s-triazine	0	0	1	**50**
Disinfectant (Slimicide)				
Bis (bromoacetoxy)-2-butene	0	0	22	**1**
Bronopol	0	0	36	**16**
Chloro-2-methyl-3 (2H)-isothiazolone	0	0	20	**41**
Dibromo-3-nitrilonamide	0	0	81	**22**
Dithiol-3-one 4,5 dichloro	0	0	14	**1**
Hydroxymethyl)amino)ethanol	0.7	0	0	**2**
Methyl-3(2H)-isothiazolone	0	0	7	**42**
Potassium N-methyldithiocarbamate	0	0	10	**7**
Thiocyanomethylthio) benzothiazole	0	0	12	**11**
Fumigant				
Chloropicrin	0	0.5	3	**8**
Dichloropropene	0.7	0.7	0	**3**

Table 1. 2000 Wholesale and Retail Pesticide Sales and Commercial Use Information; Sorted by Major Use Classification and Alphabetically by Common Name; June 27, 2002

Common name	Thousands of pounds Active			# Products registered in Maine 2001
	Wholesale sales	Retail sales	Commercial use	
Ethylene oxide	2	0	0	**6**
Gluteraldehyde	0	0	6	**23**
Methyl isothiocyanate	0	0	13	**1**
Fungicide				
Azoxystrobin	0	2	0.8	**2**
Benomyl	0.9	2	0.2	**3**
Captan	17	34	0.3	**19**
Chlorothalonil	135	777	40	**45**
Copper hydroxide	19	28	0.4	**18**
Copper Chloride hydroxide	0	3	0	**10**
Cymoxanil	0	1	0	**3**
Dodine	0	0.7	0	**1**
Fenarimol	10.7	0	0	**4**
Fentin hydroxide	18	13	0.2	**2**

Table 1. 2000 Wholesale and Retail Pesticide Sales and Commercial Use Information; Sorted by Major Use Classification and Alphabetically by Common Name; June 27, 2002

Common name	Thousands of pounds Active			# Products registered in Maine 2001
	Wholesale sales	Retail sales	Commercial use	
Ferrous sulfate monohydrate	3	2	0	**4**
Fludioxonil	1	1	0	**5**
Iodine	0	0	2	**16**
Iprodione	0	0.6	1	**11**
Mancozeb	834	514	11	**28**
Maneb	2	21	0	**4**
Metalaxyl-M	7	9	0	**15**
Metam sodium	1	1	0.3	**9**
Methylene bis thio cyanate	0	0	7	**19**
Metiram	0	57	2	**1**
Myclobutanil	12	0.2	0.01	**10**
Pentachloronitrobenzene	18	18	17	**17**
Propiconazole	6	6	10	**7**
Sulfur	2	24	0	**24**

Table 1. 2000 Wholesale and Retail Pesticide Sales and Commercial Use Information; Sorted by Major Use Classification and Alphabetically by Common Name; June 27, 2002				
Common name	**Thousands of pounds Active**			**# Products registered in Maine 2001**
	Wholesale sales	**Retail sales**	**Commercial use**	
Thiabendazole	7	4	0	**7**
Thiophanate methyl	0.7	8	1	**23**
Triadimefon	0	0.3	2	**21**
Vinclozolin	1	2	0.9	**2**
Herbicide				
Copper sulfate pentahydrate	6	0	0	**18**
Acetochlor	0.6	0.3	0	**13**
Alachlor	0.6	0.6	0.2	**7**
Atrazine	44	43	13	**38**
Bensulfuron-methyl	0	0.9	0	**0**
Boron sodium oxide(B8Na2O13) tetrahydrate	0	0.6	10	**18**
Clethodim	0.9	0.8	0.1	**1**
Clopyralid	0.7	0.3	0.2	**10**
Cyanazine	0.3	1	0	**6**

Table 1. 2000 Wholesale and Retail Pesticide Sales and Commercial Use Information; Sorted by Major Use Classification and Alphabetically by Common Name; June 27, 2002

Common name	Thousands of pounds Active			# Products registered in Maine 2001
	Wholesale sales	Retail sales	Commercial use	
Linuron	9	14	0.1	**2**
MCPA Dimethylamine salt	0.4	24	4	**11**
MCPA, 2 ethylhexyl ester	0	4	0	**2**
MCPB, sodium salt	1	0	0	**0**
Mecoprop	7	5	0.2	**17**
Metolachlor	65	29	4	**16**
Metribuzin	26	22	0	**7**
Napropamide	14	17	4	**5**
Oryzalin	3	0.8	0.3	**6**
Paraquat dichloride	2	14		**3**
Pendimethalin	56	27	16	**22**
Sethoxydim	4	5	2	**2**
Simazine	8	44	0.9	**16**
Sodium bentazon	6	3	0	**3**

Table 1. 2000 Wholesale and Retail Pesticide Sales and Commercial Use Information; Sorted by Major Use Classification and Alphabetically by Common Name; June 27, 2002				
Common name	Thousands of pounds Active			# Products registered in Maine 2001
	Wholesale sales	Retail sales	Commercial use	
Terbacil	3	4	2	**1**
Trifluralin	4	5	2	**31**
2,4-D Acetic acid, 2-ethylhexyl ester	0.3	0.6	0.3	**22**
2,4-D Butoxyethyl	2	0.2	0	**5**
2,4-D Dichlorophenoxyacetic acid	9	5	0.3	**23**
2,4-D Dimethyl 2- propionate	3	0.3	0	**14**
2,4-D Dimethylamine	20	36	11	**73**
2,4-D Triiospropanolamine	3	6	4	**5**
2,4-D TOTAL [a]	**37.3**	**48.1**	**15.6**	**142**
Erioglaucine	0	0.6	0	**3**
Copper (I) oxide	219	0	0.5	**93**
Dicamba, dimethylamine salt	3	3	2	**42**
Dicamba, diglycoamine salt	5	1	3	**2**

Table 1. 2000 Wholesale and Retail Pesticide Sales and Commercial Use Information; Sorted by Major Use Classification and Alphabetically by Common Name; June 27, 2002

Common name	Thousands of pounds Active			# Products registered in Maine 2001
	Wholesale sales	Retail sales	Commercial use	
Terbacil	3	4	2	**1**
Trifluralin	4	5	2	**31**
2,4-D Acetic acid, 2-ethylhexyl ester	0.3	0.6	0.3	**22**
2,4-D Butoxyethyl	2	0.2	0	**5**
2,4-D Dichlorophenoxyacetic acid	9	5	0.3	**23**
2,4-D Dimethyl 2- propionate	3	0.3	0	**14**
2,4-D Dimethylamine	20	36	11	**73**
2,4-D Triiospropanolamine	3	6	4	**5**
2,4-D TOTAL [a]	**37.3**	**48.1**	**15.6**	**142**
Erioglaucine	0	0.6	0	**3**
Copper (I) oxide	219	0	0.5	**93**
Dicamba, dimethylamine salt	3	3	2	**42**
Dicamba, diglycoamine salt	5	1	3	**2**

Table 1. 2000 Wholesale and Retail Pesticide Sales and Commercial Use Information; Sorted by Major Use Classification and Alphabetically by Common Name; June 27, 2002

Common name	Thousands of pounds Active			# Products registered in Maine 2001
	Wholesale sales	Retail sales	Commercial use	
Dicamba TOTAL [a]	**8**	**4**	**5**	**44**
Picloram triisopropanolamine salt	0.7	0	0.1	**2**
Picloram, potassium salt	0	0	1	**1**
Picloram TOTAL [a]	**0.7**	**0**	**1.1**	**3**
Butoxyethyl triclopyr	7	4	12	**6**
Triethylamine triclopyr	0.5	1	1	**13**
Triclopyr TOTAL [a]	**7.5**	**5**	**13**	**19**
Herbicide (desiccants)				
Diquat dibromide	1	70	0.1	**13**
Endothall,	0	2	0	**0**
Endothall, mono(N,N-Dimethylcocamine) salt	5	3	0	**3**
Endothall TOTAL [a]	**5**	**5**	**0**	**3**
Sulfuric acid	961	867	887	**2**
Insect repellent [b]				

Table 1. 2000 Wholesale and Retail Pesticide Sales and Commercial Use Information; Sorted by Major Use Classification and Alphabetically by Common Name; June 27, 2002

Common name	Thousands of pounds Active			# Products registered in Maine 2001
	Wholesale sales	Retail sales	Commercial use	
Diethyl-meta-toluamide and other isomers	0.5	0	0	**71**
Insecticide				
Acephate	0.3	0.7	0.3	**19**
Ammonium salts of C8-18 and C18' fatty acids	0.5	0	0	**4**
Azinphos-methyl	4	5	2	**203**
Bacillus thuringiensis subsp tenebrios in potatoes	2	0	0	
Bacillus thuringiensis subsp kurstaki	0.6	0	0	**25**
Benzoic acid, 4 chloro, 2 benzol-2-(1,1-dimethylethyl) hydrazide	0.9	0.7	1	**4**
Boric acid	0.2	0	1	**35**
Carbaryl	31	6	3	**56**
Carbofuran	5	5	0	**2**
Chlorpyrifos	352	32	10	**156**
Cyfluthrin	1	0.3	4	**40**
Cyhalothrin	0	0.7	1	**12**

Table 1. 2000 Wholesale and Retail Pesticide Sales and Commercial Use Information; Sorted by Major Use Classification and Alphabetically by Common Name; June 27, 2002

Common name	Thousands of pounds Active			# Products registered in Maine 2001
	Wholesale sales	Retail sales	Commercial use	
Diazinon	32	10	1	**102**
Dicofol	0	0.8	0	**4**
Disulfoton	10	7	0	**21**
Endosulfan	0.3	4	0	**14**
Esfenvalerate	0.8	0.6	0	**21**
Ethoprop	0.7	8	0.3	**3**
Fosetyl-AL	1	0.8	0.3	**3**
Imidacloprid	28	27	2	**36**
Kaolin	0	3	0	**2**
Malathion	4	2	0.4	**31**
Methamidaphos	4	16	0.2	**2**
Methomyl	2	3	0.2	**5**
Permethrin	4	3	0.6	**203**
Phosmet	21	21	8	**6**

Table 1. 2000 Wholesale and Retail Pesticide Sales and Commercial Use Information; Sorted by Major Use Classification and Alphabetically by Common Name; June 27, 2002

Common name	Thousands of pounds Active			# Products registered in Maine 2001
	Wholesale sales	Retail sales	Commercial use	
Tebufenozide	1	0.3	0.3	**2**
Thiodicarb	3	0.3	0	**1**
Trichlorfon	3	0	0.1	**2**
Potassium salts of fatty acids	0.6	0.2	0.6	**15**
Plant growth regulator				
Aminoethoxyvinylglcine hydrochloride	0.7	0.2	0	**2**
Maleic hydrazide K+	147	121	0	**5**
Snail and slugs				
Metaldehyde	1	0	0	**16**
Solvent (Multi-use)				
Kerosene	0.6	18	0	**1**
Petroleum Aliphatic hydrocarbons	209	220	1	**25**
Sprout inhibitor Potatoes				
Chlorpropham	10	26	18	**10**

Table 1. 2000 Wholesale and Retail Pesticide Sales and Commercial Use Information; Sorted by Major Use Classification and Alphabetically by Common Name; June 27, 2002				
Common name	Thousands of pounds Active			# Products registered in Maine 2001
	Wholesale sales	Retail sales	Commercial use	
Wood preservatives				
Arsenic acid anhydride	0	0	305	**3**
Chromic acid	0	0	176	**3**
Coal tar creosote	0	0	10	**2**
Copper Naphthenate	0	2	0	**10**
Copper (II) Oxide	0	0	237	**4**
Sodium dichromate	0	0	1	**2**
Sodium fluoride	0	0	13	**6**

a Herbicides such as 2,4-D, triclopyr, etc. are sold as a number of salts and esters, the amounts reported sold have been aggregated.

b Insect repellents are exempt form reporting

Table 2. 2000 Homeowner Sales Report by Quantity of Active Ingredient, June 27,2002

Common name	**Thousand lbs**	**Primary Type**	**Total**	**Fed-01**	**ME-01**
Diazinon [(a)]	31	Insecticide	2445	436	102
Glyphosate Isopropylamine salt	23	Herbicide	410	184	68
2,4-D, Dimethylamine salt and Dimethyl 2- propionate	18	Herbicide	1230	518	110
Carbaryl	9	Insecticide	2428	313	56
Mecoprop	7	Herbicide	120	73	17
Copper sulfate pentahydrate	6	Herbicide	349	91	18
Chlorothalonil	5	Fungicide	506	165	45
Dimethylamine 2-(2-methyl-4-chlorophenoxy) propionate	4	Herbicide	340	196	11
Malathion	4	Insecticide	2454	219	31
Chlorpyrifos [(a)]	3	Insecticide	2517	485	156
Trichlorfon	3	Insecticide	250	12	2
Pendimethalin	2	Herbicide	158	86	22

Table 2. 2000 Homeowner Sales Report by Quantity of Active Ingredient, June 27,2002

Common name	**Thousand lbs**	**Primary Type**	**Total**	**Fed-01**	**ME-01**
Metaldehyde	1	Snail and slugs	194	5	16
Petroleum Aliphatic hydrocarbons	1	Multi-use	7541	238	25
Permethrin	0.6	Insecticide	2148	872	203
Ammonium salts of C-8-18 and C18' fatty acids	0.5	Insecticide	7	5	4
Captan	0.5	Fungicide	1064	100	19
DEET (Diethyl-meta-toluamide and other isomers)	0.5	Insect repellent (b)	617	111	71
Imidacloprid	0.5	Insecticide	116	112	36
Acephate	0.3	Insecticide	376	142	19

a Homeowner uses are being phased out
b Exempt from reporting

Table 3. Retail Pesticide Active Ingredients (with reported sales of > 1,000 pounds) and Registration and Re-registration Status (Sorted by YR 2000 Sales)

Active Ingredient	Registration NOTES	Sales in Thousands of pounds		
		2000	**1997**	**1995**
Sulfuric acid	RED [5] Complete [1] Not listed [2]	867	3,188	1,998
Chlorothalonil	RED signed (09/1998)[2]	777	334	374
Mancozeb	Data call in 1995 Supported [1] Special review 1989 changed agricultural use patterns	514	181	290
Aliphatic hydrocarbons	Pre-RED [1]	220	51	64
Maleic hydrazide, potassium salt	RED signed (06/1994)[2]	121	49	45
Glyphosate Isopropylamine salt	RED signed (09/1993)[2]	120	108	112
Diquat dibromide	RED signed (03/1995)[2]	70	42	41
Metiram	Supported Pre-RED [1] Special review 1989 changed agricultural use patterns	57	60	12
2,4-D (Acid plus salts and esters)	Some derivatives supported other not supported Pre RED: Pre Special review [1]	48	13	13
Simazine	Triazine: subject to cumulative assessment 04/2002 [2]	44	12	9
Atrazine	Triazine: subject to cumulative assessment 04/2002 [2]	43	49	76

1995 and 1997 data was tabulated from major agricultural and forestry dealer reports. 2000 data includes additional dealers and more ornamental and turf sales than were handled by those restricted use pesticide dealers in the previous years..

Table 3. Retail Pesticide Active Ingredients (with reported sales of > 1,000 pounds) and Registration and Re-registration Status (Sorted by YR 2000 Sales)

Active Ingredient	Registration NOTES	Sales in Thousands of pounds		
		2000	**1997**	**1995**
Captan	RED signed (09/1999)[2]	34	46	51
Chlorpyrifos	IRED [6] signed (09/2001)[2]	32	13	22
Copper compounds	Some derivatives supported other not supported Pre RED [1]	31	61	55
Hexazinone	RED signed (09/1994)[2]	30	35	29
Metolachlor	RED signed (12/1994)[2]	29	35	41
MCPA	Some derivatives supported other not supported Pre RED [1]	28	18	11
Pendimethalin	RED signed (04/1997)[2]	27	38	23
Imidacloprid	New Active ingredient (1994) [1]	27	7	10
Chlorpropham	RED signed (09/1995)[2]	26	9	11
Sulfur	RED signed (03/1991)[2]	24	1	3
Metribuzin	RED signed (06/1997)[2]	22	15	43

1995 and 1997 data was tabulated from major agricultural and forestry dealer reports. 2000 data includes additional dealers and more ornamental and turf sales than were handled by those restricted use pesticide dealers in the previous years..

Table 3. Retail Pesticide Active Ingredients (with reported sales of > 1,000 pounds) and Registration and Re-registration Status (Sorted by YR 2000 Sales)				
Active Ingredient	Registration NOTES	Sales in Thousands of pounds		
		2000	**1997**	**1995**
Maneb	Supported Pre-RED (1) Special review 1989 changed agricultural use patterns	21	122	229
Phosmet	IRED signed (10/2001)(2)	21	20	34
Pentachloronitrobenzene	Supported Pre-RED (1)	18	0	1
Napropamide	Supported Pre-RED (1)	17	7	23
Methamidaphos	Technical briefing- public meeting (12/2000)(2)	16	24	34
Paraquat dichloride	RED signed (08/1997)(2)	14	6	6
Linuron	RED signed (12/1994)(2)	14	11	18
Fentin hydroxide (triphenyltin hydroxide)	Supported Pre-RED (1)	13	5	3
Diazinon	60 Day Public participation period of risk management completed on (03/2001)(2)	10	3	2
Metalaxyl-M	RED signed (09/1994)(2)	9	96	11
Ethoprop	60 Day Public participation period of risk management completed on (11/1999)(2)	8	9	8

1995 and 1997 data was tabulated from major agricultural and forestry dealer reports. 2000 data includes additional dealers and more ornamental and turf sales than were handled by those restricted use pesticide dealers in the previous years..

Table 3. Retail Pesticide Active Ingredients (with reported sales of > 1,000 pounds) and Registration and Re-registration Status (Sorted by YR 2000 Sales)

Active Ingredient	Registration NOTES	Sales in Thousands of pounds		
		2000	**1997**	**1995**
Thiophanate methyl	Supported Pre-RED [1]	8	4	5
Disulfoton	60 Day Public participation period of risk management completed on (05/2000)[2]	7	17	28
Carbaryl	Supported Pre-RED [1]	6	13	13
Propiconazole	Section 18 on Blueberries	6	0	0
Diuron	Supported Pre-RED [1]	6	0	0
Trifluralin	RED signed (09/1995)[2]	5	2	2
Triclopyr (salts and esters)	RED signed (09/1997)[2]	5	22	5
Carbofuran	Supported Pre-RED [1]	5	0	0
Mecoprop	Some derivatives supported other not supported Pre RED [1]	5	0	0
Sethoxydim	Supported Pre-RED [1]	5	2	1
Azinphos-methyl	Organophosphate IRED Signed 10/2001)[2]	5	13	17

1995 and 1997 data was tabulated from major agricultural and forestry dealer reports. 2000 data includes additional dealers and more ornamental and turf sales than were handled by those restricted use pesticide dealers in the previous years..

Table 3. Retail Pesticide Active Ingredients (with reported sales of > 1,000 pounds) and Registration and Re-registration Status (Sorted by YR 2000 Sales)				
Active Ingredient	Registration NOTES	Sales in Thousands of pounds		
		2000	**1997**	**1995**
Endothall	Some derivatives supported other not supported Pre RED [(1)]	5	4	1
Endosulfan	Preliminary risk assessment released (09/2001)[(2)]	4	3	15
Thiabendazole	RED signed (09/1999)[(2)]	4	0	0
Dicamba	Some derivatives supported other not supported Pre RED [(1)]	4	3	4
Terbacil	RED signed (09/1997)[(2)]	4	0	0
Permethrin	Supported Pre-RED [(1)]	3	1	3
Methomyl	RED signed (03/1998)[(2)]	3	2	3
Kaolin	New Active ingredient (1998) [(4)]	3	0	0
Bentazon	RED signed (09/1994)[(2)]	3	0	2
Dimethanamid	New Active ingredient (1993) [(1)]	2	2	3
Vinclozolin	RED signed (09/2000)[(2)]	2	0	0

1995 and 1997 data was tabulated from major agricultural and forestry dealer reports. 2000 data includes additional dealers and more ornamental and turf sales than were handled by those restricted use pesticide dealers in the previous years..

Table 3. Retail Pesticide Active Ingredients (with reported sales of > 1,000 pounds) and Registration and Re-registration Status (Sorted by YR 2000 Sales)

Active Ingredient	Registration NOTES	Sales in Thousands of pounds		
		2000	**1997**	**1995**
Malathion	60 Day Public participation period of risk management completed on (02/2001)(2)	2	3	3
EPTC	RED signed (09/1999)(2)	2	7	16
Benomyl	Voluntarily cancelled (8/2001)(2)	2	8	5
Azoxystrobin	New Active ingredient 1997 (1)	2	0	0
Alachlor	Pre-RED (1)	1	0	6
Cyanazine	Triazine: subject to cumulative assessment 04/2002 (2)	1	1	8
Cymoxanil	New product (1998) (3)	1	0	0
Imazapyr, isopropylamine salt	New Active ingredient (1987) (1)	1	0	0
Fludioxonil	New Active ingredient (1996) (1)	1	0	0
Metam sodium	Supported Pre-RED (1)	1	2	3
Dodine	Pre-RED (1)	0	2	2
Fenvalerate	Pre-RED (1)	0	0	1
Piperonyl Butoxide	Pre-RED (1)	0	0	5

1995 and 1997 data was tabulated from major agricultural and forestry dealer reports. 2000 data includes additional dealers and more ornamental and turf sales than were handled by those restricted use pesticide dealers in the previous years..

Table 3. Retail Pesticide Active Ingredients (with reported sales of > 1,000 pounds) and Registration and Re-registration Status (Sorted by YR 2000 Sales)

Active Ingredient	Registration NOTES	Sales in Thousands of pounds		
		2000	**1997**	**1995**
Thiodicarb	Pre-RED (1)	0	0	1
Isofenphos	Tolerances revoked and registrations cancelled (05/1999)(2)	0	0	1
Actetochlor	New Use 1994 (1)	0	0	2
Propamocarb hydrochloride	RED signed (09/1995) (2) Section 18 Potatoes	0	0	2
Fonofos	Voluntary cancellation will propose to revoke tolerances (03/1999)(2)	0	0	2
Parathion, ethyl	60 Day Public participation period of risk management completed on (05/2000)(2)	0	0	8
Methoxychlor	Supported Pre-RED (1)	0	9	3
DCPA	RED signed (09/1995)(2)	0	2	3
Propargite	RED signed (09/2001)(2)	0	0	6
Formetanate hydrochloride	Supported Pre-RED (1)	0	0	3
Triadimefon	Supported Pre-RED (1)	0	0	1
Ethalfluralin	RED signed (12/1994)(2)	0	6	0

1995 and 1997 data was tabulated from major agricultural and forestry dealer reports. 2000 data includes additional dealers and more ornamental and turf sales than were handled by those restricted use pesticide dealers in the previous years..

RED/IRED = Registration (and Interim) Eligibility Documents (EPA)

Table 3. Retail Pesticide Active Ingredients (with reported sales of > 1,000 pounds) and Registration and Re-registration Status (Sorted by YR 2000 Sales)

Active Ingredient	Registration NOTES	Sales in Thousands of pounds		
		2000	**1997**	**1995**
Cryolite	RED signed (06/1996)[2]	0	0	3
Triforine	Supported Pre-RED [1]	0	9	4
Oxamyl	IRED signed (12/2000)[2]	0	0	2
Ziram	Cancelled	0	0	1
Phorate	IRED signed (03/2001)[2]	0	0	1

(1) EPA (1998) Status of Pesticides in Registration, Re-registration and Special review.
(2) EPA Re-registration website: http://www.epa.gov/pesticides/reregistration/status2.htm#M
(3) EPA Fact Sheet for Cymoxanil (1998)
(4) EPA Biopesticide Fact Sheet for Kaolin

1995 and 1997 data was tabulated from major agricultural and forestry dealer reports. 2000 data includes additional dealers and more ornamental and turf sales than were handled by those restricted use pesticide dealers in the previous years..

Maine Board of Pesticides Control **Pesticide Use on Crops Survey** Phone: (207) 287-2731 Web: www.thinkfirstspraylast.org	Date:	Time:
	Inspector Name:	

Crop Surveyed (where appropriate, indicate bearing or non-bearing):	Crop Year:	Acreage Grown of Crop Surveyed: 10, 20, 30, 40, 50, 51-75, 76-100, 101-150, 151-200, 201-300, 301-400, 401-450, 451-500, 501-600, 601-700, 701-1000, > 1000 (Circle appropriate acreage figure)

Pesticide Name	RUP √	EPA Reg. No.	Rate of Formulation/Unit Area (i.e. Lbs or Quarts per Acre)	No. of Identical Applications/Crop Cycle	Broadcast (B) Directed (D) Spot (S)	Boom (B) Airblast (AB) Aerial (A) Fumigation (F) Granular Spreader (G) Chemigation (C) Hand Can (HC) Back Pack (BP) Other: specify	Months Crop Treated With Each Pesticide May & June (enter as 5,6)
Grass B Gon		123-456	1 Quart/Acre	5	B	AB	4,5,6,7,8,9

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STATE OF MAINE
DEPARTMENT OF AGRICULTURE, CONSERVATION & FORESTRY
BOARD OF PESTICIDES CONTROL
28 STATE HOUSE STATION
AUGUSTA, MAINE 04333

JANET T. MILLS
GOVERNOR

AMANDA E. BEAL
COMMISSIONER

January 3, 2022

To: Board of Pesticides Control, Public Board

Re: Service Contract with Metro Institute Inc.

The Board of Pesticides Control is in the process of entering into a contract with Metro Institute Inc. that will administer pesticide certification exams at six testing centers in Maine. Metro Institute Inc. is located in Phoenix, Arizona and currently provides pesticide certification exams for 12 other states. This contract is for one year and will be implemented on or around February 15, 2022.

Metro Institute Inc. will provide the following:

- Certification exams to become certified as an Agricultural Basic, Private, or Commercial Operator Pesticide Applicator.
- The BPC will provide a quantity of exam questions greater than the number of questions necessary for each exam. Metro Institute Inc. will use these questions to randomly generate a new exam for each applicant.
- Metro Institute Inc. will grade each exam and provide test results to the BPC.
- Metro Institute Inc. will schedule all exams and be the contact source for applicants.
- Metro Institute Inc. will provide live proctors for each testing center.
- Metro Institute Inc. will provide the applicant with complete instructions on the testing process.
- Metro Institute Inc. will confirm the applicants name, date of birth, and identity by validating the applicants government issued photo identification.
- Metro Institute Inc. will provide the BPC reports that include test results, average completion time, and individual question results. Metro Institute Inc. will work with the BPC to provide custom reports and data.

Cost:

The BPC will not pay Metro Institute Inc any amount directly for completing all services and delivering all goods required under this contract. Revenue generated by Metro Institute Inc. will be generated through the administration of the Statement of Work in the

MEGAN PATTERSON, DIRECTOR
90 BLOSSOM LANE, DEERING BUILDING

PHONE: (207) 287-2731
WWW.THINKFIRSTSPRAYLAST.ORG

contract. Metro Institute Inc. will retain $65.00 from exam fees for all commercial exams and $55.00 for private and agricultural basic exams that it administers in accordance with the contract. Metro Institute Inc. must remit $10.00 to the Department for each commercial exam given.

The BPC will not lose any revenue from the change to online testing. The BPC will still receive $10.00 for every commercial exam offered, and will see a savings in staff time. There will be less proctoring required from BPC staff, a reduction in photo copying, filing, and grading exams. There will also be a reduction in staff time spent scheduling and answering questions about exams.

The contract has been reviewed by Megan Patterson, BPC Director; John Pietroski, Manager of Pesticides Programs; Mark Randlett, Maine Assistant Attorney General; Ann Gibbs, Director, Division of Animal & Plant Health; and Betty Rancourt, DACF Resource Administrator.

First U.S. T-30 Drone Approval Granted to Iowa-Based Rantizo

By **CropLife Staff (https://www.croplife.com/author/croplife-staff/)**

November 18, 2021

FAA approval adds an above-55-pound drone option for ag retailers and custom applicators.

Precision ag tech company **Rantizo (https://www.rantizo.com/)** has announced that they have become the first company approved by the Federal Aviation Administration (FAA) for operation of the DJI Agras T-30 drone for agricultural applications.

The announcement comes highly anticipated, as the T-30 drone launched earlier in 2021, but could not be operated due to the FAA regulation only allowing the use of drones 55 pounds and under. With the exemptions received, Rantizo is the first and only company in the U.S. with the necessary approvals to operate the drone on a commercial scale.

What does that mean for agricultural spraying in 2022?

“This new platform is more than just a larger drone,” said Rantizo Special Projects Manager Beau Brown. “The DJI T-30 represents a three-generation jump in technological advancements in aerial drone sprayers, such as new avionics, obstacle avoidance and more intelligent field management.

These tools, combined with Rantizo's expertise and support, will ensure our contractors and pilots continue to be the most successful in the drone application industry."

Considered the most productive drone spraying tool on the market, the T-30 comes with a bigger tank that when fully loaded weighs up to 169 pounds. Yet the drone can fit in the back of the average truck bed.

"We've been seeing demand for bigger drones since day one," said Rantizo Marketing Manager Emily Carlson. "However, we are calculated in what products we offer within our system for drone applications and when we release them. Headed into the 2022 season, our approvals for use of the T-30 will be a game changer for both Rantizo contractors and the growers they serve."

For farmers, drones supply another tool in the toolbox of options to increase efficiency in realm of precision agriculture. Benefits of on-farm drone usage include:

- Little to no crop damage when compared to conventional sprayers
- Major cost savings on inputs with spot-spraying capability
- Improved soil health due to no machinery-caused soil compaction
- More versatility in application, less reliance on weather due to precise application
- Additional method of cover crop broadcast seeding

Rantizo offers a turnkey system for drone application designed to make in-field applications such as pesticide application or the broadcast application of cover crops simple, efficient, safe and legal. The Rantizo system includes drone equipment, but more importantly, a streamlined path to use in the field, with peace of mind on regulations and legalities for those providing custom drone application services.

"Ag retailers want to stay on the cutting edge," Rantizo Director of Sales Sam Pendleton explained. "It's what their customers expect," he added. "But at the same time, they have to consider how drone applications could work in their operation. Whether that's covering the awkward acres to make their ground rigs more efficient, adding a more precise option to their aerial fleet, or simply gaining the ability to target site-specific areas to provide cost-effective options to their customers. Rantizo has been committed to providing those retailers with a system designed to do all of that for them in a safe and legal way; the addition of the T-30 is only going to enhance those benefits."

To date, Rantizo's system has been primarily focused around the 10 Liter DJI Agras MG-1P. The Iowa City-based startup added proprietary technology such as their **Upgrade Kit (https://www.rantizo.com/drone-spraying-equipment/)** and additional waivers for multi-drone swarming to optimize productivity in the field. The addition of a larger drone with more payload capacity, speed and use-case functionality will bring drone application viability across a larger spectrum into the 2022 season.

"As a company, we have developed a culture around product development that originates from what the customer wants," said CEO Michael Ott. "In our case we have two customer segments to consider: our network of contractors who want the most productive drone application system available to provide services, and their farmer customers who want both precision and cost-effective options for in-field applications. Whether we tackle this with multiple drones, or larger drones, the result is a win-win for both and that's always what we keep at the forefront. Our approvals for the T-30 are just the next step in the evolution of where drone applications are headed for ag."

Rantizo received their initial approvals for single drone spraying operations from the FAA in July of 2019. At that time, the company became the first and only approved for drone spraying in the state of Iowa. In July of 2020, the company became the first approved for 3-drone swarming nationwide. Now, with approvals for operation of the T-30, the company just shy of four years old, continues a path of fast-paced innovation.

With the latest approvals, Rantizo now has the green light to offer the T-30 drone for sale.

"We could have put the T-30 up on our website with a 'buy now' button several months ago, and I'm confident we would have sold out," Pendleton shared. "The demand has been there. But we don't just sell someone a drone and let them figure out the rest on their own. It doesn't do the customer any good, and it certainly doesn't do the industry any favors. Now, Rantizo is able to offer the largest, most productive drone on the market to our customers with a clear-cut path to use and profitability they can feel confident in. That's what sets us apart."

Rantizo plans to roll out the T-30 availability for purchase by December.

In today's complex and fast-paced crop production sector, the team at ***CROPLIFE*** *keeps 21,000 agricultural retailers, distributors and their suppliers up to date on such decidedly 21st century issues as seed technology, biotechnology, precision agriculture, customer service and retention, and business management.* ***See all author stories here. (https://www.croplife.com/author/croplife-staff/)***

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Report on the State of the Knowledge – Literature Review on Unmanned Aerial Spray Systems in Agriculture

Series on Pesticides
No. 105

OECD
BETTER POLICIES FOR BETTER LIVES

Series on Pesticides
No. 105

Report on the State of the Knowledge – Literature Review on Unmanned Aerial Spray Systems in Agriculture

About the OECD

The Organisation for Economic Co-operation and Development (OECD) is an intergovernmental organisation in which representatives of 38 industrialised countries in North and South America, Europe and the Asia and Pacific region, as well as the European Commission, meet to co-ordinate and harmonise policies, discuss issues of mutual concern, and work together to respond to international problems. Most of the OECD's work is carried out by more than 200 specialised committees and working groups composed of member country delegates. Observers from several countries with special status at the OECD, and from interested international organisations, attend many of the OECD's workshops and other meetings. Committees and working groups are served by the OECD Secretariat, located in Paris, France, which is organised into directorates and divisions.

The Environment, Health and Safety Division publishes free-of-charge documents in twelve different series: **Testing and Assessment**; **Good Laboratory Practice and Compliance Monitoring**; **Pesticides**; **Biocides**; **Risk Management**; **Harmonisation of Regulatory Oversight in Biotechnology**; **Safety of Novel Foods and Feeds; Chemical Accidents; Pollutant Release and Transfer Registers; Emission Scenario Documents; Safety of Manufactured Nanomaterials;** and **Adverse Outcome Pathways.** More information about the Environment, Health and Safety Programme and EHS publications is available on the OECD's World Wide Web site (www.oecd.org/chemicalsafety/).

This publication was developed in the IOMC context. The contents do not necessarily reflect the views or stated policies of individual IOMC Participating Organizations.

The Inter-Organisation Programme for the Sound Management of Chemicals (IOMC) was established in 1995 following recommendations made by the 1992 UN Conference on Environment and Development to strengthen co-operation and increase international co-ordination in the field of chemical safety. The Participating Organisations are FAO, ILO, UNDP, UNEP, UNIDO, UNITAR, WHO, World Bank and OECD. The purpose of the IOMC is to promote co-ordination of the policies and activities pursued by the Participating Organisations, jointly or separately, to achieve the sound management of chemicals in relation to human health and the environment.

IOMC

INTER-ORGANIZATION PROGRAMME FOR THE SOUND MANAGEMENT OF CHEMICALS

A cooperative agreement among **FAO, ILO, UNDP, UNEP, UNIDO, UNITAR, WHO, World Bank and OECD**

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Foreword

In 2019, the OECD Working Party on Pesticides (WPP) established a Subgroup which was tasked with defining aspects of drone technology which will influence the risk characterisation in comparison with existing pesticide product evaluations (e.g. aerial application), to establish if there are any additional requirements needed / information gaps to fill and to recommend an approach to the WPP to address any related risks.

The Subgroup arranged an information call-in request for April 2020, but the response was disappointing (only nine responses) and with WPP agreement a second information call-in request took place in September 2020. The requests when added to the references from the Canadian Regulatory Authority literature search generated 57 responses ranging from regulatory studies, research papers, presentations and abstracts.

A consultant was employed in October 2020 (funded by the Australian Pesticides and Veterinary Medicines Authority, APVMA) to review the responses to the information request as well as several research papers identified by members of the Subgroup. Supported by a small project team from the Subgroup, the consultant graded and reviewed the quality of the information provided. The completed literature review (see Annex A) was made available to the Subgroup in March 2021.

This thematic review is entitled ***State of the Knowledge – Literature Review on Unmanned Aerial Spray Systems in Agriculture***. The review defines aspects of Unmanned Aerial Spray Systems (UASS) technology that influence the risk characteristics in comparison with existing pesticide product evaluations (for example, comparisons with application using fixed-wing aircraft, helicopters, airblast, boom and knapsack sprayers), seeking to establish if there are any additional requirements to address any related risk.

This report recognises that OECD member countries will have different interests and requirements relating to the use of UASS to apply pesticides because of the nature of the crops grown or other targeted applications (for example, non-agricultural uses) and the degree of regulatory infrastructure already available. The document does not prescribe the use of any particular UASS equipment or approach but identifies factors that determine how the risks from UASS application differ from more established, traditional methods. It outlines factors OECD member countries should consider when assessing UASS use, either within existing risks already assessed, or when seeking to develop new assessments and models.

The OECD would like to acknowledge the contribution by the Australian Pesticides and Veterinary Medicines Authority of the Literature Review document drafted by a consultant, which formed the background information of this report. The report was prepared under the framework of the OECD Drone/UAV Subgroup which reviewed and provided input to the report, led by the United Kingdom. The report is published under the responsibility of the OECD Chemicals and Biotechnology Committee.

Table of Contents

Abbreviations

AgDRIFT	Agricultural DISpersal – a model for estimating near-field spray drift from aerial applications
APVMA	Australian Pesticides and Veterinary Medicines Authority
BBCH	Biologische Bundesantalt Bundessortenamt and Chemical Industry (Scale of key stages of phenological development in plants)
BCPC	British Crop Production Council (Congress invariably held in Brighton)
ISO	International Organization for Standardization
OECD	Organisation for Economic Co-operation and Development
PPP	Plant protection product)
Risk envelope	Term used to describe a known set of parameters and effects based on a previous evaluation
SETAC DRAW	Society of Environmental Toxicology and Chemistry Drift Risk Assessment Workshop
UAAS	Unoccupied Agricultural Aircraft System
UASS	Unmanned aerial spray system
UAV	Unmanned Aerial Vehicle
WPP	Working Party on Pesticides

Executive Summary

This document recognises that OECD member countries will have different interests and requirements relating to the use of drone (Unmanned Aerial Vehicle (UAV) platforms, and the associated Unmanned Aerial Spray Systems (UASSs) in relation to the application of pesticides, because of the nature of the crops grown, the infrastructure already available and their jurisdictions' legal requirements. The document does not prescribe the use of any particular equipment or approach but identifies factors that determine how the risks from UASS application differ from more established, traditional methods of application, which OECD member countries should take into account when considering related risks from adopting such new technology for the application of pesticides.

The use of UASS for pesticide applications has the potential to provide benefits such as the reduction of applicator exposure in comparison to backpack spraying, better quality applications in difficult to access scenarios (e.g., sloped vineyards), and the enablement of precise zone or spot application linked with UASS/UAV-based whole field scouting. These could contribute to the more sustainable use of pesticides; however, these potential benefits cannot be realized without improving the available data on UASS applications.

The process used by regulators for assessing the hazards and risks associated with the proposed use of pesticides considers human toxicology; operator and bystander exposure; dietary exposures; environmental fate and behavior; ecotoxicology; physical and chemical properties; and efficacy. The data that are lacking with UASS technology for regulators assessing risk is primarily that related to exposure, efficacy, and drift.

While the information from the review is not substantial enough to enable the development of fully harmonized use policies and guidelines for regulators and product registrants, it does provide an overview of the current state of knowledge and practice and outlines how the risk associated with UASS applications could be viewed and addressed.

This review concludes that a combination of UASS design, working practices and products applied have the potential to create significantly different risks from those associated with more traditional and established methods of application. The nature and relative degree of risk alters depending on the factors described above. It may be possible to enable limited UASS application by permitting use within existing 'risk envelopes', but in order to facilitate more widescale adoption of this technology regulators are likely to have to develop new and possibly bespoke assessments.

The Drone / UAV Subgroup has created experience and an understanding of the available information. It also has identified areas of additional work needed to support the development of OECD WPP guidance for the regulatory risk assessment and decision processes for UASS application of pesticides. For instance, there is a clear and urgent need for a set of standard testing protocols to be agreed for the assessment of UASS; standards are needed for calibration and appropriate deployment, for efficacy testing, operator exposure scenarios and for spray drift assessment. These methods are necessary to ensure that data is of an appropriate quality for regulatory decision making.

The next step must be to carry out work aimed at filling the identified gaps to develop new UASS focused models for use in regulatory approval processes, and this will require greater engagement with those bodies and organisations which create and provide such data.

1 Introduction

The use of UASS for applying pesticides has the potential to provide benefits such as the reduction of operator exposure in comparison to knapsack spraying, safer applications in difficult to access scenarios (e.g., sloped vineyards), and the enablement of precise zone or spot application linked with UASS/Unmanned aerial vehicle -based whole field scouting. However, these potential benefits cannot be confirmed and so realised without improving the available data on UASS applications to ensure they can be adequately evaluated from a risk assessment and risk management perspective.

The process used by regulators for assessing the hazards and risks associated with the proposed use of pesticides considers human toxicology, operator and bystander exposure, dietary exposures, environmental fate and behaviour, ecotoxicology, physical and chemical properties, and efficacy. For existing authorised products, the data that are lacking for regulators to assess application via UASS technology are primarily those related to human and environmental exposure, spray drift and efficacy.

Some published papers reviewed by this Group lacked the level of detail or raw data necessary to allow them to be relied on quantitatively for regulatory purposes. Many were not designed to specifically meet regulatory requirements. Of the papers obtained for this review 35 were not considered relevant, 53 were classed as relevant. Of those considered relevant 20 were also fully reliable for regulatory purposes and a further 25 reliable with restrictions. The most common reason for discounting the study was due to the lack of appropriate methodology for trial conduct (there is currently no existing protocol or standard for assessing pesticide application from a UASS) or lacked sufficient replication of the experiment. The rest were not relevant or not possible to include in the review, for example due to unavailable data or translated text. While the information from the review is not substantial enough to enable the development of fully harmonized standard work practices and guidelines for regulators and product registrants, it does provide an overview of the current state of knowledge and practice and outlines how the risk associated with UASS applications could be viewed and addressed.

This review concludes that a combination of factors, UASS design, operational characteristics and application practices have the potential to create different risks from those associated with more traditional and established methods of application. The nature and relative degree of potential risk varies depending on the factors described above.

It is not yet possible, based on the quality of the available data, to determine whether the nature and degree of risk is substantially different to that resulting from existing forms of application. In the absence of information to determine this the authors of this review conclude, based on the evidence reviewed, that the potential for it to do so exists to sufficient extent to warrant regulatory authorities taking a cautious approach to currently authorising the application of pesticides by UASSs. Furthermore, based on the findings of this review it has been possible to identify information requirements and processes that would enable regulators and others to determine the risks associated with this novel form of application. Generation and development of these information and processes is necessary for regulators to be assured that proposed UASS operations fall within established risk envelopes / parameters; and / or can be approved for use in their own right.

2 Human Health Considerations

2.1. Literature Review Findings

2.1.1. Bystanders

The literature review identified studies with measurements of airborne spray drift downwind of the target area which could be of relevance when assessing bystander and resident exposure. In most studies airborne drift was sampled using monofilament lines positioned on frames at different heights from the ground and at various downwind distances. Drift measurements taken at 2 m from the treated area represented a worst case for bystanders. As with all other pesticide application methods, airborne drift further downwind depends on the height and volume of the spray plume exiting the target area, its droplet size distribution and the meteorological conditions.

The literature reviewer noted that when the airborne drift measurements from line samplers are expressed as a percentage of the applied amount the results will be artificially high because the numbers are not corrected for sampling rate: hence the reported collection of more than 100% of the applied dose in some cases. Therefore, the results reported in these studies should be used only as a comparative measure between treatments within a particular study and not used to compare different studies.

The literature review also identified studies measuring airborne drift using active samplers (rotary impactors). In one study active samplers were positioned 5, 10 and 20 m away from the target zone on towers at 1, 2, 3 and 4 m above ground level. The reported overall averaged airborne spray drift percentage for the three UASS models under investigation ranged from 2.5 to 25%. Active samplers are often used with ultra-low volume applications due to their high sampling rate and collection efficiency, but comparison to passive line samplers is difficult.

2.1.2. Operator Exposure

The literature review identified very little information on levels of operator exposure resulting from the use of UASS. Operators may be exposed through contact with the UASS if residues are transferred to the skin during work activities. Qualitative observations and numerical simulations show that the spray released from a UASS will have an upward component that could lead to residues of the active ingredient accumulating on the aircraft. There is also potential that the aircraft will fly back through spray that has yet to settle.

One study showed average external residues on a UASS were five times that compared to on an air-assisted sprayer, potentially reflecting the higher concentration of the pesticide solution used for the UASS. In another study minimal active substance was recovered on a UASS with highest residues on the spray boom and arms. As operators may lift the UASS by the arms, wearing proper personal protection equipment (PPE), as required on product labels, is important.

2.2. Conclusions

Although studies on operator and bystander exposure were limited in the review, some data in process of publication may be available in the future. A data gathering exercise for operational practices mixing and loading scenarios would help with understanding the potential exposure pathways and with developing or adapting exposure scenarios to be representative for work activities with UASS.

The reviewed literature had little information on levels of operator exposure although some measurements of residues on different parts of the UASS are potentially useful for predicting exposure from contact with surfaces that have residues.

To understand the risks to operators from being exposed to pesticides through UASS spraying, information is needed on the potential for exposure to the pesticide concentrate, spray solution and surface residues from tasks such as mixing, loading, maintaining, cleaning and transport. The potential for increased risk of sensitization or irritation due to using high in-use concentrations is another area to consider. It is not known if the physical distance from UASS in operation effectively mitigates operator exposure to potentially higher concentration sprays. Once typical operational practices have been identified (i.e. the individual tasks being performed by the UASS operator and ground crew, their frequency and duration), it may be possible to use established exposure models and approaches to predict levels of operator exposure resulting from the use of UASS.

For bystander and resident exposure, regulatory authorities need to understand if and how the pattern of airborne spray drift from UASS differs from conventional application methods (both ground-based and aerial). Another consideration affecting the bystander and resident risk assessment is the potential use of more concentrated spray solutions for UASS applications to maximize the work rate for a small tank capacity and limited flight time. Application volumes of 15 L/ha are typical for UASS in Asia from where much of the data available is derived, and the necessitated use of fine spray qualities increases the risk of airborne drift in comparison to larger droplet sizes. In other regions, such as North America and Australia, the trend is towards larger application volumes and use of low drift nozzles.

2.3. Recommendations

For estimating bystander exposure further work is required to identify the impact of turbulence on the levels of airborne drift and the variability of turbulence with the different UASS platforms (e.g. number of rotors and nozzle placement). Although modelling approaches are being developed to address this issue and to predict the influence of height and speed, this is not yet available for regulatory use. Future studies should use a single collector type and a single test protocol (following appropriate ISO standards or SETAC (Society of Environmental Toxicology and Chemistry) DRAW (Drift Risk Assessment Workshop) workshop proposals) to allow data pooling and comparison, and all aspects of the study (such as equipment calibration and replication) should meet regulatory standards. (Note – links to referenced workshops and Standards are in Annex C).

To understand the risks to operators from being exposed to pesticides through UASS spraying, information is needed on the potential for exposure to the pesticide concentrate, spray solution and surface residues from tasks such as mixing, loading, maintaining, cleaning and transport. The potential for increased risk of sensitization or irritation due to using high in-use concentrations is another area to consider. Once typical operational practices have been identified (i.e. the individual tasks being performed by the UASS operator and ground crew, their frequency and duration), it may be possible to use established exposure models and approaches to predict levels of operator exposure resulting from the use of UASS.

3 Environmental Considerations

3.1. Literature Review Findings

Data of most relevance to environmental exposure measured off-target spray drift, deposition to the target or impact of rotor downdraft. The literature review aimed to answer two key questions: how the amount and distance of drift resulting from spraying by UASS compared to other spray equipment and whether UASS presented any specific risks that needed to be considered. Some of the unique risks may be the release height of application; the nozzle position in relation to rotors; understanding the turbulent air flow from multi-rotors and potential interaction of any downdraft from rotors with canopy or ground as well as effect of UASS design, height, and forward speed on potential downdraft. While these aspects still need to be confirmed there are papers that did try to compare UASS to existing methods and based on that data these are some conclusions /recommendations.

3.1.1. Differences in UASS spray drift versus existing application methods

At least one study each directly compared spray from UASS to knapsack, ground boom/airblast sprayer or crewed aircraft. Two reliable studies contrasted drift from UASS against standard spray drift curves used by some regulators for ground sprayers. Compared to a drift curve for ground boom sprayer, the UASS with fine spray generated more drift, as might be expected due to greater release height (note that the use of drift reducing nozzles would need to be balanced against retaining efficacy). Compared to a drift curve for airblast sprayers, drift from UASS was lower for both coarse and fine droplets than airblast sprayers in vineyards, and less or comparable with fine spray. This may reflect that rotor downdraft creates a downward directed spray as opposed to ascending from airblast sprayer. We recommend contacting study authors to source additional data in a format that may be useful for inclusion in a spray drift database. There is enough data for the beginnings of an empirical database and standard drift curve, but additional data would ensure conclusions are representative.

3.1.2. Consensus needed on spray drift/deposition sample collector

The review discusses the merits and limitations of sampler material. Differences in samplers used, and whether they permitted residues to be expressed per surface area and therefore as percent applied, restricted direct comparison of different studies. It is proposed that regulators decide on a preferred sampling method and material to make future trial data more useful. This is not specific to UASS and existing ISO standards already describe a range of appropriate sampling materials, but it could be considered in the context of reviewing existing ISO standards, and the SETAC DRAW workshop, which also previously considered this, may also have useful information. One point specific to UASS was that the currently recommended sampler size (1000 cm^2) may be too large to ensure detectable concentrations from very low and ultra-low volumes.

3.1.3. Lack of calibration, flow rate checks and insufficient pump systems

It is important that the flow rate and amount applied are experimentally measured before every spray run and that this is reported to have taken place. Low-capacity pumps, often without pressure gauges may not achieve the pressures required to keep nozzles open as application rate increases. Flow rate checks are critical to ensure nozzles are working properly. Total volume sprayed should be measured so deposition and drift can be reliably expressed as percent applied.

The development of UASS technology and design is rapid and improvements are already being observed with UASS on the market, for example, increased capacity pumps are fitted to UASS released to the market in 2021.

3.1.4. Application height affects drift and deposition

Ground boom sprayers usually operate at 0.5 m above the crop, while with crewed aircraft the boom is at least 3-4 m above crop. In the literature reviewed UASS most typically sprayed from 1.5-3 m above the crop. Investigation of the influence of release height on drift supported the hypothesis that spray drift increased with height.

Increased forward speed will reduce deposition unless flow rate is adjusted and may weaken the interaction between UASS downdraft and the canopy. Understanding how different operating practices affect drift may in future allow for an optimal application height and flight speed to be identified to reduce drift.

3.1.5. Nozzle position affects drift

It is accepted (ISO standard 16119-5, point 5.9.2) for crewed rotary aircraft that nozzles should be within 75% of the rotor diameter to reduce drift. At present not all UASS are configured in this way. Some studies concluded that greater drift occurred if nozzles were placed under rotors, beyond or close to the UASS rotor diameter (as illustrated in Figure 1), as opposed to within the rotor diameter. The same recommendation on positioning nozzles within 75% of the rotor diameter for UASS could decrease off-target losses. Where best to place nozzles and boom in relation to rotors requires further investigation, as some nozzles are placed directly under rotors, assuming downwash will minimise drift, but as downwash can be weakened by forward speed, this is not necessarily true.

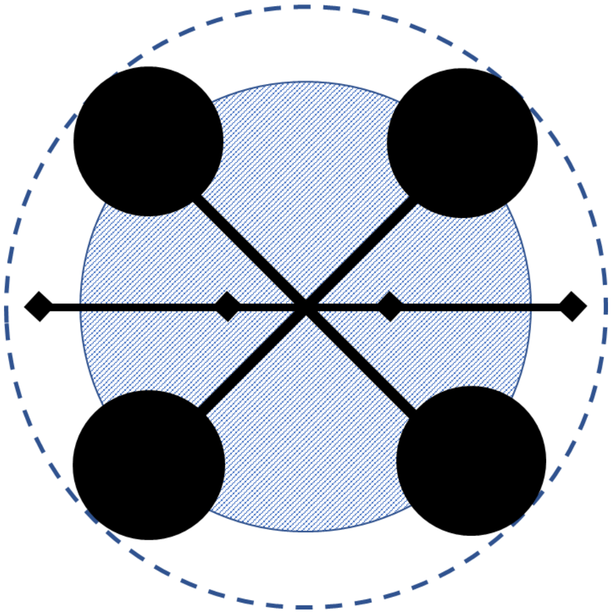

Figure 1: Schematic illustrating the spray nozzle location (denoted as diamonds on the horizontal line, representing the boom) relative to UASS rotors (denoted as the four black circles). The larger dotted line represents the circular area covered by the rotors. The shaded area within the larger circle represents the area covered by 75% of the rotor diameter.

3.1.6. Effect of UASS downdraft on canopy penetration and environmental exposure

Simulations and field measurements confirmed the velocity of downdraft from UASS rotors is fastest when at low altitude and low speed. Downdraft decreases with height and is weakened by increasing forward speed, turning to outwash if forward speed exceeds downdraft speed.

Downdraft may interact with the crop canopy or ground resulting in different spray deposition to other spray methods. It is not known if the force of downdraft affects the amount of pesticide intercepted by a crop and reaching the ground, or if subsequent passes dislodge any previously deposited spray from leaves. This has implications for assessing pesticide concentrations in soil and the exposure of non-target soil organisms. Conversely, turbulent airflow could cause a rebound effect where spray bounces back from the soil surface or increases leaf movement, allowing spray to better penetrate the canopy or reach underside of leaves. Results that compared canopy penetration and ground deposition for UASS with other sprayers were mixed for different crops and at times confounded with effect of forward speed.

3.1.7. Research only compares whole field treatments

Two areas not addressed by the review that need further information were spot spraying by UASS and spraying using swarms of UASS.

There is mounting interest in precision application and only spraying localised areas where a pest or disease is present in a crop, rather than treating the whole field. This offers benefits such as lower water use, reduced application of pesticide overall and lower off-target deposition. Though this interest is not specific to UASS application, such systems are potentially well suited to this; by combining remote sensing of weeds, pests or disease with variable rate, or spot spraying, the process could be automated and offer far greater work efficiency compared to knapsack sprayers. As with other spray methods for spot spraying, overall reduction in pesticide application across a whole field does not necessarily equate to lower risk to the non-target species if the organism comes into contact where the spray is applied (i.e. direct exposure or via consumption of residues on dietary item). This approach will decrease the amount of active substance applied compared to a whole field application. Regulators will need to determine how the environmental exposure arising from spot treatments compares to whole field treatment.

3.2. Conclusions

Conclusions from considering the environmental context of UASS application:

- Application height, speed and droplet size are the major factors affecting spray drift and deposition that should be considered by regulatory authorities;
- The position of nozzles relative to UASS rotors may have a significant effect on spray drift. However, at this time there is insufficient information available to assess the nature and degree of risk which can arise leading to the conclusion that it is not possible for regulatory authorities to assess the respective risks that arise from UASS with differing configurations (e.g. number and location of rotors, the power they generate and nozzle position relative to the rotors);
- There are some currently available data on drift from UASS that would be considered reliable from a regulatory standpoint to quantify UASS spray drift potential to support off-site exposure estimation in a risk assessment. These data could be gathered to develop a draft standard spray drift curve or a predictive model to estimate off-site movement that could inform regulatory exposure estimates. Authors of some other papers considered in the review could be contacted as to whether additional raw data on drift from UASS are available. Data from such studies can be accumulated to derive a statistically supported interim drift prediction curve;
- Downdraft from UASS has the potential to interact with the crop canopy or ground and result in different environmental risk compared to that arising from application using established technologies. At present, data are limited and suggest that lower soil exposure may arise from UASS application; this would mean that existing regulatory crop interception assumptions may be protective of UASS application. However, data are limited to two studies studying deposition in wheat crops also sprayed with knapsack or ground boom sprayers.
- More research is required to expand this information and to confirm these effects. Initial ideas are at Annex B.

3.3. Recommendations

- For UASS, flow rate must be checked, and the amount applied measured before every spray run. Studies should report whether this has been conducted;
- Encourage manufacturers to improve the spraying equipment on UASS, especially the pumping systems and controls, to meet the requirements on application rates and quality. Survey manufacturers about design developments and trends, with a view to regulators focusing research efforts on a commonly used standard UASS platform. In principle the spraying systems should comply with the requirements defined by ISO 23117-1 (which is under development);
- Drift data are available from the review that may allow a drift curve to be prepared for use by regulatory authorities. The data tentatively indicate that drift

from UASS will be higher than ground sprayers, but lower than from crewed aerial application or airblast sprayers, but further data are needed for confirmation;

- To reduce the need for specific assessments for every UASS platform configuration, data could be gathered from this review and future studies into an empirical database classifying UASS models and operating parameters, and collating estimates of on-target deposition, spray drift, and in swath uniformity;
- Datasets be established enabling regulators to determine how spray drift from UASS application differs from that of established technologies. Ideally, datasets should be established to help develop a spray drift curve and a predictive model to estimate off-site movement for regulatory use; this would benefit from collaboration between regulators, academics, drone manufacturers and the pesticide industry;
- More research is conducted to determine how UASS downdraft impacts upon canopy penetration, interception and soil exposure in various crops and for different heights, speeds and number of rotors;
- Work should be undertaken to reach consensus on the type of sampler used for spray drift studies, as advised by the SETAC DRAW workshop. One option may be to incorporate this into any revision of ISO standards on drift trials. This is not specific to UASS but would be beneficial for cross-comparison between studies and in making broadest use of any data available;
- Consider operational practices, such as UASS accelerating or decelerating at the edge of field, or 'sidestepping' rows, while continuing to spray may result in unintended over application or increased off-target losses;
- Nozzles should, where practical, be positioned within 75% of the rotor diameter of UASS to reduce off-target drift. The influence of nozzle and boom position in relation to rotors on spray drift requires further investigation

4 Efficacy Considerations

Literature Review Findings

The efficacy of products when applied via ground based hydraulic nozzle boom application equipment, airblast sprayers, knapsack sprayers and via crewed aerial spray systems is known. Efficacy data are typically generated by crop protection companies in support of product registration. Reliable comparisons of UASS efficacy with known systems would assist in understanding any differences in efficacy of these systems and whether specific consideration is required for pesticides which are to be applied via UASS. For example, the payload of a UASS may be less than that of a ground-based system with the spray solution applied at a much higher in-use concentration. An assessment should be made of how the concentration of the product influences effectiveness and crop safety. It is, of course, possible that some spray solution concentrations will be within those currently used in more conventional application systems.

As mentioned above, the review identifies the importance of accurate calibration of application equipment. Pump systems on UASS can sometimes be low capacity, low grade and lack a pressure gauge. The flow rate from the nozzles and the spray pattern and quality are affected by the pressure in the delivery system. Furthermore, different nozzles are designed to work at different pressures. The application rate is a combination of multiple factors: nozzle output, forward speed and spray height above the crop canopy influencing the spray swath eventually are all important in delivering the effective application rate. It is therefore important to be able to accurately control the system pressure to obtain the required spray pattern and quality. Accurate calibration of spray equipment must be conducted prior to application. The spray pattern will also determine the appropriate height above the crop to achieve the required coverage.

A good even coverage of spray is required to achieve optimum efficacy; and is essential for those active substances/ingredients with a contact mode of action, but potentially less so for those with a systemic mode of action. The review included trials investigating differences in application height and forward speed on coverage which has been examined in various studies.

In some cases though the experimental design meant one parameter confounded another making it difficult to draw conclusions on the impact of each. For example differences in forward speed were confounded with droplet size (finest spray tested with slowest speed and strongest downwash, larger droplets tested with fastest speed, which decreased penetration due to horizontal element to spray). Deposition results from one study with different working heights, were opposite to what would be expected. In this case the higher of two altitudes gave better penetration of the canopy, whereas one would expect reduced downwash interaction compared to lower application heights. However, but due to lack of replication this study was not considered fully reliable.

Some efficacy data are available from trials conducted in rice, wheat, sugar cane, cotton and orchards and have been discussed in the review summary.

Most of the data currently available is from the Asia Pacific region (the main area of current UASS use) and the spray droplet range used in these UASS experiments reported in the literature appears to be "fine." Europe/ USA tend towards low drift technology and therefore more medium to coarse spray droplets. As this potentially affects coverage, there is a need for more information on droplet deposition and efficacy when UASS is used with medium or course spray droplet range. Therefore, the droplet deposition data discussed in the review may be of limited use with regards to extrapolation for efficacy. However, spray droplet spectrum will be determined by the nozzle type and pressure and does not depend on application platform.

Some of the studies have made comparisons between UASS and knapsack sprayers which have a motorised pump to achieve the operating pressure and may not be in common usage in many OECD countries. A knapsack with a motorised pump may give different coverage/deposition to one without a motorised pump. Therefore, trials where UASS was compared to motorised pump knapsack may not be representative to extrapolate conclusions to knapsack without this.

Conclusions

There is an extremely limited understanding of how the efficacy of pesticides applied from UASS differs from that of other forms of application equipment. There are currently insufficient published data to allow regulatory authorities to bridge existing efficacy for conventional spray application systems with UASS.

The studies summarised in the review cover a range of types of UASS, actives and crops. Application by UASS has been conducted using different release heights, forward travelling speed, active substances and nozzles. Little information has been given on calibration and the actual methodology. These are singular studies conducted disparately with no standard protocol.

The available efficacy data fall into the following categories, a comparison of spray methods or UASS alone; measuring effectiveness of biological control and / or measuring deposition data.

More emphasis has been made on deposition data in these studies as opposed to comparisons in biological effectiveness. Since not all OECD country regulatory systems consider deposition data when evaluating biological effectiveness and crop safety, it is unclear how applicable this literature is to the current regulatory approach.

All the UASS treatments have been at a higher concentration when a comparison with a ground-based applicator can be made. Higher concentrations of active ingredients / substances in a spray solution can cause detrimental crop safety effects such as phytotoxicity. None of the trials reviewed in the present review have considered or reported any aspect of crop safety.

Based on the limited evidence available, applications made by UASS tend towards delivering a lower degree of efficacy than ground-based boom or knapsack sprayers. However, this is not universal and it is not possible to quantify the relative performance of the technologies. UASS applied product efficacy may be improved using adjuvants. Although some studies showed that performance can be comparable with a ground-based application, these have been with systemic active substances where coverage is not as important as it is with active substances with a contact mode of action and it cannot be concluded that systemic actives are the exception to this rule.

If comparability of efficacy performance from treatment with different application regimes and under what conditions can be consistently demonstrated, then this may permit extrapolation from one spray method to another. Alternatively, data could be generated to demonstrate the efficacy of a product when applied from a UASS tested alone.

A data base of classifications of platforms and configurations is proposed and some data from these studies were considered useful for that. Information over time may allow us to group these for the purpose of assessment.

Recommendations

We recommend that structured programmes of work are established to develop datasets enabling regulators to determine product efficacy (where this is considered as part of registration processes). The work should be directed to generate packages of studies/datasets developed using standard protocols containing information on: configuration of the equipment (number of rotors, nozzle type and position relative to the rotor, etc), flight patterns (height and speed); spray solution (volume of product, use of adjuvants, impact on crop safety etc); deposition; comparability of treatment regimes and degree of control.

5 Conclusions and Recommendations

Conclusions

This report concludes that a combination of UASS design and working practices (including those arising from different crop types) have the potential to create different risks from those associated with established methods of application. Currently there are inadequate, reliable data available to satisfy all the requirements of many regulatory authorities. Good practice in methodology and study design is vital. The differences in risks from other spray methods are due to height of application above canopy, turbulent airflow/downdraft due to rotors, UASS specific operating activities/tasks, nozzle position, size of droplets and coverage. The nature and relative degree of risk alters depending on the factors above. It may be possible to enable UASS application by permitting use within existing risk envelopes, (Report on application to Vines - (Anken & Dubois)) but to facilitate more widescale adoption of this technology regulators are likely to have to develop UASS specific assessments.

Actions are required to improve the reliability of data and application of pesticides via UASS in practice. This can be done by ensuring the existing standards are updated to include important aspects for UASS. The importance of calibration of the spray system cannot be over emphasized. UASS manufacturers should be encouraged to improve the pumping systems placed on UASS. Additionally, a user-friendly summary of best practice, pitfalls, troubleshooting guide (both for generating trials data and applying pesticides via UASS in practice) should be developed and published.

Some data on drift from UASS currently available is considered reliable and can be used to start to develop an interim standard drift curve to inform regulatory estimates in comparison to known drift curves for ground spray equipment. Additional drift data for UASS may be obtainable from authors of other papers in the review. These data could also be added to a database for future regulatory reference and used to increase confidence in the interim drift curve. Further work is required to characterize the spray distribution more accurately from UASS, alongside operational practices that could be important to operator exposure and off-target losses.

The project has indicated that the configuration of the UASS does have an influence on pesticide spray drift and consequently on human health and environmental exposure. The number and power of the rotors; the type and location (relative to the rotors) of the nozzles used; a combination of the height at which the drone flies above the crop/area to be treated and speed at which it flies will influence the amount of spray drift, downdraft and interception of spray by the crop canopy.

The project has also indicated that there is a lack of information on work practices. Standard work protocols would assist regulators in constructing exposure scenarios to help understand the potential degree of worker exposure. The protocols should cover practices such as frequency and duration of handling and filling operations (including whether closed transfer systems are used), length of a working day, proximity to spray operations and cleaning operations. Information on cleaning operations could be supplemented by data/information indicating exposures from residues to be cleaned from the machinery following spray operations. In the absence of any information on these points, we recommend that regulatory authorities adopt a ‘reasonable worst-case scenario’ approach to assessing exposures. Regulatory authorities should also take steps to ensure that UASS operators intending to spray pesticides are suitably qualified and have a good understanding of best practices in pesticide application. For the operator exposure component, there is also the need to construct exposure scenarios that are representative of the mixing loading steps and the work activities for UASS.

There is a clear and urgent need for a set of standard testing protocols to be agreed upon for the assessment of UASS. Standards are needed for calibration and appropriate deployment, for efficacy testing and for spray drift assessment. These methods are necessary to ensure that data are of an appropriate quality, are considered acceptable across jurisdictions for regulatory decision making and can be combined to build up data sets. Protocols and standards for the conventional (non UASS) spray application of pesticides are available. Some aspects such as calibrating spray equipment and sampling are generic to all spray equipment in principle. As spraying by UASS is an area where services may be offered by companies that are primarily UASS specialists or pilots and not necessarily always experts in pesticide application, the review recommends that best practice and potential pitfalls should be emphasised. Some operational practices will also be specific to UASS.

Another aspect that needs additional consideration for UASS applications that is relevant for dietary exposure (e.g., crop residue) and operator exposure is the potential reduced carrier volume - which may influence spray concentrations, compared to conventional ground applications. However, for dietary exposure, it should be noted that piloted aerial applications (e.g., rotary or fixed wing aircraft in North America and Australia) and remotely operated helicopters (e.g. radio controlled helicopters in Japan) have utilized lower carrier volumes for several decades. Experience with these conventional application systems has led some OECD countries to stop requesting field crop residue studies for these application methods. For the operator exposure component, there is also the need to construct exposure scenarios that are representative of the mixing and loading steps, handling of the UASS and the work activities for UASS.

Recommendations

Through its work under the initial charge from the WPP, the Drone / UAV Subgroup has created experience and an understanding of the available information. It also has identified areas of additional work needed to support the development of OECD WPP guidance for the regulatory risk assessment and decision processes for UASS application of pesticides.

With respect to data generation, the focus on generating information / data for submission to regulatory authorities should 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. Generated data will also contribute toward the evaluation of existing regulatory models or the development of new UASS-focused models that estimate exposures in risk assessment and regulatory approval processes.

Below are some specific recommendations for considerations in developing new assessments and models.

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 standard platform as a common starting point for regulators (others may differ and need bespoke assessment but would cover most common uses).
3. Encourage manufacturers to develop improved spray systems including the pump systems, nozzle placement and closed transfer loading systems.

4. Develop set of standard methodologies that will support regulatory decision making.
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.
7. Develop an empirical database and standard drift curve or model to estimate off target exposure.
8. A data gathering exercise for operational practices mixing, loading, cleaning and transport scenarios.
9. Develop a useable publicly available model for predicting spray deposition and drift including parameters for static hovering, forward speed and spray equipment.

Annex A. Full Report

State of the Knowledge – Literature Review on Unmanned Aerial Spray Systems in Agriculture

Australian Government

Australian Pesticides and Veterinary Medicines Authority

State of the Knowledge Literature Review on Unmanned Aerial Spray Systems in Agriculture

OECD Working Party on Pesticides (WPP), OECD Drone Sub-Group

Bonds Consulting Group LLC, Australian Pesticides and Veterinary Medicines Authority

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Introduction

China, Japan and Korea have been active in the commercial use of Unmanned Aerial Spray Systems (UASS) for delivery of Plant Protection Products (PPP) for over 30 years. Currently, there is worldwide interest from growers, applicators, and industry regarding the use of UASS for pesticide application. This application technique, however, poses new regulatory challenges as there are unknowns associated with UASS applications that need to be answered to evaluate the risks posed.

To aid in better understanding these unknowns, the OECD Working Party on Pesticides (WPP) created a team to consider the application of pesticides by UASS (OECD Drone Sub-Group) in June 2019. The objective of this team is to "generate guidance on the necessary data requirements to support pesticide application by UASS, in recognition of any different risks from conventional applications (both ground-based and aerial), with the objective of building-in future proofing (recognizing the pace of technological developments)". The process for assessing the hazards and risks associated with the proposed use of pesticides considers the following factors: human toxicology, operator and bystander exposure, dietary exposures, environmental fate and behavior, ecotoxicology; physical and chemical properties; and efficacy. The data that are lacking with UASS technology is primarily exposure, efficacy, and drift.

The parameters that drive the chemical dispersal of PPP are not new or unique to UASS; it is the relative impact that is important. For example, droplet size from a UASS application will have the same impact as it does with all other pesticide application techniques. Smaller droplet sizes will provide better crop coverage, yet they will also be more susceptible to drift in comparison to larger droplet sizes. The question is how much considering the altitude at which the spray is released, the velocity and the trajectory of those droplets. Generally, the physics is the same for UASS applications; the primary deviation is the impact of turbulence and the variability of that turbulence with the different platforms (e.g. one vs. four vs. eight rotors). In addition, due to their size and payload capacity, UASS tend toward lower application volumes than their counterparts. As the carrier volume is reduced, the concentration of the active ingredient increases, which raises additional questions for bystander, operator, non-target organism and sensitive habitat exposure.

Published papers by their nature may lack the level of detail or raw data necessary to allow them to be relied on quantitatively for regulatory purposes. Also, they will not have been designed to specifically meet that regulatory requirement. In this area, there is a lack of agreed guidelines or testing protocols to standardize such trials or equipment. Consequently, although many of the papers reviewed had direct relevance to the areas this project was considering, there were frequently experimental aspects that limited their robustness or reliability to be useful in a regulatory context. Therefore, only 20 of the 61 studies pertaining to UASS obtained for this review were considered to be both relevant *and* reliable for regulatory purposes. Many of the studies that are considered relevant are not fully reliable due to the lack of appropriate methodology for trial conduct or lack sufficient replication of the experiment. While the information from the review is not substantial enough to enable the development of harmonized use policies and guidelines for product registrants, it does provide an overview of the current state of knowledge and practice. This report discusses the state of knowledge and practice, highlighting key findings and information gaps, identifying what is recommended to fill them.

In swath measures

From a regulatory perspective we need to know that UASS delivers spray material effectively, with a maximum on-target delivery and minimal off-target loss. Equipment calibration and accurate measurement of in-swath deposition is an important first step in this process. The aim is to know exactly how much volume has been applied and that it has been distributed in a form that can effectively achieve the intended outcome. An effective spray distribution can be described as an appropriate volume of spray material applied, a coverage metric of that volume (volume per unit area, percent cover or droplet density), a uniformity metric (coefficient of variation), a measure of efficacy and ultimately off-target losses. The methods necessary to do this are discussed below, highlighting essential experimental procedures for scientifically robust execution and reporting. One of the most glaring gaps in the state of the knowledge, apparent from the available published literature, is a basic understanding of pesticide application and the calibration of the machine and its spray system.

Physical characterization of deposition: Calibration

The standard for calibration and distribution testing for manned aircraft from the American Society of Agricultural and Biological Engineers (ASABE-S386.2 1998) can be easily applied to UASS research. Without calibration it cannot be confirmed that the intended application rate was applied, which could undermine the validity of the experimental results and conclusions. The test consists of four parts that are to be replicated to account for random variation:

1. determination of the output rate from the aircraft;
2. determination of the swath distribution pattern by measurement of the applied materials from suitable collectors;
3. determination of the maximum effective swath width and the corresponding uniformity of distribution for overlapped swaths; and
4. determination of application rate.

The majority of available studies only partially completed these four steps. This must be done for each treatment as no conclusions can be drawn from studies where the application rate is not verified.

Flow rate

It is essential that the flow rate is known prior to the deployment of any pesticide application unit. This confirms the output of the chemical and allows the operator to ensure the system is functioning effectively. Too many of the published manuscripts provided flow information as only a nozzle type and operational pressure. For example, a LU110-01 nozzle at a pressure of 250 KPa and a forward speed of 3.3 m/s applied 15 L/ha (Chen et al. 2020). Where the information is presented in this format, it can be concluded that charts have been used, rather than a flow rate check or measurement from the test vehicle. An actual flow rate check on these systems is critical as most pumps placed on UASS do not have pressure gauges. Currently the normal practice is that the pumps on UASS are lightweight, electric diaphragm pumps that typically have low overall flow capacity that limits the number and size of nozzles they can functionally operate. This can be seen in Martin et al. (2020) where the first study used four TTI110-015 nozzles across the boom but only three opened due to inadequate pump pressure. For the second study, two nozzles were removed to provide an increase in pressure (414 kPa) to fully open the nozzles (35.6 L/ha).

For manned aircraft, the output rate is determined by measuring the amount of liquid discharged from the tank for a measured time interval while the aircraft is operated under normal conditions. With UASS, the pumping systems do not require the engine or the platform powering the UASS to be in operation. UASS have separate battery operated pumps that allow for flow rate to be checked for each nozzle on the ground. In addition to a flow rate check, the total volume sprayed should be measured at the end of each experimental treatment so that deposition and drift numbers can be normalized to percent of applied (Brown 2018). This can be done by refilling the sprayer to a set point with a measured quantity, emptying the sprayer, or for battery operated sprayers, taking pre- and post-application system weights.

Methods for measuring swath

The coefficient of variation (CV; Equation 1) is the standard metric for swath uniformity analysis and a means of defining the effective swath or flight line separation.

$$\text{Mean} = \overline{X} = \frac{\Sigma X_i}{n}$$

$$\text{Standard deviation} = \left[\frac{n(\Sigma X_i^2) - (\Sigma X_i)^2}{n(n-1)}\right]^{1/2}$$

$$\text{Coefficient of variation} = \frac{\text{standard deviation} \times 100}{\overline{X}}$$

where:

$\overline{X}$ = arithmetic mean

X_i = quantified deposit for one collector location for the combined swaths

n = number of collector locations used

Equation 1

While ASABE S386 specifies that the swath overlapping analysis be conducted for each spray pattern replicate, a common approach used for manned aircraft pattern evaluations averages the pattern data from three or more replicated spray passes to a single pattern. It has been noted by Richardson, Kimberley, and Schou (2004) that CVs determined using multiple individual swath patterns that incorporated the normal variation were potentially double the CV compared to those determined using a single averaged pattern (Martin, Woldt, and Latheef 2019). Whether the determination of swath is conducted by averaging or overlaying independent swaths, there is agreement on the methods used to undertake that measurement. The ASABE standard sits in line with the Korean and Japanese standards, in all but sampler type. The ASABE standard does not define the sampler type but water sensitive papers (WSP) are the most commonly used tool; the Japanese (Kromekote box) and Korean (deposition cards bent at a right angle) standards include a vertical measure which is relevant to efficacy but not necessary for the two-dimensional swath analysis. Each protocol requires a minimum of three swaths be flown independently over the line of samplers, a maximum of 0.5 m apart, perpendicular to the flight line. The Korean standard suggests that the length of that line be a minimum of four times the length of the spray boom (or nozzle separation). All standards require a base measure flying into the wind for a swath analysis to minimize crosswind effects on the pattern. After establishing an acceptable pattern, crosswind testing may be conducted to determine the resulting pattern under those conditions. In practice, this is rarely done, with system adjustments and effective swath width recommendations determined based solely on in-wind passes. Recent work showed that patterns from the same spray system setup and operation varied significantly under in-wind and crosswind conditions (Fritz et al. 2011).

The Chinese standard for swath assessment differs from the other standards (NY/T3213 2018). To achieve control of disease and pests, 15-40 drops/cm^2 are required with a CV of 60 % or less. The central sampling zone is 20 m in length consisting of three lines of water sensitive papers perpendicular to the flight line 10 m apart, at canopy height, arranged symmetrically on each side of the flight line. The numbers and positions of the samplers can change from study to study. Zhang, Qiu, et al. (2020) showed 15 sampling points being symmetrically distributed from left to right with the 8 m mark being the center (flight line) with 0.5 m between the middle two samplers (samplers 7 – 8 - 9), and 0.25 m between the next samplers on either side (i.e., 6 - 7 and 9 - 10), and then 0.2 m separation until the end location on both sides of the flight route. Each sample line is considered a replicate with one pass of the platform being tested, not the three individual passes included in other standards. In the Chinese standard, the edge of the effective swath is the sampling location where < 15 drops/cm^2 are collected on cards. This approach to the demarcation of swath width, rather than finding the appropriate overlap of the patterns to conform to a defined level of uniformity, leads to high CVs. Zhang, Qiu, et al. (2020) reported CVs all exceeding 50 % (ranging from a minimum of 53 % to a maximum of 97 %), meaning that the deposition uniformity fluctuated greatly within the effective swath width.

A study conducted by Wang, Song, et al. (2017) explored the uniformity and coverage of droplet deposition both inline (uniformity of forward speed) and perpendicular (swath uniformity) to the line of flight with a number of different UASS. The in-swath uniformity followed standard protocols (NY/T3213- 2018) with three lines of water sensitive papers perpendicular to flight line. An additional sampling routine placed water sensitive papers in line with the flight line to look at uniformity of forward speed. The in-swath variability showed CVs for three similarly sized single-rotor UASS were 65, 63, and 43 % for UASS models 3WQF120, 3CD-15, and HY-B-15L, respectively, and 71 % for a six-rotor UASS model WSZ 0610. These uniformity measures are particularly high considering that the Chinese standard is < 20 % for tractor boom and < 60 % for UASS; note this value is typically much lower in other countries for ground and aerial sprayers (e.g., 30 % in Korea and 25 - 30 % in Europe and the USA). The study by Wang, Song, et al. (2017) is not unique in demonstrating what appear to be overly high CV values; much of the literature from China reports similar values and trends toward non-uniformity due to this standard.

The in-flight line uniformity in Wang, Song, et al. (2017) highlighted something not typically reported: there was higher deposition at the field boundary due to acceleration and deceleration of the UASS. It should be noted that with manned aircraft the velocity is maintained over the target with the spray turned off at edge of field. With UASS, the vehicle typically stays within the field and side steps for the next flight line. The authors register an over application within the first and last 10 m as the UASS decelerated and accelerated at the field edge with the spray still on. This application practice could lead to increased edge-of-field deposition and off-target losses.

In Switzerland, there are approximately 25 operational UASS (manufactured by either HSE or DJI) and no standard for regulating the quality of the spray distribution (personal communication: T. Anken, 2020). The regulatory authorities adopted ISO 16122-2, where a patternator is used to determine the uniformity of the UASS in hover by measuring the transverse volume distribution of the sprayed liquid (16122-2 2015). The patternator was modified to a width of 3 m and a length of 6 m. The width and depth of the single grooves were 10 cm draining to 500 mL graduated cylinders. Preliminary studies showed that the lateral distribution was affected by the height above the patternator; the 2.5 m height had a CV of 12 % compared to the 1 m height with a CV of 39 %. At the 1 m height, almost no liquid was measured in the middle of the swath. Therefore, a test height of 2.5 m is to be maintained until roughly 100 mL is collected in the cylinders and the CV calculated. The UASS tested on the patternator achieved CVs between 6 % and 15 %. The average for the HSE UASS was 12.2 % and the DJI UASS was 9.4 %. The requirements for conventional field sprayers are to achieve a CV of 10 % (ISO-16119-2 2013). However, because UASS are mainly used in viticulture in Switzerland where no specific regulation exists, a maximum CV of 15 % has been set to pass the regulatory standards and specifications. The main issue with this technique is that the UASS is stationary and, therefore, not representative of a field application. The forward component has a significant impact on swath pattern and by staying stationary the sample size increases, artificially improving uniformity (Anken and Waldburger 2020).

Parameters that influence deposition

It is important that researchers in this area have a basic understanding of the effects of various application settings so that the experimental design parameters are not confounded. Some studies in the review have been identified that support and describe generally accepted norms and underlying physics. For example:

- as the height of the UASS increases so does the swath width;
- as the swath broadens the deposition density decreases;
- as flight height increases so does potential drift (since there is increased distance and time for spray to be entrained by ambient air); and
- as velocity of the UASS increases, deposition may be reduced, unless the flow rate is adjusted to maintain application rate (even then some deposition may be lost due to reduced downwash and an increased horizontal component to the spray).

Wang, Zhang, et al. (2017) made multiple passes over water sensitive papers that were set perpendicular to the flight line 0.5 m apart over 10 m (21 in total), using a single-rotor CD-15 UASS, with an electric centrifugal nozzle (LXPT-03). When the flow rate was set in this study and the flying speed was lower than or equal to 2 m/s at different altitudes, the peaks of droplet coverage density were more than the required 15 - 40 droplets/cm^2 across a 5 m deposition zone or swath. The swath widened as the altitude increased, and drift or spread out of the 5 m swath was observed alongside a reduction in the droplet coverage density. The authors showed a negative linear correlation ($R^2 = 0.92$) between uniformity and an increase in flight speed and height alongside a clear decrease in droplet density. The study authors concluded that, when speed was > 4 m/s and altitude was > 2 m, the droplet density was lower than the standard value required to control a disease or pest. This study was an exercise that confirmed expected norms.

There are, however, several studies with low altitude and speed that show an increase in swath width in conjunction with a decrease in height, especially with large multi-rotor UASS. Based on experience in application research, this outcome is due to in-ground effect and the ballooning out of the spray creating a larger swath than with a higher altitude and speed. It is known that at low flight speeds and heights, the downwash from the rotors pushes the spray quickly toward the ground and, with nowhere else to go, the vorticial field expands outward. In a numerical simulation that considered forward motion, Zhang, Qi, et al. (2020) showed that, with a set speed of 2 m/s when the flight altitude was 1.5 or 2.0 m, the downwash airflow reached the ground at a relatively high velocity. The transverse spreading of the air flow under these conditions reached a maximum of 6.0 m. When the flight altitude increased to 2.5, 3, and 3.5 m, the downwash airflow reached the ground at a comparably low velocity, and the ground effect gradually weakened. This caused the transverse spreading of the airflow to gradually decrease lowering the width of the airflow field to 5, 4, and 3 m, respectively. In summary, as the flight altitude increased in this simulation, the width of the airflow field gradually decreased. However, this study only modeled the rotor and did not consider the effects of the fuselage and spray system on wake effects. Based on experience with other application systems, addition of structures like these would slow the flow. Because of this and other shortfalls, simulations can only provide directionally correct information. Like Zhang, Qi, et al. (2020), there were other published simulations that could be used as teaching tools, and to inform field experimentation (Wang, Chen, Yao, et al. 2018; Wang, Chen, Zhang, et al. 2018).

As mentioned previously, droplet size has a significant effect on spray coverage. Li et al. (2020) presented an example that utilized knowledge of droplet size effects to target different areas of a dense almond canopy. The targeted pest caused damage in different sections of the canopy at different times through the season, starting in the upper canopy, moving later to lower canopy levels. Two applications were made, the first with a nozzle delivering coarse droplet size distribution and the second with a medium droplet size distribution (defined in Table 1). The assumption was that coarse droplets were more likely to deposit at first contact with the upper canopy. Subsequently, a medium droplet size was used for the second application when damage would occur at lower canopy levels. Substituting the coarse nozzle for a medium nozzle led to better canopy penetration with 1.2 - 1.3 times more compound penetrating into the lower canopy.

Because UASS tend toward the application of ultra-low volumes (defined in Table 2), the droplet size distributions have been in the fine category. In general, nozzles that deliver a fine droplet distribution provide improved coverage and efficacy against foliar pests with these low and ultra-low volume applications. Systems have been developed by the British Crop Protection Council (BCPC) and ASABE for classifying agricultural sprays by droplet size. Table 1 shows the various droplet size classifications and their associated Dv0.5 range that will be used throughout this document (volume median diameter (VMD) or Dv0.5 is where 50 % of total spray volume is made up of droplets of equal or lesser diameter).

Table 1 Droplet Size Classification based on ASABE S572.1

Size Classification	VMD* Range (Microns)
Extremely Fine	<60
Very Fine	61-105
Fine	106-235
Medium	236-340
Coarse	341-403
Very Coarse	404-502
Extremely Coarse	503-665
Ultra-Coarse	>665

* Volume Median Diameter

Researchers, especially within Europe and the USA, are incorporating low drift nozzles that shift the spray distribution up to the medium and coarse categories. Wang, Zeng, et al. (2020) conducted a large wind tunnel study to describe the droplet size distribution from an array of nozzles, representative of those in use in China. This study showed that the nozzles typically selected for UASS applications produce a fine spray that increases the potential for drift or off-site movement. Also included in the study was the Lechler F110 03 which is the standard reference nozzle to discriminate between fine and medium spray characteristics, and low drift air induction nozzles. The airborne and the sediment spray drift was measured to study the effects of the nozzle type, flight speed, adjuvant, temperature and humidity on spray dispersion. As expected, this wind tunnel study demonstrates that an increased droplet size and reduced windspeed reduces drift, and that especially under low humidity and high temperatures some adjuvants can also reduce drift. Regarding the implementation of drift reduction practices, it should be noted that some coarser low drift nozzles require pressures that the pumping systems currently commonly employed on UASS cannot achieve. This emphasizes the need for a flow rate check to ensure that nozzles are working properly (Anken and Dubuis 2020).

Centrifugal nozzles are not uncommon on UASS and can be used to reduce the range within a droplet size distribution. With centrifugal nozzles (e.g. ‘spinning disks’), as the flow rate increases, the diameter of droplets increases; and as rotational speed increases, droplet size decreases (Wang, Zhang, et al. 2017). There has also been some interest in the use of electrostatic nozzles which impart an electrical charge to the spray droplet to improve deposition. In high-sheer, turbulent environments, electrostatics is unlikely to work as the charge is stripped from the droplet. Preliminary work with an electrostatic nozzle showed that droplet size was the predominant factor affecting deposition and that any improvement in deposition due to electrostatics was small with no effect on the underside of the obstacle, meaning that the charge to mass ratio of the particles was too low (Zhang, Lian, and Zhang 2017). Based on this study, electrostatics are not an effective option for reducing the droplet size distribution of UASS applications.

In general, the spraying systems on UASS identified in this review are unsophisticated compared to conventional ground and aerial application systems. Wen, Zhang, et al. (2019), however, developed a variable rate spray system via pulse width modulation[1] demonstrating that as UASS technology progresses, technical advancements are possible. Unmanned Aerial Vehicles (UAV) are frequently used for remote sensing, providing for the possibility of linking on-site mapping with UASS variable rate spraying to potentially provide so-called ‘dial-a-dose' and in-field, location specific application.

Application rate is an important discussion point with UASS. If the carrier volume is reduced to improve the working rate of the machine, the pesticide concentration increases. In certain exposure scenarios, the increase in concentration could create additional occupational exposure. In addition, as the carrier volume decreases, so too does coverage of the plant surface, which could be detrimental to efficacy. Although there may not be a consensus between OECD countries on the definition of ultra-low volume, Matthews (2000) provides some guidance using Volume Application Rate (VAR; amount of formulation applied per hectare) as presented in Table 2.

Table 2 the general classification of volume application rates (in l/ha) for field crops and bush/tree crops

	Field Crops	Tree and Bush Crops
High Volume (HV)	>600	>1000
Medium volume (MV)	200-600	500-1000
Low volume (LV)	50-200	200-500
Very-low volume (VLV)	5-50	50-200
Ultra-low volume (ULV)	<5*	<50
* VARs of 0.25 - 2 L/ha are typical for aerial ULV application to forest or migratory pests and less for vector control.		

[1] The variable spray technology via pulse width modulation PWM = Duty cycle and Frequency. Duty cycle describes the amount of time the signal is in HIGH state as a percentage of total time it takes to complete one cycle. Frequency describes how fast the PWM completes a cycle and therefore how fast it switches between HIGH and LOW. Such a controller adjusts the flow rate of the micro-diaphragm pump over a larger range than pressure alone without changing the droplet size spectrum.

Using the categories outlined in Table 2, in Asia, the trend is toward improved working efficacy. This has led to the carrier volume rates in the very-low or ultra-low volume range; the average carrier volume rate is approximately 15 L/ha according to the literature.

In Switzerland, the motivation to use UASS is aimed to mitigate the negative perception of helicopter applications in steep vineyards, which are linked to noise and spray drift complaints. It is estimated that over 50 % of the 15,700 ha of vineyards in Switzerland are so steep that they cannot be accessed by means of a tractor. Therefore, the application of plant protection products in these vineyards must be performed with small orchard sprayers mounted on manually driven track vehicles, by hand, or by helicopter. The UASS carrier volume rates in these vineyards are closer to a very-low volume application (80 - 100 L/ha). In Germany, the application volumes for vineyards are proposed to be 40 or 75 L/ha (personal communication, A. Herbst 2021).

Similar to the European model, the published UASS research in the USA has been focused on small acreage, high value crops using lower carrier volumes than normally employed using ground application equipment, but not ULV applications. Giles and Billing (2015) applied 47 L/ha in a vineyard, compared to an airblast sprayer applying 935 L/ha. Li et al. (2020) applied 93.6 and 46.8 L/ha to almond trees, compared to ground-based sprays at 935 L/ha. In a vineyard setting over four seasons, the ground-based applications used rates of 500 to 1000 L/ha while UASS based applications used 50 to 100 L/ha, following the rates on product label recommendations for conventional aerial application (Giles 2019).

Efficacy studies

From a regulatory standpoint, information is needed on whether there is any difference in levels of efficacy following treatment by UASS compared to conventional application equipment. Therefore, studies involving a direct comparison of spray equipment under similar conditions are the most useful. There are additional studies that did not have such comparisons but monitored pest/disease control and physically measured spray deposition patterns from UASS application. The reliability of these depended on the method used to measure deposition and whether results could be interpreted in terms of a rate, or an amount per area.

Spray distribution sampling

How the measures are taken is important, especially from a regulatory perspective, as the deposition measurements require units (e.g., amount/area) to allow for interpretation of these results. Again, as stated above, an emphasis on proper calibration and appropriate samplers and other equipment to measure application rate is needed in the performance of efficacy trials. Where the natural target (e.g., plant foliage) is used to measure deposition, it is preferable to take a measure of leaf area so the units can be an amount of active ingredient to a given area. For comparisons within a trial, the deposition amount could be given as a mass of active ingredient (e.g., grams detected/sample), but these measurements do not allow comparisons between trials with different natural targets. As is known from previous experiments with other application methods, the use of natural targets can also increase variability in measuring deposition. For example, deposition on filter papers showed slightly lower CV values (16 – 85%) than the almond residue samples (24 – 97%), possibly because of the regular geometry and standard way of positioning the collection material versus a more randomly positioned, sized, and shaped natural target (Li et al. 2020).

Artificial targets are more typical than natural targets in pesticide application research because they can be standardized, and thus afford greater potential to build a usable dataset for regulatory purposes.

Water sensitive papers (WSP) are a popular measure; they are cheap, easy to use and are easily accessible. The WSP comes in many different sizes and the yellow coating changes to blue when spray droplets impact on the surface. Spray characteristic values such as droplet size, coverage, deposition density, deposition rate and other values can be obtained by digital image processing of the WSP. There are several software options available to conduct image processing such as the popular freeware program Deposit Scan (USDA Agricultural Research Service). Kromekote cards, which are a white glossy card stock, may be utilized in the same way as WSP when a visible dye (also known as a tracer) is added to a spray mixture in deposition experiments. Like all samplers used for spray deposition measurement, WSP and Kromekote cards have their benefits, but they also have limitations. For example, the metrics of droplet size and density can be converted into a deposited application rate giving liquid volume per unit area. However, this conversion has varying accuracy as it is heavily influenced by the degree to which a droplet spreads on the paper surface (also known as spread factor), which is influenced by the droplet size, the applied product formulation and active ingredient, and in the case of Kromekote cards, the visible dye used. As larger droplets spread more, it is also important to know which droplet size distribution bin (or range of size class) has been used for the conversion, and this is rarely reported in studies. Therefore, the accuracy of such conversions to liquid deposition rates is questionable.

Sampling and analytical methods that allow for volumetric measurement presented as a percentage of applied are preferred from a regulatory standpoint. Volumetric measures can be obtained from filter papers, petri dishes or mylar cards (which is plastic card stock). The petri dish and mylar cards have the advantage that they are not adsorptive, unlike filter papers. Adsorption to the paper means that not all the measured compound is recovered, resulting in longer sample processing times because the papers need to soak. The fluorescent tracers or colored dyes used in conjunction with this sampling method can be analyzed by fluorimetry or colorimetry, respectively. Finally, some study protocols exist (e.g., field crop residue trials that include Good Laboratory Practice stipulations) that measure the pesticide residues directly on the plant. However, these studies are expensive in terms of equipment, expertise and analytical reagents required, leading to a reduction in the number of samples that can be processed from an individual experiment.

There were several efficacy studies identified through this review; in general, these studies can be categorized as follows:

- A comparison of the control of a specific pest by UASS application compared to accepted norms for percent efficacy;
- A comparison of the control of a specific pest by UASS application compared to an industry standard method; and
- An investigation into the physical characterization and the effect of different application settings and the use of adjuvants to improve coverage.

To summarize the available information, the efficacy trials have been ordered into different crop types and the ability of UASS to address the challenges of different canopy structures is presented below.

Rice

Rice is a semiaquatic annual grass with a canopy comprised of mostly vertical, thin leaves. Xue et al. (2014) conducted a drift and deposition study with rice seedlings (13 cm height), employing an UASS flight height of 5 m, speed of 3 m/s, and a carrier volume of 15 L/ha. The in-swath rice sampling points were a matrix of 5 × 3 (2 m separation) mylar cards divided into an upper and lower canopy height; the sampling was volumetric with mylar cards with the tracer Rhodamine B. In this experiment, there was no difference between droplet deposition on the upper and lower rice plants in the sprayed target area. The average deposition on the upper canopy was 28 % and in the lower canopy was 26 % of the total applied due to the small canopy structure present in rice at the seedling stage. Wang, Li, et al. (2020) investigated the effects of spray volume and tank-mix adjuvants on droplet deposition in rice at the panicle initiation crop stage, where a fully structured canopy was present. The control of rice blast and leaf roller with a four-rotor (TAX) UASS was compared to a backpack sprayer application. The UASS height was 2.0 m above the crop, with an effective swath of 4 m, applying a carrier volume of 9 and 18 L/ha at flight speeds of 6 and 3 m/s, respectively. The electric backpack sprayer (also known as a knapsack sprayer) used a hollow cone nozzle at 3 bar to apply a carrier volume of 450 L/ha. Increasing the spray volume and adding an adjuvant (methylated crop oil) significantly ($P < 0.01$) increased droplet density, percentage of spray coverage, and control of rice blast and rice leaf roller for the UASS application. Among all treatments, the UASS at 18 L/ha with adjuvant returned the best rice blast control efficacy of 62.7 %. For rice leaf roller, control efficacy was high, ranging from 84.3 % to 96.3 % for the UASS at 18 L/ha, which was not significantly different from the backpack sprayer at > 96 %.

Chen et al. (2020), used a four-rotor drone-Freedom Eagle UASS to investigate spray distribution and insect control with three different droplet sizes of rice planthoppers in rice at the tillering and flowering crop stages. The spray droplet size distribution for the three different nozzles used in this study was small: Dv0.5 of 132 - 167 µm (ASABE Fine category). Nozzles were LU110-01, LU110-015, and LU110-020; the volume applied was maintained at 15 L/ha for each nozzle by changing the forward speed to 3.3, 5, and 6.1 m/s, respectively. Allura Red (10 g/L) was used as the tracer and Kromekote cards for image analysis. The density of the droplets was highest with the LU110-01 nozzle, while the coverage densities of the LU110-015 and LU110-02 nozzles would not have met the requirement of > 15 drops/cm^2 to achieve acceptable efficacy. Control of planthoppers treated by the LU110-01 nozzle at the tillering and flowering stages was 89.4 % and 90.8 % respectively; this result was significantly higher than the 67.6 % and 58.5 % control with the LU110-020 nozzle. The authors suggest that selecting a nozzle with a small particle size improves planthopper control. However, it should be noted that by maintaining application rate with an alteration of the forward speed of the UASS, the authors confounded the droplet size treatments with downwash interactions. The finer nozzle was applied with a forward speed of 3 m/s followed by 5 and 6 m/s for the two larger drop size distributions at an altitude of 1.5 m. The slower forward speed would have had a stronger downwash, thereby improving the deposition through the canopy. Further, with such fine nozzles, the 5 and 6 m/s forward speed would have incorporated a horizontal trajectory to the spray, potentially decreasing penetration and increasing loss. The confounding of these factors again emphasizes the importance of considering all the factors that will influence deposition to the targeted plant canopy that will therefore have the potential to impact the resulting application efficacy. Encouragingly, with rice canopies the efficacy studies showed that applications by UASS were considered by the authors to be effectual.

Wheat

Wheat is an annual bunch grass with upright tillers, sturdier than rice but still creating a canopy with mostly vertical thin leaves. Meng et al. (2018) compared the standard practice of backpack spraying to a UASS (single-rotor model 3WQF120-12) investigating the effect of dose reduction (imidacloprid at 90 g a.i./ha and 72 g a.i./ha) with two formulations with different adjuvants (organosilicon or methylated vegetable oil). The fate and efficacy studies compared low carrier volume (12.6 L/ha) formulation treatments to a high-volume backpack sprayer (260 L/ha). There were two study sites: a site in Xinxiang was used to characterize the spray distribution, pesticide fate and resultant efficacy of preventative aphid control, while a site in Anyang was used to investigate insecticidal efficacy on an infested crop. In Xinxiang, Kromekote cards at canopy top were used to gather data on drop density percent coverage. Canopy penetration at this site was measured on natural targets with plants divided into four parts (wheat head, upper flag leaf, middle and lower), and the analytical technique was colorimetry (levels of recovered Allure red dye). Canopy penetration studies (Xinxiang) showed that the reduced dose treatment without adjuvant deposited significantly less to the upper and middle canopy compared to all other treatments. In contrast, the reduced dose organosilicon treatment retained the highest drop density and coverage. Accordingly, the efficacy study showed that dose could be reduced with the 12.6 L/ha UASS application without the loss of effect with the organosilicon adjuvant (82 % control) compared to the standard backpack treatment using a volume of 270 L/ha (87 % control). Pesticide dissipation measured at 0.083 d (2 h), 1 d, 3 d, 7 d and 14 d showed no difference in initial residue nor half-life between UASS applications (high product/active ingredient concentration) and knapsack applications (low product/active ingredient concentration). The efficacy studies in Anyang were conducted on aphid infested crops. After 14 days, there was no difference in aphid control between the full dose and the reduced dose with organosilicon applied by UASS, and the backpack control (91, 90, and 92 % control, respectively); all these treatments were significantly higher ($P < 0.05$) than the reduced dose treatment without adjuvant and the reduced dose with the methylated vegetable oil (87 and 89 %, respectively).

Wang et al. (2019) compared a six-rotor UASS using a carrier volume of 10 L/ha (3WTXC8-5) to three standard application methods (boom sprayer at 300 L/ha, backpack at 300 L/ha and a mist blower at 75 L/ha), measuring both the spray distribution and biological efficiency against wheat aphids. Each application platform sprayed 70 % imidacloprid at 86 g a.i./ha along with Allure red dye for volumetric assessment using filter papers placed in the wheat canopy. The deposition numbers were converted from volume of liquid to mass of active ingredient (µg) showing that the deposition of active ingredient was comparable across all sprayers tested. The % CV for total deposition on the plant from the UASS was 87 %, which was higher than the boom sprayer of 32 % and higher than the 60 % maximum from the Chinese aviation authority (China 2016). The area of coverage from the UASS was significantly lower (2 % coverage) compared to the tractor boom, mist blower and backpack, which achieved 38, 17, and 21 % coverage, respectively. The UASS also had reduced canopy penetration compared to the higher volume applications, which led to the lowest losses to the ground; the UASS deposited 0.13 $µg/cm^2$ to the soil surface compared to the boom sprayer at 0.39 $µg/cm^2$. It is noted that the data on the loss to the ground could be useful from a regulatory standpoint, as canopy interception is a factor in the ecological/environmental exposure assessments in some OECD countries). The results show that control with the UASS on Day 1 was lower than other application methods (50.5 % less than the boom sprayer). On Day 7, control with the UASS was 70.9 % which the authors considered acceptable, especially when relative working efficiency of the application methods was considered. The working efficiency of the UASS was 4.1 ha/h, the boom sprayer 2.4 ha/h, the mist blower 1.6 ha/h, and the backpack 0.2 ha/hr.

Qin et al. (2018) compared the spray distribution from a single-rotor UASS (model N-3) at 5 and 3.5 m above the crop canopy with a velocity of 4 m/s and an application volume of 15 L/ha to a battery powered knapsack sprayer at 300 L/ha, 0.5 m above the crop. The UASS coverage at 3.5 m was 2.67 % in the upper and 0.91 % in the lower canopy; at 5 m it was 3.66 % in the upper and 1.67 % in the lower canopy, while coverage with the knapsack sprayer was 14.9 and 4.3 % in the upper and lower canopy, respectively. The results from the physical distribution led the study authors to choose the 5 m height over the 3.5 m height. The lower height should have had higher deposition and penetration numbers, but there was no replication nor flow rate check in this study; hence differences reported could easily be due to an application error. For the efficiency study, active ingredient application rates of 270, 360, and 450 g/ha sprayed by UASS were applied alongside 450 g/ha sprayed by a knapsack sprayer. Results were compared against a blank control. Seven days after the application, mildew control with the UASS was low (36, 47, 55 % of the control at 270, 360 and 450 g/ha respectively) but better than the knapsack sprayer: (35 % of the control) respectively, with the, 360 and 450 g/ha UASS applied being significantly ($P < 0.05$) higher than the knapsack treatment. Ten days after application, control with the UASS was lower than the knapsack powered sprayer: 68 % for the UASS at the highest dose and 73 % for the knapsack ($P < 0.05$). When considering the level of control with the UASS compared to the industry standard, the authors suggested the addition of an adjuvant to improve coverage and retention of the compound.

Orchards

Efficacy studies in dense almond tree canopies using two application rates compared a single-rotor UASS (chlorantraniliprole 111 g a.i./ha, plus Dyne-Amic surfactant 0.06% v/v) to a standard orchard airblast sprayer (Li et al. 2020). The large Yamaha RMAX model UASS was used with manual controls in this study; spray release height was maintained between 1.8 - 2.4 m with a flight speed of 1.3 m/s. The UASS applied a carrier volume 46.8 L/ha and 93.6 L/ha, the latter by flying over twice with the UASS, compared to an orchard airblast sprayer applying a carrier volume of 935.4 L/ha. The natural target (almonds) was sampled for pesticide residues alongside filter papers and water sensitive papers to characterize the spray distribution in the canopy. The percentage of coverage was greater with the high volume of the airblast sprayer at 12 % compared to the 93.5 L/ha (4 %) and the 46.8 L/ha application rates (2 %). The results of this study showed comparable overall pesticide residue levels on whole, un-hulled almonds. There were distinct differences in residue patterns at different canopy elevations between the aerial and ground application methods, with the UASS depositing more to the upper canopy and the airblast sprayer to the lower canopy. No difference in control was seen between treatments mainly because damage was low; this meant it was not possible to statistically separate treatments. There were additional studies in orchards that showed lower coverage but retention of the same rate of active ingredient compared to an industry standard. (Tang et al. 2018; Liu et al. 2020).

Sugar cane

Deposition experiments conducted by Zhang, Song, et al. (2020) investigated the effect of spray volume, flight height and flight velocity, with a four-rotor UASS in a 3.2 m sugarcane canopy. There were 9 treatment groups combining 3 factors. Three volumes (9, 12 and 15 L/ha) were each applied from a height of 2, 3, and 4 m. Each volume was also investigated at one of three speeds (4, 5, and 6 m/s). i.e. although each height was tested with each speed, this was with different volumes. The droplet deposition densities on the crop were highest under the highest volume, the slowest speed, and the medium fight height (15 L/ha, 3 m, 4 m/s). This arrangement deposited 55, 32, and 26 droplets/cm^2 in the upper, mid, and lower layers, respectively. From a range analysis of the data, the order of the factors affecting deposition density were spray volume, flight height, and flight velocity. However, since the flow rate was not adjusted for forward speed, velocity should have been dominant over height. Note that the orthogonal design of the analysis of this study had velocity as the weakest parameter to impact deposition. The lowest droplet deposition densities (18, 9, and 7 droplets/cm^2) resulted from the lower spray volume (9 L/ha) and the highest flight height (4 m), and the highest velocity (6 m/s) where the three parameters were aligned. Fewer treatments and full factorial designs should be used over orthogonal designs, especially when the importance of a critical factor like flow rate is not understood nor accounted for in the experimental design. The optimal combination of the upper layer of sugarcane canopy was with 15 L/ha spray volume, 3 m flight height and 4 m/s flight velocity. The optimal combination of the mid- and lower layers was set with 15 L/ha spray volume, 2 m flight height and 4 m/s flight velocity, showing that a lower flight height improved canopy penetration. This is important in crops with a large, dense canopy such as that in sugar cane.

Cotton

Hu et al. (2020) compared a four-rotor UASS (model 3WQFTX-10), to a manual knapsack sprayer (MATABI Super Green16), for the control of cotton aphids in the seedling stage of the crop. Kromekote cards were attached to the upper side and underside of leaves to measure droplet deposition. Different treatments investigated 1, 1.5, and 2 m flight heights above the seedlings at velocities of 3, 4, and 5 m/s. The PPP used was imidacloprid SC 600 g/L (45 g a.i./ha) mixed with 4.5 % beta-cypermethrin EC (27 g a.i./ha) and Allure red tracer dye (150 g/ha). The results showed that the droplets deposited on the underside were smaller than those on the upper side of leaves. This is not specific to UASS application as it is an accepted norm that smaller droplets become entrained in air and disperse more widely through the canopy, whereas larger droplets are typically deposited on the first surface they intercept. Under the same flight height, the coverage at 3 and 4 m/s was higher than that at 5 m/s, indicating to the author that higher UASS velocity tends to result in poor droplet deposition (note again velocity was confounded with flow rate/application rate). The deposition uniformity was lowest at the 3 m/s velocity and heights of 2 and 1 m. The slower velocity and lower height should have had the lower uniformity, but the 1.5 m height had a lower uniformity than the 2 m height. The authors, therefore, used the 4 m/s velocity and 1.5 m flight height for the efficacy studies which returned acceptable control (by the authors' standards) of 57.9 % to 80.5 % on the seventh day after application. Lou et al. (2018) also investigated droplet deposition from a four-rotor UASS in cotton comparing two application heights (1.5 and 2 m) in the distribution assessment. At the flight height of 1.5 m, the average percent cover was 2.5, 3.2, and 1.9 % for the upper, middle, and lower layers of the cotton canopy, respectively, whereas, at 2 m, the average percent cover was 4.9, 5.5, and 5.0 %, respectively. The drift component was also significantly ($P < 0.05$) higher; the average drift percentage (7.9 %) at 1.5 m was much lower than that at 2 m (20 %). The spray volumes recovered for the 1.5 m application was low for both deposition and drift, but with no replication it can only be assumed this was caused by an application error. The study compared application by UASS with a boom sprayer, for the biological assessment of control of aphids and spider mites. Five days after treatment, the level of control observed was 90 % (boom sprayer) and 64 % (UASS) for aphids, and 68 % (boom sprayer) and 61.3% (UASS) for spider mites.

The previous studies were conducted in early season cotton plants; in contrast, mature cotton canopies can be dense and overlapping, making spray deposition into such canopies a challenge. Liao et al. (2019) investigated the use of three battery powered UASS (YR-GSF06 with four rotors, TXA with six rotors, and YR-AU 15 with eight rotors) alongside a tractor boom sprayer to apply defoliants to allow boll harvest. The application rate was changed with pressure of 200, 300, and 400 kPa and corresponded to respective application volume rates of 48, 72, and 96 L/ha. Carrier volume was the main treatment parameter returning roughly 2, 5, and 10 % coverage, respectively. As it was not a fully factorial design, the effect of speed and altitude was mixed and lost to evaluation. Although there were clear differences in terms of percent coverage with changes in carrier volume, there was no difference in the defoliation or boll opening between any of the treatments. All UASS applications achieved high levels of defoliation, more than the tractor boom sprayer. It is not clear why, but the authors concluded on an optimal scenario for the three UASS as a volume rate of 48 L/ha, tank mix and adjuvant combination (Tuotulong 225 + Sujie 750 + Ethephon 2250) mL/ha, flight altitude of 1.5 m, and flight speeds at the highest tested of 3 m/s.

Xiao et al. (2019) studied the effect of a two-spray strategy for defoliation of a dense cotton canopy with a P30 four-rotor UASS. The first application removed the upper canopy, allowing the second application to defoliate the lower canopy. The flight height above the crop was 2 m and the effective spraying width was 3.5 m, applying 15 L/ha. There were six treatments of alkyl ethyl sulfonate[2]: 0, 4.2, 8.4, 84, 168, and 252 g a.i./ha. When alkyl ethyl sulfonate was added at 4, 8, 84, and 168 g a.i./ha, the average droplet density on WSP was 21 drops/cm^2 and the percent coverage ranged from 3 - 9 %. The control and the full dose of alkyl ethyl sulfonate (252 g a.i./ha) had an average droplet density of 11 drops/cm^2 and 15 drops/cm^2, respectively, and a percent coverage of < 3 %. It is not known why the full dose had lower deposition rates than the lower doses; with no replication in this experiment, this result could have been due to an application error. When the authors investigated the contact angle of droplets, the full dose adjuvant treatment had lower wettability compared to the low doses.

To improve the effect of defoliation and reduce the damage caused by boom sprayers, Xin et al. (2018) investigated the effect of defoliant dosage and carrier volume on defoliation. A six-rotor battery operated (JT-30) UASS was used in a dual spray application regime. During the first application, the spray carrier volume was 22.5 L/ha and carried thidiazuron with ethephon at three treatment levels: 150/300, 300/600; and 450/900 g/ha, respectively. These treatments resulted in defoliation rates of 45, 52, and 61 % respectively. The second application of thidiazuron + diuron (180 g/ha) and ethephon (900 g/ha) defoliated all treatments by > 90 %. In a second set of experiments, the effect of volume was investigated at 9.3, 17.6, 24.2, and 29 L/ha with a single rotor (3WQF120 12) gasoline powered UASS with the same treatment dose 180 g/ha thidiazuron + diuron with ethephon (1st application 450 g/ha and 2nd application 1050 g/ha). Although there was no difference between treatments, the authors concluded that application volumes should be between 17.6 and 29 L/ha. The results indicate that UASS could be used for cotton defoliant spraying with a strategy of two spray applications. The low volumes may not have had an impact with the defoliant applications because the compounds used were systemic; this is something to consider with ULV applications in that the dose applied to the target is the same and systemic compounds can subsequently redistribute themselves irrespective of application volume.

Spray drift

Spray drift refers to pesticide that is deposited off-target. This can be of importance to environmental exposure, ecotoxicological effects to non-target species or adjacent crops and to bystander/residential exposure. This can be measured either as airborne drift to predict bystander exposure, or as sedimenting deposits on the ground at distances downwind of the treated area to determine levels of environmental exposure. Predicted measurements of drift for different methods of application and crop types are used in regulatory risk assessments. A key question in the application of pesticides by UASS is how the amount and distance drift travels compare to existing methods of application, and whether this is bounded by predictions from the exposure models currently utilized in regulatory risk assessments. Another question is whether there are any unique risks related to drift with UASS.

Spray drift sampling

Drift can be collected as either flux or deposition downwind (Balsari, Marucco, and Oggero 2002; Behmer et al. 2010). Sampling of flux is more complicated than sampling ground deposition due to the differences in collection efficiency with the sampling device, atmospheric conditions, and droplet size distribution. Comparative assessments of drift collectors have shown that there are significant differences between sampler types (Bui et al. 1998; Donkersley and Nuyttens 2011); 2 mm lines are considered optimal due to their small, well defined surface area (Herbst and Molnar 2002). When

[2] in all tests, 360 g/L thidiazuron·180 g/L diuron suspension concentrate at 121.5 g a.i./ha (Bayer Crop Science) and 40% ethephon at 480 g a.i./ha (September 22, 2018 was 600 g a.i. /ha).

surface area cannot be defined, data can only be given as volume recovered. Therefore, the preferred unit ‘percentage of the total application’ cannot be calculated (Di Prinzio et al. 2010). Van de Zande et al. (2004), the developer of the Dutch collection of empirical off-site movement studies, used flux measurements taken with spherical pads. The collection efficiency is not known for these samplers, so they can only be used for within treatment group comparisons.

For future studies with UASS application, with the benefit of hindsight, the use of a single collector type and a single test protocol would be important to allow data pooling and comparison. The recommended sampler standard would be string collectors, monofilament (fishing lines) with a set distance and elevation for each study. If other sampling devices are used, the ISO standard 22866-2005 advises that 2 mm strings should be included in the study as well to enable comparisons. The 2 mm strings have a known collection efficiency that is relatively high for fine droplets which is the part of the spray distribution that is more prone to off-site movement (May and Clifford 1967). Using 2 mm strings allows for a defined surface area, meaning that data can be presented as $\mu g/cm^2$ and can then be normalized to percentage applied (Donkersley and Nuyttens 2011; Gaskin et al. 2008; Salyani and Cromwell 1992). In addition, when droplet size distribution and wind speed are known, monofilament line can be corrected for collection efficiency (May and Clifford 1967).

Active samplers are often employed in drift studies but these are complex with high collection efficiencies and sampling rates meaning it is harder to determine what the volume collected truly means. Rotating impactors are considered relatively effective as an active collection method due to their increased sampling rate and collection efficiency (Fritz et al. 2011; Wolf and Caldwell 2001). Air samplers are popular but can be problematic when the inlet airflow is not isokinetic with the ambient windspeed. Miller (2003) suggested that air samplers should not be used when wind speeds are less than 2 m/s due to their low collection efficiency in these conditions.

Active samplers could work alongside strings to provide additional high-resolution data on volume and, with the rotating impactors, droplet size distribution. Gil et al. (2013) stated that drift cannot be accurately extrapolated from point-source measurements; instead, there is justification for using Light Detection and Ranging (LIDAR) to observe and quantify spray dispersion. However, such devices are cost prohibitive and remain a measurement of potential drift with questionable quantitative accuracy.

Current risk assessments focus on off-target or off-site deposition to ground and water, so horizontal collection devices are considered the simplest and most important measurement systems from a regulatory standpoint. Horizontal ground samplers are easily compared, as they are basic sedimentation collection devices. Yates, Akesson, and Cowden (1974) used Mylar horizontal deposition samplers for drift assessment and found a nearly straight-line correlation with deposits measured on alfalfa. While most of the publications in the available literature used horizontal samplers, only one researcher followed the ISO (ISO 22866) suggested sampling surface of 1000 cm^2 (Brown 2018). The ISO recommendation is based on the fact that larger samples more closely approximate the population of spray droplets. However, with ULV applications that deposit smaller volumes, the amount of rinsate from such a sampler should be low, ensuring detectable concentrations. This would make it difficult to work with such a large sampler in these low volume applications. The shape and size of the samplers do not affect the quantity of deposit per unit area when the target is not elevated (Goering et al. 1977). The style and fabric texture has been shown to make a difference. Within the SETAC-DRAW (2018), evaluation of European drift study methodologies showed that there was a significant difference between sampler material; creped filter paper, petri dish, filter paper or techno filter strip samplers. With that in mind, an agreement on sampler type for future UASS off-site studies would be useful. In short, the more standardized the methodologies are, the more the results from different researchers can be directly compared and utilized to inform the regulatory approach. In this section of report, sedimenting drift is considered, with airborne drift discussed under the bystander exposure section.

Spray drift studies

The spray drift aspect of this literature review had the greatest number of studies that were considered both relevant and reliable. The primary reason for this was that there is a precedent for trial conduct in the form of an ISO standard on measuring drift of plant protection products with detailed specifications for ground sprayers (ISO 22866). The data currently available can provide some information on the overall position of UASS compared to other application types, but also highlights the need for a standard test protocol.

Several studies have provided the data as a 'percentage of applied' which is useful for normalizing between applications with different application rates. However, some studies made this calculation from a measure of what was deposited in canopy, which is a highly variable measure, especially where low to no treatment replication was employed. Brown (2018) highlighted this variability with three in-swath deposition samples analyzed returning 23, 54, and 81 % of applied. The scientifically rigorous method of doing this can only be from measuring what was sprayed out of the tank at the end of each treatment run with a precise measure of the area treated (Brown 2018; Herbst et al. 2020).

Drift distances

ISO 22866 (2005) suggests that samplers collect drift down to a representative distance where 90 % of the spray has been collected. For UASS it is not currently known what that range would be although preliminary data has shown that this could be within the range estimated for manned aerial application. Further, regulators would prefer to see near analytical limit of detection numbers as opposed to the ISO recommended 90%, although such measurements normally occur after the deposition curve is in an asymptotic phase. Data from this review could help define the required resolution for UASS studies, it is an important factor to consider in terms of appropriately focusing experimental resources.

The longest downwind distance included in a study covered by this review was in a trial conducted by Xue et al. (2014) with a Z3 UASS. Mylar cards were placed on the ground at distances of 2, 4, 6, 8, 10, 20, 50, and 100 m downwind with monofilament lines at 2 and 50 m. The flight height was at 5 m above the crop (0.7 m tall) at a speed of 3 m/s. This flight height would be considered relatively high and although the sampling methodology followed the ISO standard there was no replication in this study. Deposition drift accounted for 12.9 % of the total spray volume, while 90 % of the drift was concentrated within the first 8 m downwind of the sprayed area. For the monofilament lines placed at 2 m, the lowest lines collected the highest volumes of the descending spray cloud; the 0.5 m height was 14.6 %, and at 4 m height was 4.8 %. At 50 m monofilament distance, the detected amount was almost zero.

Wang, Han, et al. (2020) compared the drift potential of three different droplet size distributions (Dv0.5) of 100, 150, and 200 µm with centrifugal nozzles repeated over a range of meteorological conditions; on a four-rotor (P20) UASS with a 4 m flight height and a 5 m/s flight speed. Field tests found that the deposition at 12 m downwind decreased by an order of magnitude compared with the average deposition within the in-swath zone. At 12 m downwind, deposition was 0.02 µg/cm^2 which was calculated as 0.034 % of the applied rate measured in the canopy. Samplers extended to 50 m downwind where deposition amounts were lower than the detection limits of 0.0002 µL/cm^2. Based on the results from this study, the drift distance of this specific UASS model and nozzle setup is described as less than that of manned aerial applications. As expected, the detected drift amount increased with increasing wind speed and decreasing Dv0.5. However, all droplet sizes were relatively small (100 - 200 µm) so drift was primarily a function of wind speed.

In another study conducted in vineyards with a single-rotor RMAX, the deposition averaged 0.4 % of the application rate at 7.5 m downwind and 0.03 % at 48 m downwind (Brown 2018). One of the more robust studies investigated the influence of flight height and windspeed with a single-rotor UASS (3WQF120-12) with a medium droplet size distribution and a forward speed of 3 m/s, operated at 1.5, 2.5, and 3.5 m flight heights over a range of atmospheric conditions. At a flight height of 1.5 m, 90 % of the spray deposited within 6.9 m with wind speeds of 0.7 m/s and 3.91 m with wind speeds of 2.2 m/s. At 2.5 m flight height, 90 % of the spray deposited within 10 m at a wind speed of 4.7 m/s, and 3.7 m at a wind speed of 1.8 m/s. At 3.5 m flight height, 90 % of the spray was contained within 46.5 m with a wind speed of 3.7 m/s and 33.5 m with a wind speed of 1.7 m. Overall, these numbers follow accepted norms, albeit with anomalies expected when there is no replication in a study (Wang, Lan, et al. 2018).

Two studies (Anken and Dubois 2020 and Herbst et al. 2020) made comparisons with standard drift curves (Rautmann, Streloke, and Winkler 2001). Anken and Dubois (2020) measured sediment drift from an Agrofly and a DJI Agras UASS operating at a height of 3 - 3.5 m with a mixture of nozzles delivering a fine and a coarse particle distribution. Petri dishes (8.8 cm, 20 dishes spaced 50 cm apart) were used to sample sediment drift at distances of 0, 1, 3, 6, 10, 15, 20, 30, and 50 m. The resulting drift was compared to standard drift curves for orchard air blast sprayers (Rautmann, Streloke, and Winkler 2001). The UASS was found to have lower drift for both nozzle types (e.g., both coarse and fine particle distributions). For crops treated with a tractor boom sprayer, the comparative drift was more for the UASS with fine nozzles. The authors, therefore, recommended a buffer zone of 20 m for ground application. However, without a Regulatory Acceptable Level being identified for each risk area, a single buffer zone may not be appropriate to mitigate all potential risks, where low drift nozzles are employed on the UASS, the buffer zones may be reduced.

In the second study, Herbst et al. (2020) initially investigated four different UASS, all operating at a speed of 2 m/s with a coarse and fine droplet size distribution at a height of 1.5 m as a bare ground arable model (ground boom) and then at 3.5 m above the ground with a 2 m artificial canopy as a vineyard model (vertical sprayer). Drift samplers were petri dishes positioned at 3, 5, 10, 15, and 20 m downwind and at each downwind distance there were 10 samplers placed perpendicular to the wind direction. For the arable model system at 1.5 m height, drift from the coarse nozzle was equal to the standard drift curve whilst the fine nozzle produced higher drift than the standard drift model would have estimated (Rautmann, Streloke, and Winkler 2001; Van de Zande et al. 2015). For the vineyard model system at 3.5 m height, drift from the coarse nozzle was lower than the standard drift curve, and from the fine nozzle was comparable to the standard curve for vineyard, which is in agreement with the results of Anken and Dubuis (2020). In the vineyard system, the deposition at 20 m was on average 0.3 % of applied across all treatments and replicates (Herbst et al. 2020; Wang, Herbst, et al. 2020). Initially, the authors had concluded that, in the arable system, the UASS style had little impact. However, the DJI model with the nozzles positioned under the rotor, as opposed to within the rotor diameter, did show a small increase in potential drift with the monofilament lines at 2 m in the low height arable system. This was followed by a marked increase in drift with the DJI model and the fine nozzle in vineyard system at the higher altitude (3.5 m). Another study looking at three single-rotor aircraft showed a similar increase in drift when the nozzles were close to the rotor diameter. In this study, the three UASS were operated at 1.5 - 2 m height at 4 - 5 m/s. All sprayers were operating with fine spray nozzles; the primary difference between the sprayers in this work was the length of the boom. The boom length was described as a % of the rotor diameter for the 3WQF120-12, 3CD-15, and the HY-B-15L; the % of the rotor diameter was 98, 58, and 56 %, respectively. The drift, described as a percentage leaving the target zone, was 24, 9.4, and 2.4 % of the total spray volume for the 3WQF120-12, HY-B-15L and 3CD-15, respectively (Wang, He, Song, et al. 2018). This requires further investigation, but it is possible that off-target losses will decrease if the spray is released within 75% of the rotor diameter as with manned rotary aircraft.

These studies offer a glimpse into the relative drift volumes and distances following spray application with UASS and an agreed system of sampler distance would be highly beneficial for cross comparison between studies. It would appear that, for UASS, sampling beyond 50 m would not be a useful expenditure of resources and that the high-resolution sampling should be within the first 20 m downwind, continuing to a final distance of at least 40 m. Two studies had a large number of samples at each distance (e.g., 20 petri dishes (Anken and Dubuis 2020) and 10 petri dishes (Herbst et al. 2020), while all other studies worked with two or three samplers per distance. Overall, the primary issue with the current published information is a lack of replication and appropriate calibration; increased sample number should also be encouraged. In terms of design and reporting, the issues also to be considered are definition of the edge of field. For example, half a swath from the downwind flight line could be considered as 'edge of field' in future studies. The flight height has a significant impact on drift and needs to be clearly defined as above the ground or above the crop, with the crop height at the time of application also provided, along with the likelihood that the altitude is maintained (e.g., manual versus RTK GPS or other autonomous UASS). Such a collection of studies could provide basic information to quantify UASS spray drift potential to support off-site exposure estimation in a risk assessment, and the raw data from such studies can be accumulated to derive a statistically supported interim drift prediction curve, until a better model is available.

Bystander and operator exposure

Bystander exposure

The data of relevance here to assess bystander exposure is a measurement of airborne spray drift downwind of the target area. For bystander exposure, the regulatory need is to understand if and how the pattern of spray drift from UASS differs from conventional application methods. Within the following section most concentrations in air were collected from monofilament lines erected on frames at different heights from the ground and different distances from the treated area.

There are a number of studies where monofilament lines have been placed at 2 m from the edge of field. These studies should be considered as a measure of potential drift and therefore considered for potential information on bystander exposure. Drift studies are designed to incorporate a crosswind that shifts the spray plume downwind, so the 2 m potential drift samplers are often in-swath or edge of field; providing a valuable initial loss profile (potential drift). As with all other pesticide application methods, the height and volume of that plume exiting the targeted spray area, its droplet size distribution, and the meteorological conditions will dictate how far it goes. Wang, Herbst, et al. (2020) conducted a potential drift study that considered airborne drift with two droplet size distributions, collected on monofilament line samplers at 2 m from the edge of field. There were three UASS under investigation: a single-rotor (3WQF120-12), a six-rotor (3WM6E-10), and an eight-rotor (3WM8A-20) aircraft each with a nozzle delivering fine spray particles (TR 80 067) and a nozzle with coarse spray (IDK 120 015) flown at 2 m/s and 3.5 m height above the crop (a vineyard). At the lowest height on the monofilament lines (0.5 m), the highest airborne deposition was obtained with the fine spray in the order of eight-rotor (142 % of applied), followed by the single-rotor (121 %), and the six-rotor (84 %). The coarse spray produced significantly less drift, the percentage leaving the target zone was 14 % with, the single-rotor, 13 % with the eight-rotor, and 6 % with the six-rotor UASS. Herbst et al. (2020) conducted a different analysis of the same data set where they integrated the downwind sedimenting drift and the potential drift on monofilament lines at edge of field. In general, the airborne spray drift in vineyard applications were higher than in the arable crop scenario; this difference was due to release height (3.5 m versus 1.5 m, respectively). The hollow cone nozzles (fine particles) versus the air induction nozzles (coarse particles) released significantly more spray from the target area. Where the drift was compared to standard curves for a boom sprayer, the UASS drift curves were higher with the fine and comparable with the coarse spray distribution.

In a separate study, Wang, Han, et al. (2020) utilized monofilament lines at 2 m and 12 m from edge of field every 1 m up to a 5 m height. Using a centrifugal nozzle, the authors adjusted rotational speed to provide 100, 150, and 200 µm median droplet size distributions. The quad copter (P20, XAG) operated at a relatively high altitude of 4 m and a forward speed of 5 m/s. The airborne drift on the monofilament lines for each treatment generally increased as the line sampling height decreased. This is due to the descent of the spray through the air column as the plume proceeds downwind. At the 2 m distance the 100 µm droplet size at wind speeds above 3 m/s, the deposits were between 40 and 60 % of applied; with winds below 3 m/s deposits of 20 % of applied were detected. As droplet size increased (150 and 200 µm) and wind decreased so too did deposition on the lines. All deposition at 12 m were less than 20 % of applied at the 1 m sampler height with the 100 µm droplet size and less than 10 % with the 150 and 200 µm droplet size distributions.

Wang, Lan, et al. (2018) conducted a drift study in a pineapple crop using a single-rotor (3WQF120-12) UASS operated at a fixed velocity of 3 m/s at 1.5, 2.5, and 3.5 m heights above the canopy with a medium droplet size distribution of 268 µm repeated over a range of wind speeds. Monofilament lines were positioned at 10, 25, and 50 m from the edge of field, with lines at the heights of 5, 2, and 1 m. At the low operating height (1.5 m) and under low wind speeds (0.5-2.2 m/s), deposition measured on monofilament lines was close to zero. At the medium flight height (2.5 m), measurable deposition (0.01 µg/cm^2) was observed at 10 m from edge of field at the higher wind speed. At the 3.5 m UASS operating height, the wind speed varied 1.0 - 5.1 m/s, and deposition was low but measurable at all distances (0.005 - 0.03 µg cm^2).

As stated previously, Anken and Dubuis (2020) worked with two UASS models (AgroFly and DJI Agras) in their assessment of drift potential. Two sets of monofilament lines were positioned at 10 m from the edge of field with lines separated every 1 m up to 6 m. There was also a specific bystander exposure measure: Tyvek® material was stretched over a frame measuring 190 x 92 cm (surface 1.75 m^2) to mimic a person. Three frames were positioned at 5 m and three at 10 m from the edge of field. These panels were then separated into two parts at a height of 1 m, the bottom part representing the exposure of a child and the entire panel (bottom + top) representing an adult[3].

The studies that used monofilament samplers are helpful in providing numbers on potential bystander exposure. However, when the data are converted into a percent of applied, the numbers will be artificially high because the numbers are not corrected for sampling rate. For example, with the edge of field sampling sites the monofilaments were collecting more than 100 % of applied in many instances. The correction for sampling rate is complex; as such, the numbers reported in these studies should be used as a comparative measure between treatments within a particular study as opposed to between studies.

Additional information from data generated using rotary impactors (3 mm acrylic rods rotated at 5.6 m/s) as active samplers of spray drift could also inform bystander exposure. For example, Wang, He, Song, et al. (2018) placed rotary impactors at 5, 10, and 20 m away from the target zone, on towers at 1, 2, 3, and 4 m above ground. The author reported that the overall averaged airborne spray drift percentage of the three UASS models under investigation was 25.0 % (HY-B-15L), 4.2 % (3CD-15) and 2.5% (3WQF120-12). (Wang, Han, et al. 2020) also discuss rotating impinger samplers following a similar trend to the sedimenting drift results but with even higher numbers. Due to the high sampling rate and collection efficiency of active samplers, comparison to passive samplers is difficult (e.g., monofilament line). The extrapolation of information should be limited to comparisons between the

[3] This research is unpublished, the data will be incorporated when permission is granted.

same sampler type within the same experiment, it would not be valid to compare data collected by these different types.

Operator exposure

To better understand the risks to operators or workers from being exposed to pesticides through UASS spraying, information is needed on the potential for exposure to residues on equipment and from tasks such as mixing, loading, maintaining, cleaning, and transport. The potential for increased risk of sensitization or irritation due to using high in-use concentrations is another area to consider. Residues on the UASS could be incurred during application since the turbulent flow from UASS is complex, especially with multi rotor aircraft. Many qualitative observations and numerical simulations show the spray to have an upward component that could lead to residues of the active ingredient accumulating on the aircraft (Zheng et al. 2018). There is also potential that the aircraft will fly back through spray that has yet to settle out.

Following a spray characterization study in an apple orchard, Liu et al. (2020) measured the active ingredient residues present on surfaces of both the UASS and airblast sprayers used in this study. The filter paper locations for active ingredient selection were on the fan or battery, front of tank and back of tank, and on the tractor or airfoil. The average residue on the UASS was 13.84 $\mu g/cm^2$ compared to 0.58 $\mu g/cm^2$ on the airblast sprayer, potentially reflecting the higher concentration of the pesticide solution in the UASS. The airblast sprayer operated at 1058 L/ha whilst the UASS operated at 60 L/ha. A different observation was made by Li and Giles et al. (2020). They conducted a similar experiment where filter papers were attached to each side of the boom holder, on each of 2 of the UASS arms and one on the UASS top cover. Recovery numbers showed that < 6 µg were recovered per filter paper. The paper size was not reported; assuming a small 6 cm diameter filter paper that would put the maximum deposition as 0.2 ug/cm^2, supporting their conclusion that the unmanned aerial applications can be a relatively clean operation. However, the spray boom and drone arms were the parts with highest residues and since the drone arms are used for lifting the aircraft by the ground crew, wearing proper personal protection equipment (PPE), as required for applicators on product labels, is important.

Pesticide concentration

In general, applications with UASS require that the carrier volume be lower than corresponding ground application meaning that concentration of the pesticide is significantly higher than in conventional ground applications. This higher concentration of active ingredient in UASS application as compared to ground applications can be demonstrated by the following publications that focused on efficacy comparisons.

In a study conducted by Wang, Li, et al. (2020), two very low volume rates of 9 and 18 L/ha were compared to a knapsack sprayer applying medium volume rates of 450 L/ha. The chemicals applied were pyraclostrobin for rice blast and chlorantraniliprole for rice leaf roller control. The concentration differences for the fungicide and insecticide for the UASS at the 9 L/ha application rate would be 80 mL/L and 8.9 g/L of each product, respectively; for the UASS at the 18 L/ha application rate 40 mL/L and 4.4 g/L of each product, respectively; and with the knapsack at the 450 L/ha application rate 1.6 mL/L and 0.18 g/L of each product respectively.

Qin et al. (2018) applied fungicides with a UASS at a very low volume rate of 15 L/ha and a knapsack sprayer at a medium volume rate of 300 L/ha. The treatments were 270, 360, and 450 g/ha sprayed by the UASS and 450 g/ha sprayed by knapsack sprayer. Active ingredient concentrations in the UASS were 18, 24, and 30 g/L, versus the knapsack concentration of 1.5 g/L. Meng et al. (2018) operated a

UASS at a very low volume rate of 12.6 L/ha alongside a medium volume backpack sprayer (270 L/ha). The rates of imidacloprid were 90 g a.i./ha and reduced dose of 72 g a.i./ha was also applied for the UASS, therefore, the active ingredient concentration for the UASS was 7.1 and 5.7 g a.i./L, compared with the knapsack at 0.3 g a.i./L.

The UASS volumes used in orchards, although markedly less than conventional ground applications, were higher than the volumes used in row crop studies. They are, however, still considered very low and ultra-low volumes for bush and tree crops (Table 2). One study in almonds compared two application rates with a UASS using 46.8 L/ha with an orchard airblast sprayer applying 935 L/ha; the compound being applied was chlorantraniliprole WDG at 111 g a.i./hectare, plus Dyne-Amic non-ionic organosilicone-based surfactant (0.06 % v/v). The relative concentrations would have been 1.18 g/L for the UASS applications and 0.001 g/L for the airblast applications (Li et al. 2020). Clearly the concentrations are higher for low volume UASS applications. The question from a regulatory standpoint would be 'is the large physical distance from the vehicle in operation enough to effectively mitigate operator exposure to higher concentration sprays?'.

Modeling

There is a need for a mechanistic model for UASS due to the large number of different configurations and operating practices, making empirical models cost prohibitive. However, there does not appear to be a model currently available that could be used for regulatory purposes. The current regulatory model used in some OECD countries for manned aerial applications (AGDISP) includes a simplified helicopter wake model that transitions from downwash under a single set of rotor blades to fully rolled-up tip vortices. This model partitions vehicle weight between hover downwash and rotor tip vortices as a function of time. Unfortunately, AGDISP is restrictive in two ways:

1. It can only be applied to aircraft with a single main rotor; and

2. The aircraft flying height and speed must be sufficiently high that the downwash model rolls up into a pair of vortices before they impact the ground.

These restrictions prevent the existing helicopter model from simulating the behavior of UASS wakes because UASS often have multiple rotors, fly much closer to the ground and at much lower speeds than manned helicopters. However, steps have been taken toward the development of an extension to AGDISP. The Comprehensive Hierarchical Aeromechanics Rotorcraft Model (CHARM) models the physics of the major wake interactional aerodynamics from multiple rotors. The two codes have been coupled together by the replacement of a single subroutine in AGDISP, which computes the velocity flow field, with the calculations in CHARM (Teske, Wachspress, and Thistle 2018).

Overall, the conclusions from the team that developed CHARM were that the lower the release height, aircraft speed and ambient wind, the more uniform, precise, and efficient the spraying process will be.

At low flight speeds, the strong downwash beneath the UASS rotors pushes the spray quickly toward the ground and may potentially provide better distribution over individual plants, as opposed to merely coating their upper surfaces. However, as flight speed increases, a critical speed is reached at which the downwash transitions to outwash (e.g., moving spray particles away from the intended target) well before the released droplets reach the ground. As the vortices form, the CHARM+AGDISP solution broadens the vortical field behind the UASS as it expands upward (because the ground prevents expansion downward). If spray material becomes trapped within this developing wake, it could travel to unanticipated distances away from the target. At speeds higher than the critical speed, if there is a crosswind, the spray drift may become considerable. What is important to note here is the authors of

CHARM have both a background in aerodynamics and pesticide application meaning that their hierarchical structuring is likely correct. However, an independent validation with relevant field data of the CHARM model is required. A further complicating factor in the use of CHARM for regulatory purposes is that this model is proprietary; any exposure model utilized in the regulatory process needs to be available for public use and verification.

Modeling publications attempting to mathematically describe spray delivery from UASS can look highly sophisticated, but where a model has been verified only against a single data set it cannot be used as an effective predictor for exposure without further validation. Instead, a large dataset not relied upon in the model development is needed to independently validate a single exposure model. Only when a model works over a range of data can it be considered validated, as opposed to tuned to one dataset. Another problem with modeling is that the modeler may not understand the first principal physics driving the process. Within the numerical simulation programs currently available (e.g., much like statistical curve fitting), one can pick and choose turbulence models from a drag down list until it looks reliable and the equations are solved. As a result of the issues mentioned above, the currently available models to predict off-site movement for UASS are not fit for regulatory use.

Hover downwash models

Hover downwash models are of interest as a mathematical exercise to identify appropriate mesh scales (e.g., particle size population and distribution) and turbulence models for future work to further elucidate factors involved in effective UASS spraying. The majority of hover downwash models currently include the rotors alone, the premise being that the rotors are the driving force and therefore all that is needed. These models could be of use for examining the location of the nozzle and boom in relation to the rotors. However, the whole aircraft needs to be modeled, a forward component and the spray needs to be incorporated for realistic estimation of application effects. The effect of a crop canopy should also be considered because in most situations there would be a porous filtration medium between the aircraft and the ground not unyielding bare ground.

Many of the hover downwash models show significant streamlines projecting up from the center of the rotor array implying that a portion of the spray moves up. Zheng et al. (2018) provided a rotor simulation which showed a substantial number of streamlines emanating from the top of the array. One field study developed a large frame for the UASS to fly through to fully characterize the spray distribution around UASS in flight. This study showed that only under very specific in-ground effect applications did the spray disperse upwards, otherwise the apparently assumed upward movement of the spray from a UASS is not observed (Wang, He, Wang, et al. 2018). It is proposed that if the fuselage of the UASS was incorporated into the simulation, the upward motion of this airflow would have been suppressed.

The literature shows that in general the simulated hover downwash speed is higher than the measured speed. This is likely because the simulations do not have the fuselage or boom of the sprayer disrupting air flow. Yang et al. (2017) conducted a numerical simulation of the rotors in hover downwash, and the authors also provided a measured verification of hover downwash speed at different distances from the rotor. The two distances sit in line with other measures, explaining the potential reason for different hover downwash speeds. The distance that the measures were taken from the rotor was the predominant factor in downwash speed. At a 1 m distance from the rotor, the hover downwash is roughly 8 m/s and at the 2 m distance the hover downwash was 4 m/s, which covers the range of numbers collected across studies (Table 3).

Table 3 Hover downwash numbers

Author	Measure	Height m	Downwash speed m/s
(Wen, Han, et al. 2019)	-	-	>5
(Wu et al. 2019)	Rotor simulation	-	6
(Yang et al. 2017) AGRAS MG-1	Simulation	-	9.6
(Yang et al. 2017) AGRAS MG-1	Measured	-	8.2
Teske et al. 2018: Rhino DP 12	Simulation	-	8.6
Teske et al. 2018: ICON	Simulation	-	5.6
Guo et al	Simulation	-	8.96
Zhang et al. (2020)	Simulation	1.5, 2.0, 2.5, 3.0, 3.5	9.5, 8.7, 6.3, 5.7, 4.4
(Yang et al. 2017)	Measured	1	8
(Yang, Xue et al. 2017)	Simulated	1	8.83
(Yang, Xue et al. 2017)	Measured	2	4.5
(Yang, Xue et al. 2017)	Simulated	2	4.95

Most importantly, getting caught up in the simulation without understanding the practical operation of the UASS can lead to erroneous outcomes. For example, Yang et al. (2017) suggests a working height of 0.6 m from the rotor to the crop. It is unclear why this number was chosen, as this height is impractical, with the addition of the tank and landing gear the UASS would be a < 20 cm from canopy top.

Forward motion

Forward motion Computational Fluid Dynamics (CFD) analysis can be an interesting exercise, providing teaching tools that visually identify and describe the effects of the primary model inputs. Zhang, Qi, et al. (2020) developed a model that incorporated forward speed and the results indicate that the flight speed and altitude had a significant effect on the distribution of the airflow field. The predicted values of air velocity in the vertical direction using the average velocity attenuation model corresponded well with experimental measurements. For flight speeds of 3.0 m/s and an altitude of 3.0 m, the velocity distribution was the most uniform. At flight speeds of 4.0 and 5.0 m/s, the wake was not strong enough to deliver spray droplets to the target directly, leaving droplets to settle on the surface of crop canopy by gravity and atmospheric turbulence or drift. Also, when the flight altitude was 1.5 or 2.0 m, the downwash airflow reached the ground at a relatively high velocity, resulting in the transverse spreading of the airflow, with the width of the airflow field reaching out to 6.0 m. Wen, Han, et al. (2019) conducted a trial which utilized a wind tunnel to provide forward velocity to the model system. To minimize the amount of droplet drift, an optimal operation parameter set of the four-rotor drone is listed as follows: the flight velocity of 2 m/s, flight height of 1 m, boom height of 0.25 m, and the nozzle spacing of 0.4 m. From this work, the dominant factors that affect the drift of droplets of quad-rotor plant protection drone are the flight speed and altitude of the UASS. The position of the nozzles had little effect on the drift and deposition of droplets (which from existing knowledge of applications would be expected to follow expected norms). However, the adjustment of the nozzles was small in this study and it was not clear where the nozzles were in relation to the rotor.

From the literature acquired for this review, there were some interesting simulations but none to date are of use from a regulatory standpoint. CFD simulations need to be more realistic and incorporate all aspects of the application process. However, a different approach to modeling is needed because as it stands every UASS would have to be modeled with CFD which would not be practical.

Conclusions

This literature review has provided useful information on the state of the knowledge with UASS. The efficacy studies showed that UASS applications with low carrier volumes returned lower overall coverage; however, the downwash could be used to improve canopy penetration. The same mass of active ingredient was typically delivered, and that efficacy was generally preserved for insecticides and systemic defoliants; fungal applications, however, require good coverage, making them more challenging. Ultimately, the same challenges apply to UASS as with other application techniques. This review has provided some preliminary data that identifies common use categories, prevailing application settings and indicators of off-target losses.

The interaction of UASS operating height and forward velocity has been the primary area of investigation, and from the field research identified within this review the following was observed:

- UASS vehicles were operated at 1 - 6 m above the canopy, with the majority of studies investigating 1.5 - 3 m altitudes;
- The velocity utilized in the literature ranged from 0.8 - 7 m/s with the majority of studies in the 3 - 4 m/s speed.

However, many of the available studies confounded the effect of forward speed and application rate, identifying higher speeds as detrimental to the deposition process. One of the problems with maintaining rates comes from the fact that the pumps typically used on UASS do not have the capacity to increase flow enough to effectively investigate a range of speeds. It is suggested that manufacturers consider incorporating more robust pumping systems on their platforms. Pesticide application is a materials transport problem with the pump being the driving force behind it all. Application rates in the Asiatic countries tend to be around 15 L/ha and the small pumps tend to work well at such low carrier volumes. At these low volumes, adequate coverage of the targeted crop canopy becomes a potential issue. To improve coverage, nozzles that deliver fine particle sizes have been widely adopted; these too work well with low-capacity pumps. Outside Asiatic regions application rates are in the order of 30 - 100 L/ha, and there is also interest in the use of low drift nozzles on UASS. This further highlights the need to address the low flow rates within the spray system. The low-capacity pumping systems that have been used on UASS cannot easily incorporate these higher rates and larger nozzle orifices.

There is a clear and urgent need for a set of standard testing protocols to be developed for the assessment of UASS. Standards are needed for calibration and appropriate deployment, for efficacy testing and for spray drift assessment. These methods are necessary to ensure that data is of an appropriate quality for regulatory decision making. These quality data can be accumulated into an empirical database for estimates of on-target deposition, off-site movement and model validation. Alongside this need for standard testing protocols, it may be useful to have a document which describes potential pitfalls for individuals new to this area of research, or to identify other methods to bring expertise in pesticide application technology to the researchers working with UASS.

Because of this increased interest and access to application expertise, the quality of the UASS spray systems has been improving and steps toward technologies, such as variable rate applications, are encouraging. The positioning of the nozzles in conventional spray systems is typically well defined, and the effects understood, while the effects of nozzle placement have generally been neglected with UASS. A few studies have confirmed an accepted norm derived from existing application knowledge that nozzles should be positioned within the rotor diameter. For example, in manned aircraft, nozzles should be within 75% of the rotor diameter to reduced off-target losses (ISO standard 16119-5, point 5.9.2). In contrast, many UASS position their nozzles directly below the rotor with the assumption that all the compound is forced downwards. As soon as forward motion provides a horizontal component to the spray, this assumption will no longer be true.

Studies suggest that the drift/off-site movement profile from a UASS application sits in between the standard drift curves from ground boom and orchard airblast applications (drift curves: Rautmann, Streloke, and Winkler 2001). This is not unexpected as the release height is higher than a boom sprayer and the rotor downwash would provide a descending spray plume compared to the ascending plume from an orchard airblast sprayer. The most unpredictable aspect of spray dispersal from a UASS relates to the turbulence present during application, especially at low altitudes when there are interactions with the ground and crop canopy. The turbulence and air displacement created by the UASS will change with each aircraft and there are an ever-increasing number of aircraft available. However, from the available literature there appears to be a distinction between the large single-rotor, the six- to eight-rotor, and four-rotor UASS aircraft in terms of size and capacity. A survey of the primary UASS manufacturers could prove to be a useful endeavor to identify which design is and will be the majority going forward. Having a standard platform or platforms would be useful to inform on UASS selection for different uses; to establish UASS categories/groupings that could be employed to inform empirical testing or regulatory guidance.

Another aspect that needs additional consideration for UASS applications that is relevant for dietary exposure (e.g., crop residue) and operator exposure is the reduced carrier volume, compared to conventional ground applications. However, for dietary exposure, it should be noted that manned aerial applications (e.g., rotary wing aircraft) have utilized lower carrier volumes for several decades and experience with these conventional application systems has led OECD countries to no longer routinely require field crop residue studies using manned aircraft. For the operator exposure component, there is also the need to construct exposure scenarios that are representative of the mixing loading steps and the work activities for UASS. As researchers continue to gather information of the dispersal characteristics from UASS application, there is the possibility of adapting existing exposure estimates (e.g., a mathematical exercise) utilized in OECD countries for UASS.

Pesticide application with UASS may not be new, but it is a rapidly expanding industry that has raised questions for regulators around the world. The use of UASS for pesticide applications has the potential to provide benefits such as the reduction of applicator exposure in comparison to backpack spraying, better quality applications in difficult to access scenarios (e.g., sloped vineyards), and the enablement of precise zone or spot application linked with UASS/UAV-based whole field scouting. However, these potential benefits cannot be realized without improving the available data on UASS applications. As discussed in this overview, the currently available literature suffers from a gap in basic knowledge of pesticide application techniques. The primary recommendation is that actions are required to improve the reliability of data. This can be done through the development of standard test protocols and teaching tools. Data on drift are currently available that would be considered reliable from a regulatory standpoint. These data could be gathered to develop an interim/draft standard drift curve that could inform regulatory exposure estimates. Further work is required to more accurately characterize the spray distribution from UASS, alongside operational practices that could be important to operator exposure and off-target losses. The example of the sprayer slowing down at the edge-of-field to sidestep to the next swath is a jarring failure in application conduct, highlighting the lack of training in pesticide applications technology. Lastly, there should be an attempt to improve the pumping systems placed on UASS and the importance of calibration of the spray system cannot be over emphasized.

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Annex B. Further research ideas

The following ideas are borne out of knowledge gaps identified by the review of the current science and by regulators considering the potential for UASS use.

1. Investigate the in-flight uniformity of spray deposition both on- and off-target. It may be worth considering the influence of reduced weight as a spray pass goes on, and the consistency of flight height and speed during a spray pass.
2. Investigate the influence of spray nozzle positioning relative to the rotors on UASS and the effect on spray drift to identify optimal positioning that minimises drift.
3. Investigate the influence of different application practices, for example at the start and end of a pass to determine the best practice to minimise off target losses and subsequent human and environmental exposure.
4. Investigate the impact of rotor downdraft on how much spray penetrates the crop canopy to the soil surface. This could be studied both in the context of efficacy and environmental exposure.
5. Compare the efficacy of UASS applications to ground boom sprayers, airblast and crewed aerial sprayers.
6. Compare the spray drift (in both human and environmental exposure contexts) arising from UASS applications to ground boom sprayers, crewed aerial sprayers and airblast sprayers. Comparisons could also be made to standard spray drift curves used in pesticide regulation (for example, the Rautmann and the Van de Zande drift curves used by European regulators, the Wolf and Caldwell and the Ganzelmeier drift curves used by Canadian regulators, the AgDRIFT model drift curves used by USA and Australian regulators).

Annex C. Further information on referenced workshops and International Organisation Standards

Information on SETAC DRAW workshop:
Link to website giving the context and scope of the SETAC DRAW workshop: https://www.spraydriftmitigation.info/setac-draw-workshop
SETAC DRAW Workshop reports:
Workshop I summary report (February 2016): https://cdn.ymaws.com/www.setac.org/resource/resmgr/Workshops/DRAW_Summary_Report.pdf Workshop II summary report (February 2017): https://cdn.ymaws.com/www.setac.org/resource/resmgr/draw_summary_report_phase_ii.pdf
Relevant ISO standards:
ISO 22369-2: Crop protection equipment -- Drift classification of spraying equipment -- Part 2: Classification of field crop sprayers by field measurements
ISO 22866: Equipment for crop protection -- Methods for field measurement of spray drift
ISO 22856: Equipment for Crop Protection – Laboratory drift methods measurements
ISO 23117-1 – under development - Agricultural and forestry machinery — Unmanned aerial spraying systems

Annex D. Study conduct recommendations for researchers conducting UASS drift studies

The following recommendations are for researchers investigating environmental exposure arising from application of PPP (Plant Protection Products) using UASS. In the absence of a formal experimental protocol for UASS studies, these recommendations will enable researchers to conduct robust experiments that could be of use to regulators.

- Calibrate and test the spray quality of each UASS set up. Each individual nozzle should be tested so that the spray volume released over a period is quantified. The amount remaining in the spray tank at the end of spraying should also be measured. This should be done for every experimental run.
- Conduct experiments with true replication, with at least three spray passes for each treatment to enable calculation of variance and other statistical analyses.
- Record meteorological conditions on site at the time of the experiment so that these can be included as covariates in statistical analyses and add context to findings. We recommend measuring wind speed and direction (including the height at which these measurements are taken), temperature and humidity, and other variables as referenced in several ISO standards relating to spray drift data generation.
- Record the crop height and growth stage with reference to the BBCH scale (or similar) for the crop.
- Study the in-flight uniformity of UASS movement and spray deposition as acceleration and deceleration may confound experimental results.
- Conduct experiments with a minimum flight path of 20 metres for the UASS. This will enable researchers to have a sufficiently sized flight path for sampling at a consistent flight speed without acceleration and deceleration influencing spray deposition.
- Collect spray drift samples up to at least 50 m downwind of the UASS flight path and preferably beyond 100 m, with a high resolution of samples in at least the first 20 m. An increased sample number is encouraged.
- Clearly report the application height and ensure this is reported as height above the crop (or above ground if measuring a bare ground application) and how altitude is maintained (e.g., manual vs RTK (Real Time Kinematics) GPS (Global Positioning Satellites) or other autonomous UASS).
- Design studies to ensure that different application factors that may interact will not confound the results and with care that the effect of each factor on the results can be observed.

The use of Unmanned Aerial Spray Systems (UASSs) has the potential to improve the sustainability of pesticide use.

Appropriately regulated use of this technology and pesticides they apply could provide benefits such as: reductions in worker exposures (in comparison to some current spraying equipment); better quality applications in difficult to access situations (e.g., sloped vineyards), and the ability for greater use of precise zone or spot application.

In order to ensure that potential benefits are realised, suitable data and information must be available to regulators to assess, in particular: the nature of risks arising from UASS applications, for example exposures resulting from work practices and spray drift; and if/how product efficacy might be impacted.

This report provides an overview of the current state of knowledge and outlines how the risk associated with UASSs applications could be viewed and addressed.

oe.cd/drones-pesticides