



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 11, 2023

1:00-2:00 PM Board Meeting—Hybrid
2:00-3:00 PM Public Forum
3:00-4:00 PM Board Meeting Continued as Necessary

Join the meeting in person in Room 101, Deering Building, 90 Blossom Lane, Augusta
Or
Join the meeting remotely in the Kennebec/Penobscot Room at the Augusta Civic Center
Or

Join the meeting remotely by video conference hosted in MS Teams:
Join on your computer, mobile app or room device

[Click here to join the meeting](#)

Meeting ID: 219 612 005 364

Passcode: AeaCkJ

Or call in (audio only)

[+1 207-209-4724](tel:+12072094724) United States, Portland

Phone Conference ID: 590 138 239#

AGENDA

1. Introductions of Board and Staff
2. Consideration of a Request for Financial Support from Maine Mobile Health

Since 1995 the Board has supported the Migrant and Seasonal Farmworker Safety Education program. The Maine Mobile Health Program (MMHP) provided training to 100 farmworkers during the 2022 season. Funding to support the effort in 2023 is being requested in the amount of \$6,432, which is the same funding amount provided by the Board in 2022. The funding has been accounted for in the Board's FY23 budget.

Presentations By: Hannah Miller, Director of Outreach, Maine Mobile Health

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

MEGAN PATTERSON, DIRECTOR
90 BLOSSOM LANE, DEERING BUILDING



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

3. Consideration of a Request to Extend Special Local Need [24(c)] Registration for Sandea Herbicide (Canyon Group and Gowan Company) to Manage Perennial Broadleaf Weeds in Lowbush Blueberries in the Nonbearing Year

In 2016 and again in 2020, the Board approved two Section 24(c) registrations for Sandea Herbicide (EPA Reg. Nos. 81880-18 and 81880-18-10163). The existing 24(c) registrations will expire December 31, 2020. The University of Maine Cooperative Extension submitted this renewal request for a 24(c) registration. This product is one of two Herbicide Resistance Action Committee (HRAC) Group 2 herbicides reviewed and supported by Extension for use in rotation on lowbush blueberries.

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

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

4. Discussion of Work Completed and Proposed by the Massachusetts Glyphosate Commission

At the July 16, 2021, meeting, the Board reviewed LD 519—An Act to Protect Children from Exposure to Toxic Chemicals, which directed the Board to convene the Medical Advisory Committee (MAC) to assess the human health impacts of herbicide use on school grounds. The MAC met and staff prepared an interim report incorporating commentary from MAC members. This report was presented to the Board and the Legislature's Agriculture, Conservation and Forestry Committee. At the December 2, 2022 meeting, staff discussed similar work underway in Massachusetts and the possibility of building upon the Massachusetts effort. Staff will now provide an update on the status and proposed direction of the Massachusetts glyphosate review.

Presentations By: Pam Bryer, PhD, Pesticides Toxicologist

Action Needed: Review/discuss provided information, provide guidance

5. Consideration of a Consent Agreement with Avesta Housing, Portland, Maine

On June 3, 1998, the Board amended its Enforcement Protocol to authorize 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 involved failure to postpone an application as requested by a tenant.

Presentations By: Alex Peacock, Manager of Compliance

Action Needed: Review and/or approve

6. Consideration of a Consent Agreement with Green Thumb Lawn Services, Brewer, Maine

On June 3, 1998, the Board amended its Enforcement Protocol to authorize 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 involved a self-reported unauthorized application and failure to positively identify the application site.

Presentations By: Alex Peacock, Manager of Compliance

Action Needed: Review and/or approve

7. Other Old and New Business

- a. Letter from Jody Spear and article from Biological Conservation
- b. Overview of 2022 certification trainings
- c. Overview of 2023 pesticide product registration renewal progress
- d. LD 8—An Act to Increase Support for the Modernization of the Board of Pesticides Control by Increasing the Annual Pesticide Registration Fee
- e. Recent EPA complaint pertaining to container fluorination
- f. Other items?

8. Schedule of Future Meetings

February 24, 2023, and April 7, 2023 are the next tentative Board meeting dates. The Board will decide whether to change and/or add dates.

The Board will also decide if future meetings will be remote, in-person or hybrid.

Adjustments and/or Additional Dates?

9. 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.



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

December 20, 2022

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 2023 harvest season.

Throughout the 2022 season, the Maine Mobile Health Program worked to provide the Worker Protection Standard (PST) training to farmworkers across the state. The program recruited a new trainer who was bilingual with the capacity to speak in Spanish and English. One highlight from the season included offering trainings to a crew of blueberry rakers that spoke Spanish, Haitian Creole, and Portuguese, using the interpretation line to support all their language needs. We were also able to build a connection between WPS training and our mobile health services at one of the larger farms. The challenging labor market made it difficult for us to hire a trainer early in the season. We also experienced a couple of last-minute cancelations from farms that limited the number of workers we could support. While our trainer was able to utilize COVID-19 safety precautions, there continued to be barriers to offering more trainings because of the pandemic.

Despite the challenges, our PST trainer was able to offer training on the WPS to 100 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 2022 completed by our trainer.

FWs trained in Worker Protection Standard	100
Heat Stress Trainings	20



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

The Association of Farmworker Opportunity Programs awarded \$1,000 to MMHP in support of on-going WPS training in 2023. 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, and 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 connect with us about this request or our activities, please feel free to contact Hannah Miller (hmillers@mainemobile.org, 207-441-1633).

All the best,

Hannah A. Miller

Hannah Miller
Director of Outreach
Maine Mobile Health Program



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

AMANDA E. BEAL
COMMISSIONER

JANET T. MILLS
GOVERNOR

To: Board of Pesticides Control Members
From: Mary Tomlinson, Pesticides Registrar/Water Quality Specialist
RE: Extension of EPA SLN ME-160001 and EPA SLN ME-160001B, Sandea Herbicide, EPA Reg. No. 81880-18 and EPA Reg. No. 81880-18-10163 respectively, to control perennial broadleaf weeds in lowbush blueberries in the non-bearing year
Date: November 21, 2022

Special Local Need registrations, ME-160001 and ME-160001B for Sandea Herbicide (EPA Reg. Nos. 81880-18 and EPA Reg. No. 81880-18-10163) expire December 31, 2022. Dr. Lily Calderwood, University of Maine Cooperative Extension Wild Blueberry Specialist, is requesting an extension of the SLNs to control perennial broadleaf weeds in lowbush blueberry in the nonbearing year. Canyon Group and Gowan Company supported the initial SLNs in 2016 and later an extension in 2020 which provided stricter language to reduce risk of phytotoxicity and to place the burden of risk on the grower.

The active ingredient is halosulfuron-methyl, and the permitted application rate is 1/2 to 1 oz/A applied as a broadcast application, in the non-crop year prior. Application is to be made prior to breaking dormancy in the spring or after the crop is completely dormant in the fall.

The previous two-year extension was to bridge the gap until the marketplace label was revised to add lowbush blueberries. However, Wyman’s of Maine was the only grower in Maine to use the product without the occurrence of phytotoxicity. Therefore, Canyon Group is requiring more testing and Wyman’s will study the efficacy of fall applications to better determine proper timing of applications.

UMaine Extension considers this an important product in resistance management, particularly in the control of fine leaf sheep fescue. The product is only one of two Group 2 pesticides listed on the extension herbicide chart for use in rotation to reduce resistance.

According to the FAO Mobility Classification used by the EPA, halosulfuron-methyl is borderline mobile to moderately mobile with a KOC of 100. The potential to runoff or leach into surface and ground water when applied to normal soils may lessen as pH decreases. Additional WIN-PST results based on a broadcast application at a rate greater than 1/4 lb Ai/A are provided below. Sandea would be applied at a rate of 0.047 lb Ai/A, as a single broadcast application, only in the nonbearing year. The risk to groundwater would be very low. Halosulfuron-methyl has not been detected in Maine groundwater surveys.

Solubility: At pH 5 is 15 ppm and at pH 7 is 1630 ppm
Field half-life: 14 days

MEGAN PATTERNSON, DIRECTOR
90 BLOSSOM LANE, DEERING BUILDING



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

Pesticide leaching potential: intermediate
Pesticide solution runoff potential: intermediate
Pesticide adsorbed runoff potential: Low

As a reminder, the EPA only permits and approves issuance of an SLN on a primary product registration. States are permitted to issue a state supplemental SLN for a distributor product based on a state approved SLN for the primary product. Canyon Group continues to support the sub SLN request by Gowan Company as stated in the letter. The extension for both the primary and the state supplemental SLNs for Sandea Herbicide are hereby submitted for the Board's approval.

Enclosed are supporting documents for your consideration to extend the SLN through December 31, 2027. Please let me know if you have any questions.

- Letter of request from Lily Calderwood, Ph.D., University of Maine Cooperative Extension
- Letter of support from Dennese Flores, Registration Specialist, Canyon Group/Gowan Company
- Sandea Herbicide draft Maine SLN labels
- Sandea Herbicide Section 3 label
- Sandea EPA master label

The toxicological review by Dr. Pam Bryer is provided under separate cover.

References:

- Parameters of pesticides that influence processes in the soil
<http://www.fao.org/3/X2570E/X2570E06.htm> (accessed 11.21.2022)
- WIN_PST 3.1.20. USDA NRC



Section 24(c) Special Local Need Label

FOR DISTRIBUTION AND USE ONLY IN THE STATE OF MAINE

This label for SANDEA herbicide expires and must not be distributed or used in accordance with this SLN registration after December 31, 2027.

HALOSULFURON-METHYL GROUP **2** HERBICIDE



EPA Reg. No 81880-18 EPA SLN NO. ME-160001

ACTIVE INGREDIENT:	% BY WT.
Halosulfuron-methyl, methyl 3-chloro-5-(4,6-dimethoxypyrimidin-2-ylcarbamoylsulfamoyl)-1-methylpyrazole-4-carboxylate.....	75.0%
OTHER INGREDIENTS	25.0%
	TOTAL 100.0%

KEEP OUT OF REACH OF CHILDREN CAUTION

DIRECTIONS FOR USE

- It is a violation of federal law to use this product in a manner inconsistent with its labeling.
- This labeling must be in the possession of the user at the time of application.
- Follow all applicable directions, restrictions, Worker Protection Standard requirements, and precautions on the EPA registered label.

DIRECTIONS FOR USE PREHARVEST INTERVAL

The required days between last application and harvest are given in () after each crop name.

CROP	OZ/ACRE	DIRECTIONS FOR USE
13-07B LOWBUSH BLUEBERRIES (14)	1/2 - 1	<p>Apply uniformly with ground equipment in a minimum of 20 gal of water per acre. SANDEA should be tank mixed with products such as Velpar® Velossa (hexazinone ai's), or Sinbar® to broaden the spectrum of weeds controlled.</p> <ul style="list-style-type: none"> • Vegetative (Non-Crop) Year • Broadcast application prior to breaking dormancy in the Spring, or after blueberries are completely dormant in the Fall for control of labeled weeds. <p>Apply SANDEA as a single broadcast spray application. Applications applied 1 to 2 months prior to breaking dormancy will allow for better weed control.</p> <p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • Overlapping boom swaths increases the potential for phytotoxicity including leaf yellowing, reddening, and/or stunting • Consult "Use Precautions" and "For Optimum Results" of label for important usage information. • Preemergence applications of SANDEA when ground cover prevents contact with the soil will result in reduced or no residual activity. • SANDEA may not control ALS resistant weeds. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Do not apply when frost is in the ground. • Do not apply to water saturated soils. • Do not apply to blueberries after vegetative bud break. • Do not apply to bushes established less than one year or to plants under stress. • Do not apply to areas where water is known to pond for periods of time following rainfall. • Do not apply SANDEA after the crop has progressed into budbreak or significant injury will occur. • Do not apply more than 1 application or 1 oz/A of product by weight (0.047 lb a.i./acre) per 12 month period. • Do not apply by rope-wick wiper application.

24(c) Registrant: Canyon Group, LLC
P.O. Box 5569
Yuma, AZ 85366-5569



Section 24(c) Special Local Need Label

FOR DISTRIBUTION AND USE ONLY IN THE STATE OF MAINE

This label for SANDEA herbicide expires and must not be distributed or used in accordance with this SLN registration after December 31, 2027.

HALOSULFURON-METHYL GROUP 2 HERBICIDE



EPA Reg. No 81880-18-10163 EPA SLN NO. ME-160001B

ACTIVE INGREDIENT:	% BY WT.
Halosulfuron-methyl, methyl 3-chloro-5-(4,6-dimethoxyimidin-2-ylcarbamoylsulfamoyl)-1-methylpyrazole-4-carboxylate.....	75.0%
OTHER INGREDIENTS	25.0%
	TOTAL 100.0%

KEEP OUT OF REACH OF CHILDREN CAUTION

DIRECTIONS FOR USE

- It is a violation of federal law to use this product in a manner inconsistent with its labeling.
- This labeling must be in the possession of the user at the time of application.
- Follow all applicable directions, restrictions, Worker Protection Standard requirements, and precautions on the EPA registered label.

DIRECTIONS FOR USE PREHARVEST INTERVAL

The required days between last application and harvest are given in () after each crop name.

CROP	OZ/ACRE	DIRECTIONS FOR USE
13-07B LOWBUSH BLUEBERRIES (14)	1/2 - 1	<p>Apply uniformly with ground equipment in a minimum of 20 gal of water per acre. SANDEA should be tank mixed with products such as Velpar® Velossa (hexazinone ai's), or Sinbar® to broaden the spectrum of weeds controlled.</p> <ul style="list-style-type: none"> • Vegetative (Non-Crop) Year • Broadcast application <u>prior to breaking dormancy in the Spring, or after blueberries are completely dormant in the Fall for control of labeled weeds.</u> <p>Apply SANDEA as a single broadcast spray application. Applications applied 1 to 2 months prior to breaking dormancy will allow for better weed control.</p> <p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • Overlapping boom swaths increases the potential for phytotoxicity including leaf yellowing, reddening, and/or stunting • Consult "Use Precautions" and "For Optimum Results" of label for important usage information. • Preemergence applications of SANDEA when ground cover prevents contact with the soil will result in reduced or no residual activity. • SANDEA may not control ALS resistant weeds. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Do not apply when frost is in the ground. • Do not apply to water saturated soils. • Do not apply to blueberries after vegetative bud break. • Do not apply to bushes established less than one year or to plants under stress. • Do not apply to areas where water is known to pond for periods of time following rainfall. • Do not apply SANDEA after the crop has progressed into budbreak or significant injury will occur. • Do not apply more than 1 application or 1 oz/A of product by weight (0.047 lb a.i./acre) per 12 month period. • Do not apply by rope-wick wiper application.

24(c) Registrant: Gowan Company, LLC
P.O. Box 5569
Yuma, AZ 85366-5569



November 16, 2022

Dear Maine Board of Pesticide Control,

On behalf of the University of Maine Cooperative Extension and lowbush (wild) blueberry producers in Maine, I request an extension of the 24C label for Sandea herbicide for use on broadleaf weeds in wild blueberry fields. Our current 24C label will expire on December 31, 2022. There has been a Sandea 24C label approved for use on this crop since 2016. I do hope lowbush blueberry can be added to the Sandea label.

My predecessor, David Yarborough, conducted a research trial on Sandea from 2012-2013. His findings support that Sandea should be applied according to the current 24C label that states a rate of 1/2-1 oz/acre. However, the proper timing of this product for most effective use in lowbush blueberry has not been identified. Wyman's of Maine is currently studying fall application timing of Sandea to manage both grass and broadleaf weeds and I am hopeful that we will find the niche for this product soon. Fine leaf sheep fescue (*Festuca filiformis*) is a particularly vigorous and difficult weed to manage. This weed is taking over fields in Washington county and is believed to have arrived from Canada on shared harvesters. This grass is one important target of Wyman's fall application trial with Kerb (pronamide) being the only other fall herbicide to control this weed. The label states that application should occur during the non-crop year before any emergence in the spring or after complete dormancy in the fall.

Broadleaf weeds compete with lowbush blueberry for nutrients, sunlight, and water. The successional habitat in which lowbush blueberry is grown exhibits the same conditions that favor certain broad leaf weeds. Through my Extension program, growers are encouraged to identify weeds in their fields and use cultural methods of weed management including sulfur application and mechanical weed removal before using chemical control. Some broadleaf weeds including the following listed on the Sandea label, grasses (Poaceae spp.), horseweed (*Erigeron canadensis*), horsetail (*Equisetum arvense*), prickly lettuce (*Lactuca serriola*), and yellow nutsedge (*Cyperus exculentus*) grow well under conditions that also favor lowbush blueberry and therefore must be suppressed using herbicides. Sandea is a group 2 herbicide and therefore fills an important rotational niche, reducing the risk of resistance development and offering another tool in the IPM toolbox for growers to use. The UMaine Extension herbicide chart, which contains 21 products, only contains two Group 2 products, Sandea being one of them.

Sincerely,

A handwritten signature in cursive script that reads 'Lily B. Calderwood'.

Dr. Lily Calderwood
University of Maine
Extension Wild Blueberry Specialist



November 21, 2022

Attention: Mary E. Tomlinson
Department of Agriculture
Maine Board of Pesticides Control
28 State House Station
Augusta, ME 04333

RE: Sandea Herbicide, EPA Reg. No. 81880-18, SLN Renewal ME- for Blueberries.

Dear. Mrs. Tomlinson:

Canyon Group and Gowan Company, LLC request renewal of Special Local Need (SLN) ME-160001 & ME-160001B for use of Sandea Herbicide (active ingredient Halosulfuron) on blueberries.

Gowan Company, LLC supports University of Maine – Cooperative Extension on the extension of this SLN. Sandea (a supplemental distributed product) is necessary to control many broadleaf weeds. Wyman's of Maine is currently testing the use of Sandea as a fall application. More time is needed in testing, before the use can be added on Sandea marketing label.

Canyon Group continues to support Gowan Company, LLC in this supplemental SLN for Sandea EPA Registration number 81880-18. Distributed by Gowan Company, LLC under registration number 81880-18-10163.

In support of this renewal application, I have enclosed the following:

- Application for/Notification of State Registration of a Pesticide to Meet a Special Local Need (EPA Form 8570-25)
- SLN no. ME-160001 – Canyon Group label
- SLN no. ME-160001B – Gowan Company, LLC label
- Letter of support from Canyon Group, LLC
- Letter of extension request from The University of Maine – Cooperative Extension

If I can provide further information or documentation, please contact me at (928) 539-5451 or dflores@gowanco.com

Kind regards,

A handwritten signature in black ink, appearing to read "Dennese Flores", with a long horizontal flourish extending to the right.

Dennese Flores
Registration Specialist
Gowan Company, LLC
dflores@gowanco.com



HALOSULFURON-METHYL GROUP 2 HERBICIDE



**SANDEA® is a selective herbicide
for control of listed broadleaf weeds and nutsedge**

ACTIVE INGREDIENT:	% BY WT.
Halosulfuron-methyl, methyl 3-chloro-5-(4,6-dimethoxy-pyrimidin-2-ylcarbamoylsulfamoyl)-1-methylpyrazole-4-carboxylate	75.0%
OTHER INGREDIENTS	25.0%
	TOTAL 100.0%

**KEEP OUT OF REACH OF CHILDREN
CAUTION**

Si usted no entiende la etiqueta, busque a alguien para que se las explique a usted en detalle.
(If you do not understand the label, find someone to explain it to you in detail.)

FIRST AID	
IF IN EYES	<ul style="list-style-type: none"> • Hold eye open and rinse slowly and gently with water for 15-20 minutes. • Remove contact lenses, if present, after 5 minutes, then continue rinsing eye. • Call poison control center or doctor for treatment advice.
IF SWALLOWED	<ul style="list-style-type: none"> • Call poison control center or doctor immediately for treatment advice. • Have person sip a glass of water if able to swallow. • Do not induce vomiting unless told to do so by the poison control center or doctor. • Do not give anything to an unconscious person.
HOT LINE NUMBER	
Have the product container or label with you when calling poison control center, doctor or going for treatment. For emergency information concerning this product, call toll free 1-888-478-0798.	

**PRECAUTIONARY STATEMENTS
HAZARDS TO HUMANS AND DOMESTIC ANIMALS
CAUTION**

Causes moderate eye irritation. Harmful if swallowed. Avoid contact with eyes or clothing.

NET CONTENTS: 10 OUNCES

EPA Reg. No. 81880-18-10163
EPA Est. No. 67545-AZ-002
Item No. XXXXX
XXXXX-US-SANH-XX-XX-RXXXX

Distributed by:
Gowan Company, LLC
P.O. Box 5569
Yuma, AZ 85366-5569

Gowan
The Go To Company



PERSONAL PROTECTIVE EQUIPMENT (PPE)

Applicators and other handlers must wear:

- Long-sleeved shirt and long pants
- Shoes plus socks

Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

ENGINEERING CONTROLS STATEMENTS: When handlers use closed systems or enclosed cabs in a manner that meets the requirements listed in the Worker Protection Standard (WPS) for agricultural pesticides [40 CFR 170.240 (d) (4-6)], the handler PPE requirements may be reduced or modified as specified in the WPS.

USER SAFETY RECOMMENDATIONS

Users should:

- Wash hands before eating, drinking, chewing gum, using tobacco or using the toilet.
- Remove clothing immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.

ENVIRONMENTAL HAZARD SECTION OF PRECAUTIONARY STATEMENTS GROUND WATER ADVISORY

Halosulfuron-methyl is known to leach through soil into groundwater under certain conditions as a result of label use. This chemical may leach into groundwater if used in areas where soils are permeable, particularly where the water table is shallow.

SURFACE WATER ADVISORY

This product may impact surface water quality due to runoff of rainwater. This is especially true for poorly draining soils and soils with shallow ground water. This product is classified as having high potential for reaching surface water via runoff for several months or more after application. A level, well-maintained vegetative buffer strip between areas to which this product is applied and surface water features such as ponds, streams, and springs will reduce the potential loading of halosulfuron-methyl from runoff water and sediment. Runoff of this product will be greatly reduced by avoiding applications when rainfall or irrigation is expected to occur within 48 hours.

PHYSICAL AND CHEMICAL HAZARDS

Do not mix or allow coming in contact with water. Hazardous chemical reaction may occur.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling. Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application. For any requirements specific to your State or Tribe, consult the agency responsible for pesticide regulation.

WINDBLOWN SOIL PARTICLES

Sandea has the potential to move off-site due to wind erosion. Soils that are subject to wind erosion usually have a high silt and/or fine to very fine sand fractions and low organic matter. Other factors which can affect the movement of windblown soil include the intensity and direction of prevailing winds, vegetative cover, site slope, rainfall, and drainage patterns. Avoid applying Sandea if prevailing local conditions may be expected to result in off-site movement.

NON-TARGET ORGANISM ADVISORY

This product is toxic to plants and may adversely impact the forage and habitat of non-target organisms, including pollinators, in areas adjacent to the treated area. Protect the forage and habitat of non-target organisms by minimizing spray drift. For further guidance and instructions on how to minimize spray drift, refer to the Spray Drift Management section of this label.

AGRICULTURAL USE REQUIREMENTS

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR Part 170. This standard contains requirements for the protection of agricultural workers on farms, forests, nurseries and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment (PPE) and restricted-entry interval. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard. Do not enter or allow worker entry into treated areas during the restricted entry interval (REI) of 12 hours. PPE required for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil, or water is:

- Coveralls
- Chemical-resistant gloves made of any waterproof material
- Shoes plus socks

PRODUCT INFORMATION

SANDEA is a dry flowable formulation that selectively controls certain broadleaf weeds and nutsedges in selected crops. SANDEA is effective both preemergence and postemergence. SANDEA can be absorbed through roots, shoots and foliage and is translocated within the plant.

WEED RESISTANCE STATEMENT

SANDEA contains a (Group 2) herbicide. Any weed population may contain or develop plants naturally resistant to (Group 2) Halosulfuron-methyl herbicides. Weed species with acquired resistance to (Group 2) Halosulfuron-methyl may eventually dominate the weed population if (Group 2) Halosulfuron-methyl herbicides are used repeatedly in the same field or in successive years as the primary method of control for targeted species. This may result in partial or total loss of control of those species by SANDEA or other (Group 2) herbicides.

Suspected herbicide-resistant weeds may be identified by these indicators:

- Failure to control a weed species normally controlled by the herbicide at the dose applied, especially if control is achieved on adjacent weeds;
- A spreading patch of non-controlled plants of a particular weed species; and
- Surviving plants mixed with controlled individuals of the same species.

To delay herbicide resistance consider:

- Rotate the use of SANDEA Herbicide or other Group (2) herbicides within a growing season sequence or among growing seasons with different herbicide groups that control the same weeds in a field.
- Use tank mixtures with herbicides from a different group if such use is permitted; where information on resistance in target weed species is available, use the less resistance-prone partner at a rate that will control the target weed(s) equally as well as the more resistance-prone partner.

- Consult your local extension service or certified crop advisor if you are unsure as to which active ingredient is currently less prone to resistance.
- Adopt an integrated weed-management program for herbicide use that includes scouting and uses historical information related to herbicide use and crop rotation, and that considers tillage (or other mechanical control methods), cultural (e.g., higher crop seeding rates; precision fertilizer application method and timing to favor the crop and not the weeds), biological (weed-competitive crops or varieties) and other management practices.
- Scout before and after herbicide application to monitor weed populations for early signs of resistance development. Indicators of possible herbicide resistance include:
 - (1) failure to control a weed species normally controlled by the herbicide at the dose applied, especially if control is achieved on adjacent weeds;
 - (2) a spreading patch of non-controlled plants of a particular weed species;
 - (3) surviving plants mixed with controlled individuals of the same species.
- If resistance is suspected, prevent weed seed production in the affected area by an alternative herbicide from a different group or by a mechanical method such as hoeing or tillage. Prevent movement of resistant weed seeds to other fields by cleaning harvesting and tillage equipment when moving between fields, and planting clean seed.
- If a weed pest population continues to progress after treatment with this product, discontinue use of this product, and switch to another management strategy or herbicide with a different mode of action, if available.

Contact your local extension specialist or certified crop advisors for additional pesticide resistance-management and/or integrated weed-management recommendations for specific crops and weed biotypes. For further information or to report suspected resistance or lack of performance, you may contact Gowan Company at 1-800-883-1844.

APPLICATION EQUIPMENT AND INSTRUCTIONS

Applications may be made by ground or aerial equipment to healthy, actively growing weeds. For best results, avoid applications when weeds are under stress due to weather, disease, insect damage, or combinations of these factors. Sandea is rainfast after 4 hours; rainfall or irrigation occurring within 4 hours after application may reduce effectiveness. Avoid streaking, skips, overlaps, and spray drift during application.

Thoroughly clean application equipment prior to mixing Sandea Herbicide spray solutions, after SANDEA Herbicide use, and prior to spraying a crop other than those listed on the label. Refer to the "SPRAYER TANK CLEANOUT" section of the label for more detailed information.

Ground Applications:

Apply SANDEA as a broadcast or band application with properly calibrated ground equipment in 15 or more gallons of water per acre unless otherwise directed in the "Application Instructions" section. Choose nozzles that provide optimum spray distribution and coverage to the target weed at the appropriate pressure (psi). For band applications, use proportionally less spray mixture based on the area actually sprayed. Do not concentrate the band. Consult the "Application Instructions" section of this label for the rates and procedures that are appropriate for your growing region.

Aerial Applications:

Apply this product or approved tank mixtures with properly calibrated equipment in 3 to 15 gallons of water per acre.

**Rope-wick or Wiper Applications:**

Apply by wiping SANDEA to the weeds using an absorbent material made of burlap, canvas, rope, sponge, or absorbent pad plumbed into a pipe reservoir filled with SANDEA. The absorbent material must maintain consistent moisture to allow for leaf wetness on targeted weeds, but not to a moisture level that allows for excess moisture to drip from the absorbent material. Selected equipment must be maintained and capable of preventing all contact of the herbicide solution with the crop or soil.

Adjust the height of the wiper applicator to ensure adequate contact with the weeds and so that no wiper contact point is at least 2 inches above the desirable vegetation. Optimum performance can be obtained when more of the weed is exposed to the herbicide solution and weeds are a minimum of 6 inches above the desirable vegetation. Weeds that do not come in contact with SANDEA will not be affected. Poor contact occurs when weeds are growing in dense clumps, in areas of severe weed infestation, when weed height varies dramatically or when operator speeds are too great. Terrain must be considered when making wiper applications. Sloping ground can cause herbicide solution to migrate to one side, causing dripping on the lower end and drying of the wiper on the upper end of the applicator. Due to decreased efficacy do not apply this product when weeds are wet.

Mix only the amount of product that will be used during a 1-day application, as reduced product performance can occur from solutions held longer than 24 hours. Avoid leaks or dripping of the herbicide solution onto the crop as contact of this product to desirable vegetation could result in plant injury or destruction. Keep wiper surfaces clean. Clean wiper parts promptly after using SANDEA by thoroughly flushing with water.

When Using Motorized Ground Equipment:

Prior to application determine the per acre output of your applicator. If the output rate is unknown it may be obtained by evaluating the output at ~100% weed density. Apply a minimum of 1 oz SANDEA per acre by mixing the desired per acre rate of SANDEA, in ratio with your determined per acre output. Do not exceed the maximum labeled rate for your crop.

The applicator device will physically wipe this product directly onto the weed in between rows of crop plants (row middles) or over the top of crops for selectively controlling weeds. Operate wiper applicators at a ground speed of no greater than 5 miles per hour. To maintain performance applicator should control chemical application rate by adjusting travel speed to match weed density. In areas of dense weeds better results can be obtained when two applications are made in opposite directions. Refer to the specific crop section of this label for rates and directions for use.

Spot Treatment:

For spot treatment or application with a hand held device, mix 1/4 oz – 1 oz SANDEA per 1 gallon of water. For best results, when using a hand held applicator, wipe the desired target weeds in a back and forth motion to ensure proper contact and coverage.

NOTE: When using a surfactant refer to the adjuvants section of this label.



SPRAY DRIFT

Ground Boom Applications:

- Apply with the nozzle height recommended by the manufacturer, but no more than 3 feet above the ground or crop canopy unless making a turf, pasture, or rangeland application, in which case applicators may apply with a nozzle height no more than 4 feet above the ground.
- For applications prior to the emergence of crops and target weeds, applicators are required to use a Coarse or coarser droplet size (ASABE S572.1).
- For all other applications, applicators are required to use a Medium or coarser droplet size (ASABE S572.1).
- Do not apply when wind speeds exceed 10 miles per hour at the application site.
- Do not apply during temperature inversions.

Boom-less Ground Applications:

- Applicators are required to use a Medium or coarser droplet size (ASABE S572.1) for all applications.
- Do not apply when wind speeds exceed 10 miles per hour at the application site.
- Do not apply during temperature inversions.

Aerial Applications:

- Do not release spray at a height greater than 10 ft above the vegetative canopy, unless a greater application height is necessary for pilot safety.
- For applications prior to the emergence of crops and target weeds, applicators are required to use a Coarse or coarser droplet size (ASABE S572.1).
- For all other applications, applicators are required to use a Medium or coarser droplet size (ASABE S572.1).
- The boom length must not exceed 65% of the wingspan for airplanes or 75% of the rotor blade diameter for helicopters.
- Applicators must use 1/2 swath displacement upwind at the downwind edge of the field.
- Nozzles must be oriented so the spray is directed toward the back of the aircraft.
- Do not apply when wind speeds exceed 10 miles per hour at the application site.
- Do not apply during temperature inversions.

SPRAY DRIFT ADVISORIES:

Handheld Technology Applications:

- Take precautions to minimize spray drift.

Boom-less Ground Applications:

- Setting nozzles at the lowest effective height will help to reduce the potential for spray drift. **THE APPLICATOR IS RESPONSIBLE FOR AVOIDING OFF-SITE SPRAY DRIFT. BE AWARE OF NEARBY NON-TARGET SITES AND ENVIRONMENTAL CONDITIONS.**

Importance of droplet size:

An effective way to reduce spray drift is to apply large droplets. Use the largest droplets that provide target pest control. While applying larger droplets will reduce spray drift, the potential for drift will be greater if applications are made improperly or under unfavorable environmental conditions.

Controlling Droplet Size - Ground Boom

- Volume - Increasing the spray volume so that larger droplets are produced will reduce spray drift. Use the highest practical spray volume for the application. If a greater spray volume is

- needed, consider using a nozzle with a higher flow rate.
- Pressure - Use the lowest spray pressure recommended for the nozzle to produce the target spray volume and droplet size.
 - Spray Nozzle - Use a spray nozzle that is designed for the intended application. Consider using nozzles designed to reduce drift.

Controlling Droplet Size - Aircraft

- Adjust Nozzles - Follow nozzle manufacturers recommendations for setting up nozzles.

Generally, to reduce fine droplets, nozzles should be oriented parallel with the airflow in flight.

BOOM HEIGHT - Ground Boom - Use the lowest boom height that is compatible with the spray nozzles that will provide uniform coverage. For ground equipment, the boom should remain level with the crop and have minimal bounce.

RELEASE HEIGHT - Aircraft - Higher release heights increase the potential for spray drift. When applying aerially to crops, do not release spray at a height greater than 10 ft above the crop canopy, unless a greater application height is necessary for pilot safety.

SHIELDED SPRAYERS - Shielding the boom or individual nozzles can reduce spray drift. Consider using shielded sprayers. Verify that the shields are not interfering with the uniform deposition of the spray on the target area.

TEMPERATURE AND HUMIDITY - When making applications in hot and dry conditions, use larger droplets to reduce effects of evaporation.

TEMPERATURE INVERSIONS - Drift potential is high during a temperature inversion. Temperature inversions are characterized by increasing temperature with altitude and are common on nights with limited cloud cover and light to no wind. The presence of an inversion can be indicated by ground fog or by the movement of smoke from a ground source or an aircraft smoke generator. Smoke that layers and moves laterally in a concentrated cloud (under low wind conditions) indicates an inversion, while smoke that moves upward and rapidly dissipates indicates good vertical air mixing. Avoid applications during temperature inversions.

WIND - Drift potential generally increases with wind speed. AVOID APPLICATIONS DURING GUSTY WIND CONDITIONS. Applicators need to be familiar with local wind patterns and terrain that could affect spray drift.

Sensitive areas:

Pesticides should only be applied when the potential for drift to adjacent sensitive areas (e.g. residential areas, bodies of water, known habitat for threatened or endangered species, non-target crops) is minimal (e.g. when wind is blowing away from the sensitive areas).

Thoroughly clean application equipment immediately after the use of SANDEA. Prepare a tank cleaning solution that consists of a 1% solution of household ammonia (one quart of ammonia for every 25 gal of water). Use sufficient cleaning solution to thoroughly rinse all surfaces and to flush all hoses. Repeat the procedure with the ammonia solution. Complete the cleaning process by rinsing with clean water.

MIXING INSTRUCTIONS

Fill the spray tank to about three-fourths of the desired volume and begin agitation. Add the labeled amount of SANDEA. Complete the filling process while maintaining agitation. Remove the hose from the mixing tank immediately after filling to avoid siphoning back into the carrier source. Add nonionic surfactant (NIS) and other adjuvants as the last ingredients in the tank. Spray solutions should be applied within 24 hours after mixing.



ADJUVANTS

Unless otherwise stated, a NIS is recommended in the spray solution for postemergence applications or for preemergence applications where susceptible weeds are present prior to crop emergence. Use only nonionic-type surfactants that are approved for use on food crops and contain at least 80% active ingredients. Use 0.25 to 0.50% nonionic-type surfactant concentration (1 to 2 quarts per 100 gal of spray solution). Use of SANDEA without an adjuvant when weeds are present may result in reduced efficacy. Use of crop oil concentrate (COC) or silicone-based adjuvants can result in increased crop injury and reduced yields and are not recommended for postemergence applications over the crop, unless stated otherwise.

TANK MIXES

Unless stated in the "Application Instructions" section or allowed by supplemental labeling, tank mix combinations have not been evaluated and are the user's responsibility. It is the pesticide user's responsibility to ensure that all products in the listed mixtures are registered for the intended use (For Example: first aid from one product, spray drift management from another). Users must follow the most restrictive directions and precautionary language of the products in the mixture. It is recommended that tank mixtures should be evaluated for miscibility and crop safety on a small test area prior to use. Tank mixtures should not be applied when the plants are under stress due to drought, water saturated soils, low fertility (especially low nitrogen levels) or other poor growing conditions.

SPRAYER TANK CLEANOUT

To avoid injury to desirable crops, clean all mixing and spray equipment before and immediately following applications of SANDEA as follows:

1. Drain tank; thoroughly rinse spray tank, boom, and hoses with clean water. Remove the nozzles and screens and clean separately in a bucket containing agent and water. Loosen and physically remove any visible deposits.
2. Fill the tank with clean water and 1 gal of household ammonia* (containing 3% ammonia) for every 100 gal of water. Flush the hoses, boom, and nozzles with the cleaning solution. Then add more water to completely fill the tank. Circulate the cleaning solution through the tank and hoses for at least 15 minutes. Again flush the hoses, boom, and nozzles with the cleaning solution and then drain the tank.
3. Remove the nozzles and screens and clean separately in a bucket containing agent and water.
4. Repeat step 2.
5. Rinse the tank, boom, and hoses with clean water.
6. The rinsate may be disposed of on-site or at an approved disposal facility.

* Equivalent amount of an alternate strength ammonia solution can be used in the clean out procedure. Carefully read and follow the individual cleaner instructions.

USE PRECAUTIONS

- Excessive amounts of water (greater than 1 inch) from rainfall or sprinkler irrigation soon after a preemergent application may cause crop injury. This potential injury can be enhanced if seeding depth is too shallow.
- Within 4 hours of a SANDEA application, avoid using overhead sprinkler irrigations or making applications when conditions favor rainfall.
- Properly crowned beds may minimize the potential for injury when broadcast applications of SANDEA are made over plastic mulch. Significant crop injury could result when spray residue is concentrated in the plant hole by irrigation or rainfall.



- SANDEA can cause injury or crop failure under cool and wet growing conditions that delay early seedling emergence, vigor or growth. Be especially cautious during the first planting of the season when these conditions are likely to occur.
- SANDEA may delay maturity of treated crops.
- SANDEA should not be applied if the crop or target weeds are under stress due to drought, water saturated soils, low fertility (especially low nitrogen levels) or other poor growing conditions.
- Use of soil or foliar-applied organophosphate insecticides on SANDEA treated crops may increase the potential for crop injury and/or the severity of the crop injury.
- Avoid spray drift outside of targeted area.
- SANDEA may be applied to labeled crops (including cultivars and/or hybrids of these) and used according to labeled directions. Not all hybrids/varieties have been tested for sensitivity to SANDEA. For untested varieties, a small amount of the field should be sprayed to determine potential sensitivity to its use.
- Thoroughly clean application equipment immediately after SANDEA use and prior to spraying another crop.
- Temporary yellowing or stunting of the crop may occur following SANDEA applications.
- Under certain environmental conditions, SANDEA applied over the top of a blooming crop may result in some bloom loss.
- Use of SANDEA without an adjuvant can result in reduced efficacy.

USE RESTRICTIONS

- Do not apply SANDEA using air assisted (air blast) field crop sprayers.
- Do not apply this product through any type of irrigation system.
- Do not apply more than 2 oz of SANDEA per acre per 12 month period (includes applications to the crop and to row middles/furrows).
- Do not make more than the maximum number of applications per year for each crop.
- CALIFORNIA ONLY SENSITIVE CROP:

PRUNES

Buffer Zones:

1. Aerial applications shall not be made closer than 4 miles.
2. Ground applications shall not be made closer than 1 mile from prunes unless wind direction during the application is away from prunes. When wind direction during the ground application is away from prunes, ground applications shall not be made closer than 1/2 mile from prunes.

COTTON

Buffer Zones:

1. Aerial applications shall not be made closer than 1 mile from cotton.
2. Ground applications shall not be made closer than 1 mile from cotton unless wind direction during the application is away from cotton. When wind direction during the ground application is away from cotton, ground applications shall not be made closer than 1/2 mile from cotton.

FOR OPTIMUM RESULTS

Control typically occurs within 7 to 14 days depending on the weed size, species and growing conditions. Heavy weed infestations should be treated early before the weeds become too competitive with the crop. Good coverage with SANDEA is essential. When applying SANDEA

follow "Weed Controlled Chart" and "Application Timing" sections of the label for improved control. When adding approved adjuvant follow mixing instructions regarding adjuvant.

- For best results, wait to cultivate treated soil area for 7 to 10 days after a postemergence application of SANDEA unless otherwise specified. (Cultivation may be necessary to control suppressed weeds, weeds that were bigger than the maximum recommended size at application, weeds that emerge after an application, or weed species not on the SANDEA label).
- To maximize control of annual weeds, it may be necessary to use sequential applications of SANDEA, but do not make more than the maximum number of applications per year for each crop. (Multiple flushes of seedlings, or treated perennials may sometimes re-grow from underground stems or roots).

For preemergence applications:

- Use a surfactant as directed in the "Adjuvants" section of this label to control susceptible weeds prior to crop emergence.
- Preemergent weed control may be improved by incorporating SANDEA with irrigation (1/4 to 1/2 inch maximum).
- Preemergence applications of SANDEA when weed coverage prevents contact with the soil will result in reduced or no residual activity.

For postemergence applications:

- Treat young actively growing broadleaf weeds 1 to 3 inches in height.
- Treat actively growing nutsedge plants at the 3 to 5 leaf stage.
- Wait 2 - 3 days after postemergent applications for to overhead irrigation.
- Avoid applications when crops are under drought, stress, disease, or insect damage.

WEEDS CONTROLLED BY SANDEA ALONE

C = Control, S = Suppression, NA = No Activity

WEED SPECIES	PRE-EMERGENT ACTIVITY	POST-EMERGENT ACTIVITY	WEED HEIGHT (IN) 1 OZ/ACRE	WEED HEIGHT (IN) 2 OZ/ACRE
Amaranth, spiny ² <i>Amaranth spinosus</i>	C ²	C ²	1 to 3	1 to 6
Bindweed, hedge <i>Calystegia sepium</i>	NA	S	1 to 2	1 to 4
Burcucumber <i>Sicyos angulatus</i>	NA	S	1 to 3	1 to 12
California arrowhead ³ <i>Sagittaria montevidensis</i>	NA	C ³	1 to 2	1 to 4
Chickweed, common <i>Stellaria media</i>	C	NA	1 to 3	1 to 5
Cocklebur, common <i>Xanthium strumarium</i>	C	C	1 to 9	1 to 14
Corn spurry <i>Spergula arvensis</i>	C	C	1 to 2	1 to 4

WEEDS CONTROLLED BY SANDEA ALONE

C = Control, S = Suppression, NA = No Activity

WEED SPECIES	PRE-EMERGENT ACTIVITY	POST-EMERGENT ACTIVITY	WEED HEIGHT (IN) 1 OZ/ACRE	WEED HEIGHT (IN) 2 OZ/ACRE
Dayflower* <i>Commelina erecta</i>	C	S	1 to 2	1 to 4
Deadnettle, purple <i>Lamium purpureum</i>	C	NA	----	----
Devils Claw <i>Proboscidea louisianica</i>	NA	C	1 to 6	1 to 10
Eclipta* <i>Ecilpta prostrata</i>	C	S	1 to 2	1 to 4
Flatsedge, rice* ² <i>Cyperus iria</i>	S ²	C ²	1 to 9	1 to 12
Fleabane, Philadelphia <i>Erigeron philadelphicus</i>	NA	C	1 to 3	1 to 3
Galinsoga <i>Galinsoga</i>	C	C	1 to 2	1 to 4
Golden crownbeard* <i>Verbesina encelioides</i>	NA	C	1 to 2	1 to 4
Goosefoot <i>Chenopodium</i>	C	C	1 to 2	1 to 4
Groundsel, common <i>Senecio vulgaris</i>	C	NA	----	----
Horseweed/Marestail ² <i>Erigeron canadensis</i>	C ²	NA	1 to 3	1 to 6
Horsetail <i>Equisetum</i>	NA	S	1 to 2	1 to 4
Jimsonweed <i>Datura stramonium</i>	C	NA	1 to 4	1 to 8
Jointvetch <i>Aeschynomene virginica</i>	NA	C	1 to 2	1 to 4
Kochia ² <i>Kochia scoparia</i>	C ²	S ²	1 to 3	1 to 6
Ladysthumb <i>Polygonum persicaria</i>	C	C	1 to 3	1 to 6
Lambsquarter, common <i>Chenopodium album</i>	C	NA	1 to 3	1 to 5

WEEDS CONTROLLED BY SANDEA ALONE				
C = Control, S = Suppression, NA = No Activity				
WEED SPECIES	PRE-EMERGENT ACTIVITY	POST-EMERGENT ACTIVITY	WEED HEIGHT (IN) 1 OZ/ACRE	WEED HEIGHT (IN) 2 OZ/ACRE
Lettuce, prickly <i>Lactuca serriola</i>	C	NA	1 to 4	1 to 6
Mallow, common <i>Malva neglecta</i>	C	NA	1 to 3	1 to 5
Mallow, Venice <i>Hibiscus trionum</i>	C	C	1 to 3	1 to 12
Mayweed chamomile (dog fennel) <i>Anthemis cotula</i>	C	NA	---	---
Milkweed, common <i>Asclepias syriaca</i>	NA	S	1 to 5	1 to 12
Milkweed, honeyvine <i>Ampelamus albidus</i>	NA	S	1 to 3	1 to 6
Morningglory, ivyleaf ² <i>Ipomoea hederacea</i>	NA	S ³	1 to 3	1 to 4
Morningglory, tall ³ <i>Ipomoea purpurea</i>	NA	S ³	1 to 3	1 to 4
Mustard, wild <i>Sinapis arvensis</i>	C	C	1 to 6	1 to 10
Nutsedge, yellow ¹ <i>Cyperus esculentus</i>	S	C ¹	3 to 6	3 to 12
Nutsedge, purple ¹ <i>Cyperus rotundus</i>	S	C ¹	3 to 6	3 to 12
Passionflower, maypop <i>Passiflora incarnata</i>	NA	C	1 to 3	1 to 3
Pigweed, redroot ² <i>Amaranthus retroflexus</i>	C ²	C ²	1 to 3	1 to 6
Pigweed, smooth ² <i>Amaranthus hybridus</i>	C ²	C ²	1 to 3	1 to 6
Plantain <i>Plantago major</i>	C	NA	----	----
Pokeweed, common <i>Phytolacca Americana</i>	NA	C	1 to 3	1 to 6
Purslane <i>Portulaca oleracea</i>	S	NA	----	----

WEEDS CONTROLLED BY SANDEA ALONE

C = Control, S = Suppression, NA = No Activity

WEED SPECIES	PRE-EMERGENT ACTIVITY	POST-EMERGENT ACTIVITY	WEED HEIGHT (IN) 1 OZ/ACRE	WEED HEIGHT (IN) 2 OZ/ACRE
Radish, wild <i>Raphanus raphanistrum</i>	C	C	1 to 4	1 to 8
Ragweed, common ² <i>Ambrosia artemisiifolia</i>	C ²	C ²	1 to 9	1 to 12
Ragweed, giant ² <i>Ambrosia trifida</i>	NA	C ²	1 to 3	1 to 6
Redstem ³ <i>Ammania auriculata</i>	NA	C ³	1 to 2	1 to 4
Ricefield Bulrush ² <i>Scirpus mucronatus</i>	NA	C ²	1 to 2	1 to 4
Sesbania, hemp <i>Sesbania exaltata</i>	S	C	1 to 3	1 to 6
Sharppoint fluveolin* ⁴ <i>Kickxia elatine</i>	C	C ⁴	---	---
Shepherdspurse <i>Capsella bursa-pastoris</i>	C	S	1 to 3	1 to 6
Sida, prickly* <i>Sida spinosa</i>	NA	S	1 to 2	1 to 4
Smallflower umbrella sedge ² <i>Cyperus difformis</i>	NA	C ²	1 to 2	1 to 4
Smartweed, Pennsylvania <i>Polygonum pennsylvanicum</i>	C	S	1 to 3	1 to 6
Sunflower <i>Helianthus</i>	C	C	1 to 12	1 to 15
Velvetleaf <i>Abutilon theophrasti</i>	C	C	1 to 9	1 to 12
Willowherb <i>Epilobium ciliatum</i>	C	NA	---	---
Yellowcress, creeping <i>Rorippa sylvestris</i>	C	C	1 to 2	1 to 4

* Except California

1. Heavy infestations of nutsedge may require sequential applications. An earlier treatment may be required to prevent nutsedge from competing with the crop.

2. Certain biotypes of this weed species are known to be resistant to ALS herbicides. Where these ALS-resistant biotypes are known to exist, an appropriate registered herbicide, active against the weed and with another mode of action, should be used alone or in tank mixtures with SANDEA to control these biotypes.
3. Use maximum label rates for best results.
4. Postemergence applications must be made when the basal diameter of the weed is the size of a U.S. quarter or smaller, and before stem elongation.

Table of Contents

CROP	PAGE #	CROP	PAGE #
Alfalfa	40-41	Honeydews	15-17
Artichokes	41-42	Millet	36
Asparagus	42	Okra	43
Beans, Dry	31-32	Pasture, Rangeland, & Forage	43-44
Beans, Succulent	32	Peas, Succulent	33
Bell peppers	22	Pome Fruit Group 11-10	27-29
Blueberries	25-26	Pumpkins	18-19
Caneberries	26-27	Rhubarb	45
Cantaloupes	15-17	Rice	37-39
Chile peppers	22	Sorghum	39
Corn, Field	34-35	Sugarcane	39-40
Corn, Pop	35	Summer Squash	19
Corn, Seed	34-35	Tomatoes	23-24
Corn, Sweet	35	Tree Nuts	29-30
Cotton	35	Turfgrass/Sod	45-47
Crenshaw Melons	15-17	Watermelons	20-21
Cucumbers	15-17	Winter Squash	18-19
Fallow Ground	43		

**APPLICATION INSTRUCTIONS
PREHARVEST INTERVAL**

The required days between last application and harvest (PHI) are given in () after each crop name.

CUCURBIT CROPS

CROP	OZ/ACRE	DIRECTIONS FOR USE
CUCUMBERS (14) <i>(including pickles)</i> MUSKMELON (including cantaloupes) (57), HONEYDEWS (57), AND CRENSHAW MELONS (57)	1/2 - 1	<p>Apply uniformly with ground equipment in a minimum of 15 gal of water per acre.</p> <p>Direct-seeded: Bare ground (no mulch)</p> <ul style="list-style-type: none"> • Preemergence - Apply SANDEA after planting, but prior to soil cracking. Use the lower rate on lighter textured soils with low organic matter. • Postemergence - Apply SANDEA after the crop has reached at least 3 to 5 true leaves but before first female flowers appear. SANDEA can be applied as an over-the-top application, a directed spray application, or with crop shields to minimize contact of the herbicide with the crop. <p>Direct-seeded: Plastic mulch</p> <ul style="list-style-type: none"> • Pre-seeding - Apply SANDEA following final bed shaping and just prior to the installation of the plastic mulch. Crop may be seeded into this treated area no sooner than 7 days after application and the installation of the plastic mulch unless local conditions demonstrate safety at an earlier interval. Use the lower rate on lighter textured soils with low organic matter. • Postemergence - Apply SANDEA after the crop has at least 3 to 5 true leaves but before first female flowers appear. SANDEA can be applied as an over-the-top application, a directed spray application, or with crop shields to minimize contact of the herbicide with the crop. Additional phytotoxicity may occur when applications are made over plastic due to concentration of product in the planting hole. NOTE: Over-the-top applications on plastic are not allowed in Northeastern and Midwestern states. <p>Transplanted: Bare ground (no mulch)</p> <ul style="list-style-type: none"> • Pre-transplant - Apply SANDEA as a pre-transplant application. Crop may be transplanted into this treated area no sooner than 7 days after application unless local conditions demonstrate safety at an earlier interval. Use the lower rate on lighter textured soils with low organic matter. Care should be taken to limit movement of SANDEA-treated surface soil during the transplanting process since if treated soil is moved into the transplant hole injury can occur.

CROP	OZ/ACRE	DIRECTIONS FOR USE
<p>CUCUMBERS (14) <i>(including pickles)</i></p> <p>MUSKMELOON <i>(including cantaloupes)</i></p> <p>(57),</p> <p>HONEYDEWS (57), AND</p> <p>CRENSHAW MELONS (57) <i>(cont'd)</i></p>	<p>1/2 - 1</p>	<ul style="list-style-type: none"> • Post-transplant - Apply SANDEA to transplants that are established and actively growing. Applications should not be made until plants are actively growing and in the 3 to 5 true leaf stage or no sooner than 14 days after transplanting unless local conditions demonstrate safety at an earlier interval, but before first female flowers appear. SANDEA may be applied as an over-the-top application, a directed spray application, or with crop shields to minimize contact of the herbicide with the crop. <p>Transplanted: Plastic mulch</p> <ul style="list-style-type: none"> • Pre-transplant - Apply SANDEA following final bed shaping and just prior to the installation of the plastic mulch. Crop may be transplanted into this treated area no sooner than 7 days after the application and the installation of the plastic mulch unless local conditions demonstrate safety at an earlier interval. Use the lower rate on lighter textured soils with low organic matter. Care should be taken to limit movement of SANDEA-treated surface soil during the transplanting process since if treated soils is moved into the transplant hole injury can occur. • Post-transplant - Apply SANDEA to transplants that are established, actively growing and in the 3 to 5 true leaf stage or no sooner than 14 days after transplanting unless local conditions demonstrate safety at an earlier interval, but before first female flowers appear. Apply SANDEA as an over-the-top application, a directed spray application, or with crop shields to minimize contact of the herbicide with the crop. Additional phytotoxicity can occur when applications are made over plastic due to concentration of product in the transplant hole. NOTE: Over-the-top applications on plastic are not allowed in Northeastern and Midwestern states. <p>Direct-seeded and Transplant:</p> <ul style="list-style-type: none"> • Row Middle/Furrow Applications - Apply SANDEA between rows of direct-seeded or transplanted crop. Avoid contact of the herbicide with the planted crop. If plastic is used on the planted row, adjust equipment to keep the application off the plastic. Reduce rate and spray volume in proportion to area actually sprayed.

CROP	OZ/ACRE	DIRECTIONS FOR USE
CUCUMBERS (14) <i>(including pickles)</i> MUSKMELON <i>(including cantaloupes)</i> (57), HONEYDEWS (57), AND CRENSHAW MELONS (57) <i>(cont'd)</i>	1/2 - 1	Split Applications for Nutsedge: <ul style="list-style-type: none"> • Preemergence followed by postemergence for nutsedge control To maximize control of nutsedge, it may be necessary to use a postemergence application to those areas where the nutsedge has emerged later following a preemergence application. For these situations, use a spot treatment method treating only those areas of emerged nutsedge. Application rate should not exceed 1.0 oz product per treated acre in these areas. Use a water volume that will allow for good coverage of the plants. Avoid contact of the herbicide with the planted crop. • Postemergence followed by postemergence for nutsedge control To maximize control of nutsedge, it may be necessary to use a second postemergence spot application to those areas where the nutsedge has emerged or re-grown. For these situations, use a spot treatment method treating only those areas of emerged nutsedge. Allow a minimum of 21 days between applications. Application rate should not exceed 1.0 oz product per treated acre in these areas. Use a water volume that will allow for good coverage of the plants. Avoid contact of the herbicide with the planted crop.
	1	Rope-wick or Wiper Applications: <ul style="list-style-type: none"> • Row Middle/Furrow Application – Apply using a minimum of 1 oz per acre.
		PRECAUTIONS: <ul style="list-style-type: none"> • Runners that come in contact with the plastic can pick up residual SANDEA and may exhibit a visual crop response. • Consult "Use Precautions" and "For Optimum Results" for important usage information. RESTRICTIONS: <ul style="list-style-type: none"> • Do not apply more than 2 applications or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period. (includes applications to the crop and to row middles/furrows)

CROP	OZ/ACRE	DIRECTIONS FOR USE
PUMPKINS and WINTER SQUASH (30)	1/2 - 3/4	<p>Apply uniformly with ground equipment in a minimum of 15 gal of water per acre. For all applications where possible, apply 1/2 to 3/4 inch of sprinkler irrigation to settle the soil after planting and prior to application.</p> <p>Direct-seeded:</p> <ul style="list-style-type: none"> • Preemergence - Apply SANDEA after planting, but prior to soil cracking. Use the lower rates on lighter textured soils with low organic matter. • Postemergence - Apply SANDEA after the crop has reached the 2 to 5 true leaf stage, preferably 4 to 5 true leaves, but before first female flowers appear. Use lower rates on lighter textured soils with low organic matter. <p>Transplanted:</p> <ul style="list-style-type: none"> • Pre-transplant - Apply SANDEA prior to transplant. Crop may be transplanted into this treated area no sooner than 7 days after application unless local conditions demonstrate safety at an earlier interval. Use the lower rate on lighter textured soils with low organic matter. Care should be taken to limit movement of SANDEA-treated surface soil during the transplanting process since if treated soil is moved into the transplant hole injury can occur. • Post-transplant - Apply SANDEA to transplants that are established, actively growing and in the 3 to 5 true leaf stage or no sooner than 14 days after transplanting unless local conditions demonstrate safety at an earlier interval, but before first female flowers appear. SANDEA can be applied as an over-the-top application, a directed spray application or with crop shields to minimize contact of the herbicide with the crop.
	1/2 - 1	<p>Apply uniformly as a broadcast spray with ground equipment in a minimum of 15 gal of water per acre.</p> <p>FOR PROCESSING ONLY - Direct-seeded:</p> <ul style="list-style-type: none"> • Preemergence - Apply SANDEA after planting, but prior to soil cracking. Use the lower rates on lighter textured soils with low organic matter. • Postemergence - Apply SANDEA after the crop has reached the 2 to 5 true leaf stage, but before first female flowers appear. Use lower rates on lighter textured soils with low organic matter. <p>Direct-seeded and Transplant:</p> <ul style="list-style-type: none"> • Row Middle/Furrow Applications - Apply SANDEA between rows of direct-seeded or transplanted crop while avoiding contact of the herbicide with the planted crop.

CROP	OZ/ACRE	DIRECTIONS FOR USE
PUMPKINS and WINTER SQUASH (30) <i>(cont'd)</i>	1/2 - 1	If plastic is used on the planted row, adjust equipment to keep the application off the plastic. Reduce rate and spray volume in proportion to area actually sprayed.
	1	Rope-wick or Wiper Applications: <ul style="list-style-type: none"> • Row Middle/Furrow Application – Apply using a minimum of 1 oz per acre.
	PRECAUTIONS: <ul style="list-style-type: none"> • When rainfall or irrigation in excess of 3/4 inch occurs following a preemergence application and the crop is in the germination to early-seedling stage, there is the potential for significant plant stunting to occur. • Consult "Use Precautions" and "For Optimum Results" for important usage information. RESTRICTIONS: <ul style="list-style-type: none"> • Do not apply more than 2 applications of 1 oz/A or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period. (includes applications to the crop and to row middles). 	
SUMMER SQUASH FOR PROCESSING (30) (AR, OK and MO only)	2/3 - 1	Apply uniformly with ground equipment in a minimum of 20 gal of water per acre. Direct-seeded: <ul style="list-style-type: none"> • Preemergence - Apply SANDEA after planting, but prior to cracking. Use the lower rate on lighter textured soils with low organic matter.
	1/2 - 1	Direct-seeded and Transplant: <ul style="list-style-type: none"> • Row Middle/Furrow Applications - Apply SANDEA between rows of direct-seeded or transplanted summer squash. If plastic is used on the planted row, adjust equipment to keep the application off the plastic. Reduce rate and spray volume in proportion to area actually sprayed. Avoid contact of the herbicide with the planted crop.
	1	Rope-wick or Wiper Applications: <ul style="list-style-type: none"> • Row Middle/Furrow Application – Apply using a minimum of 1 oz per acre.
	PRECAUTIONS: <ul style="list-style-type: none"> • Consult "Use Precautions" and "For Optimum Results" for important usage information. RESTRICTIONS: <ul style="list-style-type: none"> • Do not apply more than 2 applications of 1 oz/A or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period. (includes applications to the crop and to Row Middles/Furrows) 	

CROP	OZ/ACRE	DIRECTIONS FOR USE
<p>WATERMELONS (57) Only: AL, AR, AZ, CA, CT, DE, FL, GA, IL, IN, KS, KY, LA, MA, MD, ME, MI, MO, MS, NC, NH, NJ, NY, OH, OK, OR, PA, RI, SC, TN, TX, VA, VT, WA, WV, WI</p>	<p>1/2 - 3/4</p>	<p>Apply uniformly with ground equipment in a minimum of 20 gal of water per acre.</p> <p>Direct-seeded: Bare ground</p> <ul style="list-style-type: none"> • Preemergence - Apply SANDEA after planting, but prior to soil cracking. Use the lower rate on lighter textured soils with low organic matter. Where soil is fumigated prior to planting, allow at least five days after soil fumigation before an application of SANDEA. <p>Direct Seeded: Plastic mulch</p> <ul style="list-style-type: none"> • Pre-seeding - Apply SANDEA following final bed shaping and just prior to the installation of the plastic mulch. Watermelons should be seeded into this treated area no sooner than 7 days after the application and the installation of the plastic mulch unless local conditions demonstrate safety at an earlier interval. Use the lower rate on lighter textured soils with low organic matter. SANDEA treated soil from the soil surface into the planting hole can result in crop injury. Care should be taken to limit movement of SANDEA treated surface soil during the transplant process. <p>Transplanted: Bare ground</p> <ul style="list-style-type: none"> • Pre-transplant - Apply SANDEA pre-transplant. Watermelons should be transplanted into this treated area no sooner than 7 days after application unless local conditions demonstrate safety at an earlier interval. Use the lower rate on lighter textured soils with low organic matter. Care should be taken to limit movement of SANDEA-treated surface soil during the transplanting process since if treated soils is moved into the transplant hole injury can occur. <p>Transplanted: Plastic mulch</p> <ul style="list-style-type: none"> • Pre-transplant - Apply SANDEA following final bed shaping and just prior to the installation of the plastic mulch. Watermelons should be transplanted into this treated area no sooner than 7 days after the application and the installation of the plastic mulch unless local conditions demonstrate safety at an earlier interval. Use the lower rate on lighter textured soils with low organic matter. Care should be taken to limit movement of SANDEA treated surface soil during the transplanting process since if treated soils is moved into the transplant hole injury can occur.

CROP	OZ/ACRE	DIRECTIONS FOR USE
WATERMELONS (57) Only: AL, AR, AZ, CA, CT, DE, FL, GA, IL, IN, KS, KY, LA, MA, MD, ME, MI, MO, MS, NC, NH, NJ, NY, OH, OK, OR, PA, RI, SC, TN, TX, VA, VT, WA, WV, WI <i>(cont'd)</i>	1/2 - 1	Direct-seeded and Transplant: <ul style="list-style-type: none"> • Row Middle Applications - Apply SANDEA between rows of direct-seeded or transplanted crop, while avoiding contact of the herbicide with the planted crop. If plastic is used on the planted row, adjust equipment to keep the application off the plastic. Reduce rate and spray volume in proportion to area actually sprayed.
	1	Rope-wick or Wiper Applications: <ul style="list-style-type: none"> • Row Middle/Furrow Application - Apply using a minimum of 1 oz per acre.
PRECAUTIONS: <ul style="list-style-type: none"> • Runners that come in contact with the plastic can pick up residual SANDEA and may exhibit a visual crop response. • Consult "Use Precautions" and "For Optimum Results" for important usage information. RESTRICTIONS: <ul style="list-style-type: none"> • Do not apply more than 2 applications or 1 oz/A of product by weight (0.047 lb a.i./acre) per 12 month period. (includes applications to the crop and to row middle) 		
OTHER COMMODITIES IN THE CUCURBIT VEGETABLES GROUP <i>Including but not limited to summer squash, gourd, watermelon</i> (See text for PHI)	1/2 - 1	Direct-seeded and Transplant: <ul style="list-style-type: none"> • Row Middle/Furrow Applications - Apply SANDEA between rows of direct-seeded or transplanted cucurbit vegetables while avoiding contact of the herbicide with the planted crop. If plastic is used on the planted row, adjust equipment to keep the application off the plastic. Reduce rate and spray volume in proportion to area actually sprayed.
	1	Rope-wick or Wiper Applications: <ul style="list-style-type: none"> • Row Middle/Furrow Application - Apply using a minimum of 1 oz per acre.
PRECAUTIONS: <ul style="list-style-type: none"> • Consult "Use Precautions" and "For Optimum Results" for important usage information. RESTRICTIONS: <ul style="list-style-type: none"> • Do not apply within 30 days of harvest for squash/cucumber subgroup. • Do not apply within 57 days of harvest for melon subgroup. • Do not apply more than 2 applications or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period. 		

FRUITING VEGETABLE CROPS

CROP	OZ/ACRE	DIRECTIONS FOR USE
PEPPERS, BELL/ CHILE (30) AZ, CA, NM, TX and OK Only	1/2 - 1	Apply uniformly with ground equipment in a minimum of 20 gal of water per acre. Direct-seeded: <ul style="list-style-type: none"> • Postemergence - Apply SANDEA as a directed spray 28 days after planting or when the plants have reached a minimum of six inches in height, but prior to flowering. Use lower rates on lighter textured soils with low organic matter. Transplanted: <ul style="list-style-type: none"> • Post-transplant – Apply SANDEA as a directed spray 21 days after transplanting or when the plants have reached a minimum of six inches in height, but prior to flowering.
	1/2 - 1	Direct-seeded and Transplant: <ul style="list-style-type: none"> • Row Middle/Furrow Applications - Apply SANDEA between rows of direct-seeded or transplanted peppers while avoiding contact of the herbicide with the planted crop. If plastic is used on the planted row, adjust equipment to keep the application off the plastic. Reduce rate and spray volume in proportion to area actually sprayed.
	1	Rope-wick or Wiper Applications: <ul style="list-style-type: none"> • Row Middle/Furrow Application – Apply using a minimum of 1 oz per acre.
		PRECAUTIONS: <ul style="list-style-type: none"> • Not all pepper varieties have been tested. • Consult "Use Precautions" and "For Optimum Results" for important usage information. RESTRICTIONS: <ul style="list-style-type: none"> • Do not apply more than 2 applications or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period. (includes applications to the crop and to row middles/furrows).

CROP	OZ/ACRE	DIRECTIONS FOR USE
TOMATOES (30)	1/2 - 1	<p>Apply uniformly with ground equipment in a minimum of 20 gal of water per acre.</p> <p>Direct-seeded:</p> <ul style="list-style-type: none"> • Postemergence - Apply SANDEA over-the-top once tomatoes have reached the 4 leaf stage through 30 days prior to harvest. Applications following bloom could cause some bloom drop under certain environmental conditions. Apply as a directed spray or with crop shield when these conditions are present. <p>Transplanted:</p> <ul style="list-style-type: none"> • Pre-transplant on Bareground - Apply SANDEA as a pre-plant application to bareground. Tomatoes can be transplanted into this treated area 7 days after the application unless local conditions demonstrate safety at an earlier interval. Use lower rate on lighter textured soils with low organic matter. SANDEA treated soil from the soil surface into the transplant hole can result in crop injury. Care should be taken to limit the movement of treated surface soil during the transplant process. • Pre-transplant Under Plastic Mulch Applications - Apply SANDEA following final bed shaping and just prior to the installation of the plastic mulch. Tomatoes can be transplanted into this treated area 7 days after the application and the installation of the plastic mulch unless local conditions demonstrate safety at an earlier interval. SANDEA treated soil from the soil surface into the transplant hole can result in crop injury. Care should be taken to limit movement of SANDEA treated surface soil during the transplant process. • Post-transplant - Apply SANDEA over-the-top, post directed or with crop shields to tomato transplants that are established, actively growing and a minimum of 14 days after transplanting unless local conditions demonstrate safety at an earlier interval. Applications following bloom could cause some bloom drop under certain environmental conditions. Application as a directed spray or with crop shields should be considered when conditions are present. <p>Direct-seeded and Transplant:</p> <ul style="list-style-type: none"> • Row Middle/Furrow Applications - Apply SANDEA between rows for the control of nutsedge and listed broadleaf weeds. Avoid contact of the herbicide with the planted crop. If plastic is used on the planted row, adjust equipment to keep the application off the plastic. Reduce rate and spray volume in proportion to area actually sprayed.

CROP	OZ/ACRE	DIRECTIONS FOR USE
TOMATOES (30) (cont'd)	1/2 - 1	<p>Split Applications for Nutsedge Direct-seeded and Transplant:</p> <ul style="list-style-type: none"> • Pre-transplant followed by postemergence for nutsedge control To maximize control of nutsedge, it may be necessary to use a postemergence application to those areas where the nutsedge has broken through the plastic mulch. For these situations, use a spot treatment method treating only those areas of emerged nutsedge. Application rate should not exceed 3/4 oz product per treated acre in these areas. Use a water volume that will allow for good coverage of the plants. SANDEA treated soil in the transplant hole may result in crop injury. If transplanting after herbicide application, care should be taken to limit movement of SANDEA treated soil during the transplant process. • Postemergence followed by postemergence for nutsedge control To maximize control of nutsedge, it may be necessary to use a postemergence spot application to those areas where the nutsedge has germinated or regrown. Allow a minimum of 21 days between applications. Application rate should not exceed 1 oz product per treated acre in these areas.
	1	<p>Rope-wick or Wiper Applications:</p> <ul style="list-style-type: none"> • Row Middle/Furrow Application – Apply using a minimum of 1 oz per acre.
		<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • Consult "Use Precautions" and "For Optimum Results" for important usage information. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Do not apply more than 2 applications or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period. (Includes applications to the crop and to row middles/furrows).
FRUITING VEGETABLES GROUP (30) Including but not limited to eggplant, peppers, tomatoes	1/2 - 1	<p>Direct-seeded and Transplant:</p> <ul style="list-style-type: none"> • Row Middle/Furrow Applications - Apply SANDEA between rows of direct-seeded or transplanted fruiting vegetables while avoiding contact of the herbicide with the planted crop. If plastic is used on the planted row, adjust equipment to keep the application off the plastic. Reduce rate and spray volume in proportion to area actually sprayed.

CROP	OZ/ACRE	DIRECTIONS FOR USE
FRUITING VEGETABLES GROUP (30) <i>Including but not limited to eggplant, peppers, tomatoes (Cont'd)</i>	1	Rope-wick or Wiper Applications: • Row Middle/Furrow Application – Apply using a minimum of 1 oz per acre.
		PRECAUTIONS: • Consult "Use Precautions" and "For Optimum Results" for important usage information. RESTRICTIONS: • Do not apply more than 2 applications or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period.

PERMANENT CROPS

CROP	OZ/ACRE	DIRECTIONS FOR USE
13-07B HIGHBUSH BLUEBERRIES (14)	1/2 - 2/3 1 - 4 year bushes	Apply uniformly with ground equipment in a minimum of 15 gal of water per acre. Apply as a directed spray application to the ground on either side of the row.
	1/2 - 1 >4 year bushes	<ul style="list-style-type: none"> • Preemergence and Postemergence directed application for control of labeled weeds: Apply SANDEA as a single or sequential directed spray application. If small weeds are present tank mix with a postemergence broad-spectrum type herbicide to maximize and enhance the spectrum of broadleaf and grass control. Preemergence applications of SANDEA when ground cover prevents contact with the soil will result in reduced or no residual activity • Postemergence directed application for control of nutsedge: Apply SANDEA as a single directed spray application when nutsedge is fully emerged. Alternatively, two directed spray applications can be made. Apply first directed spray application to the initial nutsedge flush when it has reached the 3 to 5 leaf stage. If a second treatment is needed, it may be applied later in the season directed to secondary nutsedge emergence. To maximize control, apply SANDEA when nutsedge plants are in the 3 to 5 leaf stage. For best results, use a minimum of 0.75 oz/A of SANDEA. SANDEA may not control ALS resistant weeds.
		PRECAUTIONS: • Contact of SANDEA with the blueberry bushes should be avoided. Contact will result in temporary chlorosis of treated leaves. • Use of a shielded boom is recommended. • Consult "Use Precautions" and "For Optimum Results" of label for important usage information.

PERMANENT CROPS

CROP	OZ/ACRE	DIRECTIONS FOR USE
<p>13-07B HIGHBUSH BLUEBERRIES (14) (Cont'd)</p>		<p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Minimum of 45 days between applications. • Do not concentrate the application rate into the treated swath. • Do not apply to bushes established less than one year or to plants under stress. • Do not apply to 'Elliott' variety bushes established less than four years. • Do not apply to areas where water is known to pond for periods of time following rainfall. • Do not contact foliage or green wood renewal canes with SANDEA. Herbicide uptake via contacted foliage or green canes will result in plant injury. • Do not apply more than 2 applications or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period. • Do not apply by rope-wick wiper application.
<p>13-07A CANEBERRY SUBGROUP (14) (Blackberry; loganberry; raspberry, black and red; wild raspberry; cultivars, varieties and/ or hybrids of these) (For use in Oregon and Washington only)</p>	<p>3/4 – 1 1/3</p>	<p>Apply SANDEA uniformly with ground equipment in a minimum of 15 gal of water per acre.</p> <ul style="list-style-type: none"> • Apply as a broadcast directed spray application to the ground on either side of the row. Applications of SANDEA should be made pre-emergence up to and including primocane burndown. Do not apply to developing primocanes in season until hardened off. • Preemergence and Postemergence directed application for control of labeled weeds: Apply a single or sequential application based on weed pressure. If small weeds are present tank mix with a postemergence broad-spectrum type herbicide to maximize and enhance the spectrum of broadleaf and grass control. For preemergence control, do not apply SANDEA if excessive weed growth prevents contact with the ground. • Postemergence directed application for control of nutsedge: Apply SANDEA as a single directed spray application when nutsedge is fully emerged. Alternatively, two directed spray applications can be made. Apply first directed spray application to the initial nutsedge flush when it has reached the 3 to 5 leaf stage. If a second treatment is needed, it may be applied later in the season directed to secondary nutsedge emergence. To maximize control, apply SANDEA when nutsedge plants are in the 3 to 5 leaf stage. For best results, use a minimum of 0.75 oz/A of SANDEA.
	<p>1</p>	<p>Rope-wick or Wiper Applications:</p> <ul style="list-style-type: none"> • Row Middle/Furrow Application – Apply using a minimum of 1 oz per acre.

CROP	OZ/ ACRE	DIRECTIONS FOR USE
<p>13-07A CANEBERRY SUBGROUP (14) (Blackberry; loganberry; raspberry; black and red; wild raspberry; cultivars, varieties and/ or hybrids of these) (For use in Oregon and Washington only) (Cont'd)</p>		<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • For best results, use a non-ionic surfactant (NIS) with applications. • Consult "Use Precautions" and "For Optimum Results" for important usage information. • Contact of SANDEA with the caneberry bushes should be avoided. Contact will result in temporary chlorosis of treated leaves. • Use of a shielded boom is recommended. • SANDEA may not control ALS resistant weeds. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Minimum of 45 days between applications. • Do not concentrate the application rate into the treated swath. • Do not apply to areas where water is known to pond for periods of time following rainfall. • Do not apply to bushes established less than one year or to plants under stress. • Do not contact foliage or green wood renewal canes with SANDEA. Herbicide uptake via contacted foliage or green canes will result in plant injury. • Do not apply more than 2 applications or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period. • Do not apply by air. • Do not apply to developing primocanes in season until hardened off.
<p>11-10 POME FRUIT GROUP (14) (West of the Rockies) Apple; azarole; crabapple; loquat; mayhaw; medlar; pear; pear, Asian; quince; quince, Chinese; quince, Japanese; tejacote; cultivars, varieties, and/ or hybrids of these</p>	3/4 – 2	<p>Apply uniformly with ground equipment in a minimum of 15 gal of water per acre.</p> <ul style="list-style-type: none"> • Postemergence application for control of nutsedge: Apply SANDEA as a single broadcast application to orchard floor on either side of the row when nutsedge is fully emerged (early - midsummer). Alternatively, two applications can be made. Apply first application to the initial nutsedge flush when it has reached the 3-5 leaf stage. If a second treatment is needed, apply SANDEA later in the season directed to secondary nutsedge emergence. To maximize nutsedge control, do not apply if nutsedge has exceeded 12 inches in height. • Preemergence and Postemergence application for control of labeled broadleaf weeds: Apply SANDEA as a single or sequential broadcast application to orchard floor on either side of the row based on weed pressure. If small weeds are present, to maximize and enhance the spectrum of broadleaf control tank mix with a postemergence broad spectrum type herbicide. Preemergence applications of SANDEA when ground cover prevents contact with the soil will result in reduced or no residual activity.

CROP	OZ/ACRE	DIRECTIONS FOR USE
11-10 POME FRUIT GROUP (14) (West of the Rockies) Apple; azarole; crabapple; loquat; mayhaw; medlar; pear; pear, Asian; quince; quince, Chinese; quince, Japanese; tejocote; cultivars, varieties, and/or hybrids of these (Cont'd)		PRECAUTIONS: <ul style="list-style-type: none"> • For best results, use a NIS or penetrating type surfactant. • Avoid spray contact with tree foliage and fruit with spray or drift. • Consult "Use Precautions" and "For Optimum Results" sections for important usage information. • SANDEA may not control ALS resistant weeds. RESTRICTIONS: <ul style="list-style-type: none"> • Do not apply when orchard temperatures exceed 85°F at the time of application. • Do not concentrate the application rate into the treated swath. • Do not apply to trees established in a permanent orchard less than one calendar year. • Do not apply to nursery stock. • Minimum of 45 days between applications. • Do not apply more than 2 applications or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period. • Do not apply by rope-wick wiper application.
11-10 POME FRUIT GROUP (14) (East of the Rockies) (Apple; azarole; crabapple; loquat; mayhaw; medlar; pear; pear, Asian; quince; quince, Chinese; quince, Japanese; tejocote; cultivars, varieties, and/or hybrids of these)	1/2 - 1	Apply uniformly with ground equipment in a minimum of 15 gal of water per acre. <ul style="list-style-type: none"> • Postemergence application for control of nutsedge: Apply SANDEA as a single broadcast application to orchard floor on either side of the row when nutsedge is fully emerged. Alternatively, two applications can be made. Apply first application to the initial nutsedge flush when it has reached the 3-5 leaf stage. If a second treatment is needed, it may be applied later in the season directed to secondary nutsedge emergence. To maximize nutsedge control, apply SANDEA when nutsedge plants are in the 3-5 leaf stage. For best results, use a minimum of 0.75 oz/A of SANDEA. • Preemergence and Postemergence application for control of labeled broadleaf weeds: Apply SANDEA as a single or sequential broadcast application to orchard floor on either side of the row based on weed pressure. For best results, apply to bare ground. If small weeds are present, to maximize and enhance the spectrum of broadleaf control tank when ground cover prevents contact with the soil will result in reduced or no residual activity. Mix with a postemergence broad-spectrum type herbicide. Preemergence applications of SANDEA when ground cover prevents contact with the soil will result in reduced or no residual activity.

CROP	OZ/ACRE	DIRECTIONS FOR USE
<p>11-10 POME FRUIT GROUP (14) (East of the Rockies) (Apple; azarole; crabapple; loquat; mayhaw; medlar; pear; pear, Asian; quince; quince, Chinese; quince, Japanese; tejocote; cultivars, varieties, and/ or hybrids of these) (Cont'd)</p>		<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • For best results, use a NIS with postemergence applications. • Avoid spray or drift contact with tree foliage and fruit. • Consult "Use Precautions" and "For Optimum Results" sections for important usage information. • SANDEA may not control ALS resistant weeds. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Do not apply when orchard temperatures exceed 85°F at the time of application. • Do not concentrate the application rate into the treated swath. • Do not apply to trees established in a permanent orchard less than one calendar year. • Do not apply to nursery stock. • Minimum of 45 days between applications. • Do not apply more than 2 applications or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period. • Do not apply by rope-wick wiper application.
<p>TREE NUT CROP GROUP 14 including PISTACHIOS (1) (Excluding Almonds)</p>	<p>2/3 - 1 1/3</p>	<p>Apply SANDEA as a directed spray to established tree nut crops. Established tree nut crops are defined as those that have been transplanted into their final growing location for a period of at least 12 months, and where the soil has firmly settled around the roots from packing and rainfall or irrigation.</p> <ul style="list-style-type: none"> • Extreme care must be exercised to avoid contact of spray containing SANDEA with trunk, stems, roots, or foliage of tree nut crops, or severe damage or death may result. • Labeled rates are based on broadcast treatment. For band applications reduce the broadcast rate of SANDEA in proportion to the area actually sprayed. For all applications, adjust the rate of SANDEA to account for high volume output nozzles, such as off-center nozzles, and overlaps in the spray pattern. Use of controlled droplet application, spot application, irrigation, or chemigation equipment for application of this product is not recommended due to variations in the actual application rate. Excessive application rates can result in severe tree injury or death.

CROP	OZ/ACRE	DIRECTIONS FOR USE
<p>TREE NUT CROP GROUP 14 including PISTACHIOS (1) (Excluding Almonds)</p> <p>(cont'd)</p>	<p>2/3 - 1 1/3</p>	<ul style="list-style-type: none"> • Use a maximum of 1 oz by weight (0.047 lb active ingredient) SANDEA per acre on coarse textured soils classified as sands, loamy sands, and sandy loams with less than 18% clay and more than 65% sand, or on soils with less than 1% organic matter. Do not apply to gravelly soils. For the best results apply SANDEA in the spring when nutsedge is not drought stressed and maximize the interval between application and subsequent irrigation. • Mechanical cultivation or mowing may be required to control weed species not on the SANDEA label. If so, a sequential treatment may be required to control weeds in areas of disturbed soil. • If SANDEA is applied to trees that have been weakened by or recovering from stress caused by, but not limited to, excessive fertilizer or soil salts, disease, nematodes, frost, wind injury, drought, flooding, previously applied pesticides, insects, winter injury, soil pan of any type, nutrient deficiency, or mechanical damage, severe injury or death may result. Application of SANDEA to weakened or stressed trees as described, especially in soils with less than 1% organic matter, significantly increases the probability of severe injury or death. • SANDEA may be applied at 2/3 to 1 1/3 oz by weight per acre in combination with glyphosate agricultural herbicides for control of emerged annual grasses, broadleaf weeds and nutsedge.
<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • Consult "Use Precautions" and "For Optimum Results" for important usage information. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Refer to the "Rotational Crop Restrictions" for applicable rotational crop information. • Do not apply more than 2 applications or 2 2/3 oz/A of product by weight (0.125 lb active ingredient) per 12 month period. On coarse textured soils classified as sand, loamy sand, and sandy loam with less than 18% clay and more than 65% sand, or on soils with less than 1% organic matter, do not apply more than 2 applications or 2 oz/A of product by weight (0.094 lb ai/acre) per 12 month period. • Do not apply by rope-wick wiper application. 		

FIELD CROPS

CROP	OZ/ACRE	DIRECTIONS FOR USE
BEANS, DRY (30)	1/2 - 2/3	<p>Apply uniformly with ground equipment in a minimum of 15 gal of water per acre.</p> <p>Direct-seeded:</p> <ul style="list-style-type: none"> • Preemergence - Apply SANDEA after planting but prior to soil cracking. Use the lower rate on lighter textured soils with low organic matter. • Postemergence - Apply SANDEA when plants have 1 to 3 trifoliolate leaves, but before flowering. Applications with a weed size of 6 inches or below will allow for the greatest control. Make only one broadcast application per season. • Only apply as a post directed row middle or furrow application in the state of California. <p style="text-align: center;">Tank Mixtures for Dry Beans:</p> <ul style="list-style-type: none"> • It is the pesticide user's responsibility to ensure that all products in the listed mixtures are registered for the intended use. Users must follow the most restrictive directions and precautionary language of the products in the mixture. • Tank mixtures for additional broadleaf weed control can be added. • Tank mixtures for postemergent grass control, including but not limited to TARGA® or other graminicides can be added.
<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • Consult "Use Precautions" and "For Optimum Results" sections for important usage information. • Not all varieties have been tested for tolerance. Under adverse growing conditions (dry or excessive moisture, cool weather, etc.), maturity of the treated crop may be delayed which can influence harvest date, yield, and quality. • Use of COC or MSO adjuvant may cause temporary crop response when plants are under stress. 		
<p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • COC or MSO adjuvants can only be used in the states of CO, MN, NE, ND, and SD. • Do not apply more than 2 applications of 2/3 OZ/A per crop cycle, not to exceed 2 OZ/A of product by weight (0.094 lb a.i./acre) per 12 month period. • Do not apply by rope-wick wiper application. 		
	1/2 - 1	<ul style="list-style-type: none"> • Row Middle/Furrow Applications for Dry Beans - Apply SANDEA between crop rows while avoiding contact of the herbicide with the planted crop. Reduce rate and spray volume in proportion to area actually sprayed.

CROP	OZ/ACRE	DIRECTIONS FOR USE
BEANS, DRY (30) (<i>cont'd</i>)		<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> Consult "Use Precautions" and "For Optimum Results" for important usage information. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> Do not apply more than 2 applications or 1 oz/A of product by weight (0.047 lb a.i./acre) per crop-cycle, not to exceed 2 oz/A (0.094 lb a.i./acre) per 12 month period (includes applications to the crop and to row middles/furrows). Do not apply by rope-wick wiper application.
BEANS, SUCCULENT SNAP (30) (<i>including lima beans</i>)	1/2 - 1	<p>Direct-seeded:</p> <ul style="list-style-type: none"> Preemergence - Apply SANDEA after planting but prior to soil cracking. Use the lower rate on lighter textured soils with low organic matter. Apply uniformly with ground equipment in a minimum of 15 gal of water per acre.
	1/2 - 2/3	<p>Direct-seeded:</p> <ul style="list-style-type: none"> Postemergence - Apply SANDEA over-the-top after the crop has reached the 2 to 4 trifoliate leaf stage, but before flowering. Use the lower rate on lighter textured soils with low organic matter. Directed sprays may limit crop injury.
	1/2 - 1	<ul style="list-style-type: none"> Row Middle/Furrow Applications - Apply SANDEA between crop rows while avoiding contact of the herbicide with the planted crop. Reduce rate and spray volume in proportion to area actually sprayed.
		<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> Application of SANDEA may cause temporary stunting. Consult "Use Precautions" and "For Optimum Results" for important usage information. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> Do not apply more than 2 applications or 1 oz/A of product by weight (0.047 lb a.i./acre) per crop-cycle, not to exceed 2 oz/A (0.094 lb a.i./acre) per 12 month period (includes applications to the crop and to row middles/furrows). Do not apply by rope-wick wiper application.
	1/2 - 1	<p>Preplant or At Planting:</p> <p>Apply uniformly with ground equipment in a minimum of 15 gal of water per acre.</p> <ul style="list-style-type: none"> Incorporation: Apply and incorporate 1/2 to 1 oz SANDEA with EPTAM 7-E at a depth of approximately 2 inches just before planting. Use lower rate on lighter textured soils with low organic matter. Refer to EPTAM 7-E label for specific incorporation directions. Rotary hoe lightly during or shortly after emergence of the beans to break any crust that occurs.

CROP	OZ/ACRE	DIRECTIONS FOR USE
6B SUCCULENT SHELLED PEA AND BEAN SUBGROUP (30) (Any succulent shelled cultivar of bean (<i>Phaseolus</i>) including lima bean, green; broad bean, succulent; (vigna) including blackeyed pea, cowpea, southern pea)	1/2	<p>Preemergence application for control of labeled broadleaf weeds - Apply SANDEA as a single broadcast application after planting but before crop emergence. Application of SANDEA may cause significant, temporary stunting and delay maturity of peas resulting in delayed harvest. This product is available to the end-user /grower solely to the extent that the benefit and utility, in the sole opinion of the end-user/ grower, outweigh the extent of potential injury associated with the use of this product.</p> <p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • Consult "Use Precautions" and "For Optimum Results" for important usage information. • SANDEA may not control ALS resistant weeds. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Do not apply more than 1 application or 1/2 oz/A of product by weight (0.023 lb a.i./acre) per 12 month period. • Do not feed to livestock. • Do not apply SANDEA to English peas and garden peas. • Do not apply by rope-wick wiper application.
	1/2 - 1	<p>Postemergence – Apply SANDEA uniformly with ground equipment in a minimum of 15 gal of water per acre. Apply as a directed spray when plants have 2 to 4 trifoliolate leaves and before flowering. Make one broadcast application. Directed sprays are recommended to limit crop injury. Not all varieties have been tested for tolerance. Under adverse growing conditions (dry or excessive moisture, cool weather, etc.), maturity of the treated crop may be delayed which can influence harvest date, yield, and quality. For untested varieties, a small area of the field should be sprayed to determine potential sensitivity to its use.</p> <p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • For best results, use a NIS with applications. • Consult "Use Precautions" and "For Optimum Results" for important usage information. • SANDEA may not control ALS resistant weeds. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Do not apply more than 2 applications or 1 oz/A of product by weight (0.047 lb a.i./acre) per crop cycle, not to exceed 2 oz/A (0.094 lb a.i./acre) per 12 month period. • Do not feed to livestock. • Do not apply SANDEA to Adzuki beans, English peas and garden peas. • Do not apply by rope wick wiper application.

CROP	OZ/ACRE	DIRECTIONS FOR USE
CORN, FIELD AND FIELD CORN GROWN FOR SEED (30)	2/3 - 1 1/3	<p>Postemergence - Apply SANDEA over-the-top or with drop nozzles from the spike-through layby stage of field corn.</p> <p><u>Tank Mixtures for Corn Only</u></p> <p>It is the pesticide user's responsibility to ensure that all products in the listed mixtures are registered for the intended use. Users must follow the most restrictive directions and precautionary language of the products in the mixture.</p> <p>Ensure that spray equipment is set up to avoid applying an excessive rate directly over the rows and into the whorl of the cornstalk. To insure good spray coverage of weeds and to reduce the risk of spraying directly into the whorl, tank mix applications made after corn is 24 inches tall should be directed or semi-directed using drop nozzles.</p> <p><u>SANDEA Post Field Corn Applications</u></p> <p>It is the pesticide user's responsibility to ensure that all products in the listed mixtures are registered for the intended use. Users must follow the most restrictive directions and precautionary language of the products in the mixture.</p> <p>Before mixing in the spray tank, it is recommended that compatibility be tested by mixing all components in a small container in proportionate quantities. For tank mixtures, add individual formulations to a spray tank in the following sequence: water soluble bags, dry flowables, emulsifiable concentrates, drift control additive, water soluble liquids followed by NIS or COC.</p> <p>Tank mixtures should not be applied if the crop is under severe stress due to drought, water-saturated soils, poor fertility (especially low nitrogen levels), hail, frost, insects or when the maximum daytime temperature is above 92° F at time of application. Tank mix applications under these conditions may cause temporary crop injury.</p> <p>Tank mixtures for additional broadleaf weed control, including but not limited to 2,4-D, Armezon™, atrazine, Buctril®, Callisto®, dicamba, Impact®, Laudis® or Yukon® can be added.</p> <p>Tank mixtures for postemergence grass control, including but not limited to Accent®, Beacon®, Option® or Steadfast® can be added.</p> <p>Tank mixtures for additional postemergence grass and broadleaf control, including but not limited to Roundup® brands or glyphosate (glyphosate-tolerant corn only) or Ignite® and Liberty® (LibertyLink® hybrids only) can be added.</p> <p><u>SANDEA and SOIL RESIDUALS in emerged corn</u></p> <p>Alachlor, acetochlor, metolachlor and dimethenamid may be tank mixed with SANDEA for residual control of foxtails and other grass weeds in field corn.</p>

CROP	OZ/ACRE	DIRECTIONS FOR USE
CORN, FIELD AND FIELD CORN GROWN FOR SEED (30) <i>(cont'd)</i>		<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> Refer to "Mixing Instructions" and "Use Rate Guides" for detailed information on SANDEA application. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> Do not apply more than 2 applications or 2 2/3 oz/A of product by weight (0.125 lb a.i./acre) per 12 month period. Refer to the "Rotational Crop Restrictions" for applicable rotational crop information. Following application to foliage, allow 30 days before grazing domestic livestock, harvesting forage, or harvesting silage. Do not apply by rope-wick wiper application.
CORN, SWEET AND POPCORN (30)	2/3 - 1	<p>Apply SANDEA over-the-top or with drop nozzles from the spike through layby stage of the corn. If necessary, a sequential treatment of this product at 2/3 oz per acre may be applied only with drop nozzles semi-directed or directed to avoid application into the corn plant whorl.</p> <p>PRECAUTIONS:</p> <ul style="list-style-type: none"> Consult "Use Precautions" and "For Optimum Results" for important usage information. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> Do not apply more than 2 applications of SANDEA per 12 month period in sweet corn or popcorn. Following application to foliage, allow 30 days before grazing domestic livestock, harvesting forage, or harvesting silage. Do not use SANDEA on "Jubilee" sweet corn. All varieties have not been tested for sensitivity to SANDEA. Do not apply by rope-wick wiper application.
COTTON (28)	2/3 - 1 1/3	<p>Apply SANDEA as a directed spray in hooded equipment for postemergent weed control in emerged cotton. Applications may be made anytime after cotton emergence until row closure inhibits use of hooded spray equipment. The applicator is responsible for maintaining proper spray speed and equipment position so spray mist does not contact cotton plants.</p> <p>PRECAUTIONS:</p> <ul style="list-style-type: none"> Consult "Use Precautions" and "For Optimum Results" for important usage information. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> Do not apply more than 2 applications or 1 1/3 oz/A of product by weight (0.062 lb a.i./acre) per 12 month period. Refer to the "Rotational Crop Information" for applicable rotational crop restrictions. Do not apply by rope-wick wiper application.

CROP	OZ/ACRE	DIRECTIONS FOR USE																							
MILLET, PROSO (0 Millet Forage) (50 Millet Grain and Straw) (37 Millet Hay)	1/2 - 2/3	<p>Millet Growth Stage: SANDEA, alone, can be applied from the 2 leaf through layby stage (before grain head emergence). Temporary stature reduction may occur to the crop following application of SANDEA if the proso millet is under stress. This effect will be most evident 7 to 10 days after application. The crop will quickly recover under normal growing conditions. Applications should be made after weed emergence and actively growing. If adding a tank mix, refer to the tank mix section of this label.</p> <p>TANK MIXTURES</p> <p>It is the pesticide user's responsibility to ensure that all products in the listed mixtures are registered for the intended use. Users must follow the most restrictive directions and precautionary language of the products in the mixture. Tank mixtures for additional broadleaf weed control, including but not limited to 2,4-D, and dicamba can be added. Insecticide and fungicide products can be tank mixed with SANDEA.</p> <p>Listed day intervals following an application of SANDEA.</p> <table border="1"> <thead> <tr> <th rowspan="2">CROP</th> <th colspan="3">All Animals (Lactating and Non-lactating)</th> </tr> <tr> <th>Pre-Grazing Interval (PGI)</th> <th>Pre-Harvest Interval (PHI)</th> <th>Pre-Slaughter Interval (PSI)</th> </tr> </thead> <tbody> <tr> <td>Millet Forage</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>Millet Grain</td> <td>N/A</td> <td>50</td> <td>0</td> </tr> <tr> <td>Millet Straw</td> <td>N/A</td> <td>50</td> <td>0</td> </tr> <tr> <td>Millet Hay</td> <td>N/A</td> <td>37</td> <td>0</td> </tr> </tbody> </table>	CROP	All Animals (Lactating and Non-lactating)			Pre-Grazing Interval (PGI)	Pre-Harvest Interval (PHI)	Pre-Slaughter Interval (PSI)	Millet Forage	0	0	0	Millet Grain	N/A	50	0	Millet Straw	N/A	50	0	Millet Hay	N/A	37	0
		CROP		All Animals (Lactating and Non-lactating)																					
Pre-Grazing Interval (PGI)	Pre-Harvest Interval (PHI)		Pre-Slaughter Interval (PSI)																						
Millet Forage	0	0	0																						
Millet Grain	N/A	50	0																						
Millet Straw	N/A	50	0																						
Millet Hay	N/A	37	0																						
<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> Consult "Use Precautions" and "For Optimum Results" for important usage information. Refer to "Mixing Instructions" and "Use Rate Guides" for detailed information on SANDEA application. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> Do apply more than 1 application or 2/3 oz/A of product by weight (0.031 lb a.i./acre) per 12 month period. 0 Day Pre grazing interval for grass forage for ALL animals (lactating and non-lactating). Do not apply by rope-wick wiper application. 																									

CROP	OZ/ACRE	DIRECTIONS FOR USE
RICE (48, CA 69)	2/3 - 1 1/3	<p>Pre-plant, at planting, preemergence and postemergence applications to rice</p> <ul style="list-style-type: none"> • Pre-plant: Apply SANDEA at 2/3 oz per acre in combination with glyphosate or other suitable agricultural herbicides for burn down of emerged annual grasses, broadleaf weeds and nutsedge. If this product is applied pre-plant burn down, refer to "TIME INTERVAL BEFORE PLANTING" table in complete directions for use. • Preemergence and Postemergence: Apply SANDEA for postemergent weed control from prior to the emergence of rice until after permanent flood is established. Apply SANDEA at 2/3 to 1 1/3 oz/A, with the total application rate not to exceed 1 1/3 oz/A of product (0.062 lb a.i./acre) per 12 month period. <p>SANDEA can be applied as a foliar spray or dry broadcast. SANDEA can be tank mixed with propanil containing rice herbicides (e.g. Stam and propanil 4E) at 2/3 to 1 1/3 oz per acre of this herbicide and labeled rates of the tank mix products.</p> <p>Foliar applications of SANDEA can be made at the 3 to 5 leaf stage of rice when weeds have 2 to 4 leaves. Dry broadcast applications can be made at the 1 to 2 leaf stage of rice when weeds have two leaves or less.</p> <p>SANDEA can also be applied post flood with dry broadcast applications of SANDEA at 2/3 to 1 1/3 oz with the total application rate not to exceed 1 1/3 oz/A of product (0.062 lb a.i./acre) per 12 month period.</p> <p>With all foliar applications of SANDEA use a minimum 3 to 15 gal of water per acre for aerial equipment and a minimum of 10 gal of water per acre for ground equipment. It is best to apply spray solutions the day they are mixed.</p> <p>Water levels in rice fields and checks should remain static (3 to 6 inch depth) following dry broadcast applications of SANDEA. Do not reintroduce water into rice fields or checks for at least five days following dry broadcast applications of SANDEA. Rice fields and checks may be irrigated to maintain water level, but this may reduce weed control.</p> <p>Control of emerged weeds with foliar applications is best when 70% to 80% of the weed foliage is exposed. Control of submerged weeds is best when weeds have 2 leaves or less. Do not reintroduce water into rice fields or checks for at least 24 hours following foliar applications of SANDEA.</p>

CROP	OZ/ACRE	DIRECTIONS FOR USE
RICE (48, CA 69) <i>(Cont'd)</i>	2/3 - 1 1/3	<p align="center">SANDEA Tank Mixture Options in Rice</p> <p>It is the pesticide user's responsibility to ensure that all products in the listed mixtures are registered for the intended use. Users must follow the most restrictive directions and precautionary language of the products in the mixture. Before mixing in the spray tank, it is recommended that compatibility be tested by mixing all components in a small container in proportionate quantities. For tank mixtures, add individual formulations to a spray tank in the following sequence: water soluble bags, dry flowables, emulsifiable concentrates, drift control additive, water soluble liquids followed by NIS or COC.</p> <p>Tank mixtures should not be applied if the crop is under severe stress due to drought, poor fertility (especially low nitrogen levels), hail, frost and insects. Tank mix applications under these conditions may cause temporary crop injury.</p> <p>• Preemergence & Pre-Plant Applications: Tank mixtures for additional preemergence weed control, including but not limited to Bolero®, Command® 3ME, glyphosate, pendimethalin or quinclorac can be added.</p> <p>• Postemergence Applications: Tank mixtures for additional broadleaf weed control, including but not limited to Grandstand®, propanil and propanil products, Aim®, Facet®, Basagran®, Londax®, Grasp®, Regiment®, NewPath®, Beyond® and 2-4-D can be added. Tank mixtures for postemergence grass control, including but not limited to Newpath®, Beyond®, propanil, Facet®, Grasp®, and Regiment® can be added. Insecticide and fungicide products can be tank mixed with SANDEA®.</p> <p>Sequential Applications - SANDEA can be applied sequentially with Ordram®, Bolero®, Clincher®, Regiment® and Shark®. Read the Ordram, Bolero, Clincher, Regiment and Shark labels for application information, restrictions and precautions.</p>
		<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • Avoid using SANDEA on rice fields which have a history of weed biotypes resistant to ALS herbicides. • For best results, use 0.25 to 0.5% NIS which contains at least 80% active ingredient with foliar applications of SANDEA. • Refer to "Application Equipment and Instructions" for spray drift management techniques. • Refer to "Mixing Instructions" and "Use Rate Guides" sections of this label for detailed information on SANDEA application.

CROP	OZ/ACRE	DIRECTIONS FOR USE
RICE (48, CA 69) (Cont'd)		RESTRICTIONS: <ul style="list-style-type: none"> Do not apply within 48 days of harvest. Do not apply within 69 days of harvest in California. Do not exceed more than 2 applications per 12 month period. Do not apply by rope-wick wiper application.
SORGHUM, GRAIN (MILO) (30)	2/3 - 1	<p>Postemergence - Apply SANDEA from the 2 leaf through layby stage (before grain head emergence).</p> <p>Temporary stature reduction may occur to the crop following application of SANDEA if the grain sorghum is under stress. This effect will be most evident 7 to 10 days after application. The crop will quickly recover under normal growing conditions.</p> <p>Tank Mixtures for Grain Sorghum</p> <p>Tank mixtures with SANDEA can include, but are not limited to atrazine, Buctril® or 2,4-D.</p> <p>It is the pesticide user's responsibility to ensure that all products in the listed mixtures are registered for the intended use. Users must follow the most restrictive directions and precautionary language of the products in the mixture.</p> <p>PRECAUTIONS:</p> <ul style="list-style-type: none"> Consult "Use Precautions" and "For Optimum Results" for important usage information. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> Do not apply more than 1 application or 1 oz/A of product by weight (0.047 lb a.i./acre) per 12 month period. Following application to foliage, allow 30 days before grazing domestic livestock, harvesting forage, or harvesting silage. Do not apply by rope-wick wiper application.
SUGARCANE (30)	2/3 - 1 1/3	<p>When used alone, apply SANDEA prior to planting, prior to emergence or after the emergence of the sugarcane, and until row closure. Mechanical cultivation may be required to control weed species not on the label. If so, a sequential treatment may be required to control weeds in areas of disturbed soil.</p> <p>Apply SANDEA at 2/3 to 1 1/3 oz by weight per acre (0.031 to 0.062 lb active ingredient per acre) in combination with glyphosate agricultural herbicides for pre-plant burn down of emerged annual grasses, broadleaf weeds and nutsedge in sugarcane.</p> <p>Tank Mixtures for Sugarcane</p> <p>Tank mixtures with SANDEA can include, but are not limited to Asulox®, atrazine, Callisto®, Envoke®, Evik®, glyphosate, or 2,4-D.</p>

SUGARCANE (30) <i>(Cont'd)</i>	2/3 - 1 1/3	It is the pesticide user's responsibility to ensure that all products in the listed mixtures are registered for the intended use. Users must follow the most restrictive directions and precautionary language of the products in the mixture.
	PRECAUTIONS: <ul style="list-style-type: none"> Consult "Use Precautions" and "For Optimum Results" for important usage information. RESTRICTIONS: <ul style="list-style-type: none"> Refer to the "Rotational Crop Restrictions" for applicable rotational crop information. Do not apply more than 3 applications (including pre-plant applications) or 2 2/3 oz/A (0.125 lb a.i./acre) per 12 month period. Following application to foliage allow 30 days before grazing domestic livestock, harvesting forage, or harvesting silage. Do not apply by rope-wick wiper application. 	

OTHER CROPS AND APPLICATIONS

CROP	OZ/ACRE	DIRECTIONS FOR USE
ALFALFA (14) AZ, CA & NM	2/3 - 1	Established Fields <ul style="list-style-type: none"> Postemergence Broadcast - Apply SANDEA as a broadcast application to established alfalfa. Alfalfa should be well established in the field for a minimum of 6 months prior to application of SANDEA. Apply uniformly with ground equipment in a minimum of 20 gal of water per acre. Use a water volume that will provide uniform coverage of plants. It is recommended to make an application as soon as possible after removal of hay from the field and prior to an irrigation to minimize crop injury. Wait for at least 48 hours after application before irrigation. Postemergence Spot Treatment - Apply SANDEA as a spot treatment application to only those areas of emerged nutsedge. Application rate should not exceed 3/4 oz product per treated acre in these areas. Use a water volume that will allow for good coverage of the plants. Postemergence followed by Postemergence - To maximize control of nutsedge, it may be necessary to use a second postemergence spot application to those areas where the nutsedge has emerged or re-grown. For these situations, use a spot treatment method treating only those areas of emerged nutsedge. Application rate must not exceed 3/4 oz product per treated acre in these areas. Use a water volume that will allow for good coverage of the plants. This use pattern will result in greater potential of growth and yield reduction.

CROP	OZ/ACRE	DIRECTIONS FOR USE
ALFALFA (14) AZ, CA & NM (Cont'd)	2/3 - 1	<p>Research has shown that alfalfa growth and yields will be reduced for one or more cuttings after a SANDEA application. Application of SANDEA to alfalfa where re-growth exceeds 6" will result in greater yield reduction. Symptoms may be temporary. Follow all directions carefully to minimize potential reduced plant growth and yield. Apply uniformly with ground equipment in a minimum of 20 gal of water per acre. Use a water volume that will provide uniform coverage of plants.</p> <p>PRECAUTIONS:</p> <ul style="list-style-type: none"> Consult "Use Precautions" and "For Optimum Results" for important usage information. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> Do not apply more than 2 applications or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period. Do not apply by rope-wick wiper application.
ARTICHOKE (5)	1 - 2	<p>Apply SANDEA uniformly with ground equipment in a minimum of 15 gal of water per acre. Apply as a broadcast application to the ground on either side of the row and winter ditches while avoiding crop foliage.</p> <ul style="list-style-type: none"> Row Middle - Apply SANDEA between rows of perennial artichokes for the control of nutsedge and listed broadleaf weeds. Applications should be made when oxalis is in full bloom. Avoid contact of the herbicide with the planted crop. If plastic is used on the planted row, adjust equipment to keep the application off the plastic. To maximize nutsedge control, apply when plants are in the 3 to 5 leaf stage. <p>Application of SANDEA may cause significant, temporary stunting and delay maturity of artichokes if sprayed directly. This product is available to the end-user /grower solely to the extent that the benefit and utility, in the sole opinion of the end-user/ grower, outweigh the extent of potential injury associated with the use of this product.</p> <p>PRECAUTIONS:</p> <ul style="list-style-type: none"> For best results, use a NIS with applications. Consult "Use Precautions" and "For Optimum Results" for important usage information. Use rates are broadcast per acre. Reduce rate and spray volume in proportion to area actually sprayed. SANDEA may not control ALS resistant weeds. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> Do not apply by air. Do not apply more than 2 applications or 2 oz/A of product by weight (0.094

CROP	OZ/ACRE	DIRECTIONS FOR USE
ARTICHOKE (5) <i>(Cont'd)</i>	lb a.i./acre) per 12 month period.	<ul style="list-style-type: none"> Do not apply by rope-wick wiper application.
ASPARAGUS (1)	1/2 - 1 1/2	<p>Apply uniformly with ground equipment in a minimum of 15 gal per acre.</p> <p>Nursery, Transplanted Crowns and Established Beds</p> <ul style="list-style-type: none"> Postemergence/Post transplant - Apply SANDEA to asparagus before or during the harvesting season. SANDEA may cause a temporary stunting or twisting of fern on certain asparagus varieties when applied during spear emergence. The addition of surfactants and postemergent grass herbicides may accentuate the crop response. Spectrum and degree of weed control may be reduced where SANDEA is used without a surfactant. Post-harvest - Apply SANDEA at the end of the harvest season. Under heavy nutsedge pressure, split applications are recommended. Contact with the fern may cause temporary yellowing. A NIS or COC should be used with post-harvest applications. Crop injury will be minimized and weeds control will be more effective when applications are made with drop nozzles as a directed spray below the ferns to allow for more complete coverage of target weeds. Split application for enhanced control of nutsedge - Apply a split application with 3/4 to 1 oz product per acre during the cutting/harvesting season when the first flush of nutsedge is in the 3 to 5 leaf stage, followed by a second application of 3/4 to 1 oz product per acre at least 21 to 30 days later up to lay-by to control later flushes of nutsedge. SANDEA can be applied post-harvest during the fern stage. Contact with the fern may cause temporary yellowing. Crop injury will be minimized and nutsedge more effectively controlled when applications are made with drop nozzles directing the spray below the ferns allowing for more complete coverage of nutsedge. <p>PRECAUTIONS:</p> <ul style="list-style-type: none"> For first year transplants, apply no sooner than six weeks after fern emergence. NIS can be used east of the Rockies to enhance weed control. Consult "Use Precautions" and "For Optimum Results" for important usage information. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> Do not use NIS west of the Rockies. Do not apply more than 2 applications or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period. Do not apply by rope-wick wiper application.

CROP	OZ/ACRE	DIRECTIONS FOR USE
FALLOW GROUND	2/3 - 1 1/3	Applications of SANDEA to fallow ground.
		<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> Refer to the "Weeds Controlled" section of this label for weed control recommendations. Consult "Use Precautions" and "For Optimum Results" for important usage information. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> Do not apply more than 2 applications or 2 2/3 oz of product by weight (0.125 lb a.i./acre) per 12 month period. Refer to the "Rotational Crop Restrictions" for applicable rotational crop information. Do not apply by rope-wick wiper application.
OKRA (30)	1/2 - 1	<p>Direct-seeded and Transplant: Row Middle/Furrow Applications/Shielded Spray - Apply SANDEA between rows of direct-seeded or transplanted okra, while avoiding contact of the herbicide with the planted crop. If plastic is used on the planted row, adjust equipment to keep the application off the plastic. Reduce rate and spray volume in proportion to area actually sprayed.</p>
		<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> Consult "Use Precautions" and "For Optimum Results" sections for important usage information. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> Do not apply more than 2 applications or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period. Do not apply by rope-wick wiper application.
CROP GROUP 17 PASTURE, RANGELAND & CRP FORAGE GRASSES/ HAY (37)	2/3 - 1 1/3	<p>Established Fields</p> <ul style="list-style-type: none"> Postemergence Broadcast – Apply SANDEA as a broadcast application to established Pasture & Rangeland. Apply uniformly with ground equipment in a minimum of 10 gal of water per acre. Use a water volume that will provide uniform coverage of plants. It is recommended to make an application as soon as possible after removal of hay or before weeds exceed label height restriction. Wait for at least 48 hours after application before irrigation. Postemergence Spot Treatment – Apply SANDEA as a spot treatment application to only those areas of emerged nutsedge. Application rate should not exceed 3/4 oz product per treated acre in these areas. Use a water volume that will allow for good coverage of the plants.

CROP	OZ/ACRE	DIRECTIONS FOR USE											
CROP GROUP 17 PASTURE, RANGELAND & CRP FORAGE GRASSES/ HAY (37) (cont'd)	2/3 – 1 1/3	<ul style="list-style-type: none"> • Postemergence followed by Postemergence - To maximize control of nutsedge, it may be necessary to use a second postemergence spot application to those areas where the nutsedge has emerged or re-grown. For these situations, use a spot treatment method treating only those areas of emerged nutsedge. Application rate should not exceed 3/4 oz product per treated acre in these areas. Use a water volume that will allow for good coverage of the plants. This use pattern will result in greater potential of growth and yield reduction. <p style="text-align: center;">TANK MIXTURES</p> <p>It is the pesticide user's responsibility to ensure that all products in the listed mixtures are registered for the intended use. Users must follow the most restrictive directions and precautionary language of the products in the mixture.</p> <p>Tank mixtures for additional broadleaf weed control, including but not limited to 2,4-D, dicamba and, Grazon® can be added. Labeled insecticides, including CONFIRM®, and labeled fungicide products can be tank mixed with SANDEA. Listed day intervals following an application of SANDEA.</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th rowspan="2">CROP</th> <th colspan="3">Lactating and Non-lactating Animals</th> </tr> <tr> <th>Pre-Grazing Interval (PGI)</th> <th>Pre-Harvest Interval (PHI)</th> <th>Pre-Slaughter Interval (PSI)</th> </tr> </thead> <tbody> <tr> <td>Pasture, Rangeland, CRP and Forage Grasses/Hay</td> <td style="text-align: center;">0</td> <td style="text-align: center;">37</td> <td style="text-align: center;">0</td> </tr> </tbody> </table>	CROP	Lactating and Non-lactating Animals			Pre-Grazing Interval (PGI)	Pre-Harvest Interval (PHI)	Pre-Slaughter Interval (PSI)	Pasture, Rangeland, CRP and Forage Grasses/Hay	0	37	0
		CROP		Lactating and Non-lactating Animals									
Pre-Grazing Interval (PGI)	Pre-Harvest Interval (PHI)		Pre-Slaughter Interval (PSI)										
Pasture, Rangeland, CRP and Forage Grasses/Hay	0	37	0										
<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • Consult "Use Precautions" and "For Optimum Results" for important usage information. • Refer to "Mixing Instructions" and "Use Rate Guides" for detailed information on SANDEA application. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Do not apply more than 2 applications or 1 1/3 oz/A of product by weight (0.062 lb a.i./acre) per 12 month period. • 0 Day pre grazing interval for lactating and non-lactating animals. • Do not apply by rope-wick wiper application. 													

CROP	OZ/ACRE	DIRECTIONS FOR USE
RHUBARB (60)	1/2 - 1	<p>Apply uniformly with ground equipment in a minimum of 15 gal of water per acre.</p> <p>Apply SANDEA as a single broadcast application to <u>dormant</u> rhubarb. The timing of the application should be as late as possible, or just prior to the breaking of rhubarb dormancy. Application of SANDEA may cause significant crop stunting. It is recommended that the user begin with a the lower rate to determine potential sensitivity to its use along with speed and degree of recovery.</p> <p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • Consult "Use Precautions" and "For Optimum Results" for important usage information. • For best results use a NIS if labeled weeds are emerged. • SANDEA may not control ALS resistant weeds. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Do not apply more than 2 applications or 1 oz/A of product by weight (0.047 lb a.i./acre) per 12 month period. • Do not apply by rope-wick wiper application.
TURFGRASS SOD	2/3 - 1 1/3	<p>SANDEA is a selective herbicide for postemergence control of sedges such as purple and yellow nutsedge in sod farms. This product will not injure nearby established ornamentals, trees, and shrubs when used according to label directions.</p> <p>For postemergence control of purple or yellow nutsedge found in established turfgrass, apply 2/3 to 1 1/3 oz by weight of this product per acre (0.031 to 0.062 lbs. a.i./acre) after nutsedge has reached the 3 to 5 leaf stage of growth. Use the lower rate in light infestations and the higher rate in heavy infestations.</p> <p>A second treatment may be required 6 to 10 weeks after the initial treatment. As a sequential treatment, when new purple or yellow nutsedge plants have reached the 3 to 5 leaf stage of growth, apply 2/3 to 1 1/3 oz by weight of this product per acre (0.031 to 0.062 lb a.i./acre). Use the lower rate in light infestations and the higher rate in heavy infestations.</p> <p>Use 0.25 to 0.5% NIS concentration (1 to 2 quarts per 100 gal of spray solution) for broadcast applications. For high volume applications, do not exceed 1 quart of surfactant per acre. Use only NIS which contains at least 80% active material. Refer to the surfactant label and observe all precautions, mixing and application instructions.</p> <p>When applied as directed under the conditions described, the following established turfgrasses are tolerant to application of this product:</p>

CROP	OZ/ACRE	DIRECTIONS FOR USE										
TURFGRASS SOD (cont'd)	2/3 - 1 1/3	<table border="1"> <thead> <tr> <th colspan="2">Established Cool-Season Grasses</th> </tr> </thead> <tbody> <tr> <td>Bentgrass, creeping (<i>Agrostis stolonifera</i>)</td> <td>Fescue, fine (<i>Festuca rubra</i>)</td> </tr> <tr> <td>Blue Grass, Kentucky (<i>Poa pratensis</i>)</td> <td>Fescue, tall (<i>Festuca arundinacea</i>)</td> </tr> <tr> <td>Ryegrass, perennial (<i>Lolium perenne</i>)</td> <td></td> </tr> </tbody> </table>	Established Cool-Season Grasses		Bentgrass, creeping (<i>Agrostis stolonifera</i>)	Fescue, fine (<i>Festuca rubra</i>)	Blue Grass, Kentucky (<i>Poa pratensis</i>)	Fescue, tall (<i>Festuca arundinacea</i>)	Ryegrass, perennial (<i>Lolium perenne</i>)			
		Established Cool-Season Grasses										
		Bentgrass, creeping (<i>Agrostis stolonifera</i>)	Fescue, fine (<i>Festuca rubra</i>)									
		Blue Grass, Kentucky (<i>Poa pratensis</i>)	Fescue, tall (<i>Festuca arundinacea</i>)									
		Ryegrass, perennial (<i>Lolium perenne</i>)										
		<table border="1"> <thead> <tr> <th colspan="2">Established Warm-Season Grasses</th> </tr> </thead> <tbody> <tr> <td>Bahigrass (<i>Paspalum notatum</i>)</td> <td>Seashore paspalum (<i>Paspalum vaginatum</i>)</td> </tr> <tr> <td>Bermudagrass (<i>Cynodon dactylon</i>)</td> <td>St. Augustinegrass (<i>Stenotaphrum secundatum</i>)</td> </tr> <tr> <td>Buffalograss (<i>Buchloe dactyloides</i>)</td> <td>Kikuyugrass (<i>Pennisetum clandestinum</i>)</td> </tr> <tr> <td>Centipedegrass (<i>Eremochloa ophiuroides</i>)</td> <td>Zoysiagrass (<i>Zoysia japonica</i>)</td> </tr> </tbody> </table>	Established Warm-Season Grasses		Bahigrass (<i>Paspalum notatum</i>)	Seashore paspalum (<i>Paspalum vaginatum</i>)	Bermudagrass (<i>Cynodon dactylon</i>)	St. Augustinegrass (<i>Stenotaphrum secundatum</i>)	Buffalograss (<i>Buchloe dactyloides</i>)	Kikuyugrass (<i>Pennisetum clandestinum</i>)	Centipedegrass (<i>Eremochloa ophiuroides</i>)	Zoysiagrass (<i>Zoysia japonica</i>)
		Established Warm-Season Grasses										
		Bahigrass (<i>Paspalum notatum</i>)	Seashore paspalum (<i>Paspalum vaginatum</i>)									
		Bermudagrass (<i>Cynodon dactylon</i>)	St. Augustinegrass (<i>Stenotaphrum secundatum</i>)									
		Buffalograss (<i>Buchloe dactyloides</i>)	Kikuyugrass (<i>Pennisetum clandestinum</i>)									
Centipedegrass (<i>Eremochloa ophiuroides</i>)	Zoysiagrass (<i>Zoysia japonica</i>)											
<p align="center">Fallow Treatments in Turfgrass Seed and Sod Production Areas</p>												
<p>This product may be used on fallow areas prior to establishing turfgrass plants. Allow 4 weeks between application and seeding or sodding of turfgrass.</p>												
<p align="center">Tank Mixtures for Turfgrass Renovation</p>												
<p align="center">SANDEA plus GLYPHOSATE AGRICULTURAL HERBICIDES plus NIS</p>												
<p>For non-selective control of all vegetation prior to turfgrass renovation, SANDEA may be applied at 2/3 oz by weight per acre in combination with glyphosate agricultural herbicides for pre-plant burndown of emerged annual grasses, broadleaf weeds and nutsedge.</p>												
<p>Refer to the glyphosate agricultural herbicide label for use instructions, weeds controlled, and application restrictions. It is the pesticide user's responsibility to ensure that all products in the listed mixtures are registered for the intended use. Users must follow the most restrictive directions and precautionary language of the products in the mixture.</p>												
<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • For best results, do not mow turf for 2 days before or 2 days after application. • This product is effective if no rainfall occurs within 3 hours, but best results are obtained with no rainfall or irrigation for at least 8 hours. 												

CROP	OZ/ACRE	DIRECTIONS FOR USE								
TURFGRASS SOD (cont'd)		<ul style="list-style-type: none"> This product may be used on seeded, sodded, or sprigged turfgrass that is well established. Allow the turf to develop a good root system and uniform stand before application. Avoid application of SANDEA when turfgrass or nutsedge is under stress since turf injury and poor nutsedge control may result. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> Do not apply as an over the top spray to desirable shrubs or trees. Do not exceed the recommended amount of surfactant due to the potential for turf injury at higher rates. Do not apply more than 2 applications or 2 2/3 oz/A of product by weight (0.125 lb a.i./acre) per 12 month period. Do not apply by rope-wick wiper application. 								
GRASSES GROWN FOR SEED	2/3 – 1 1/3	<p>ESTABLISHED GRASSES</p> <p>For postemergence control of listed broadleaf weeds and nutsedge found in established grasses grown for seed, apply 2/3 to 1 1/3 oz by weight of this product per acre (0.031 to 0.062 lbs. a.i./acre). Postemergence applications for control of sharpshoot fluvellin must be made when the basal diameter of the weed is the size of a U.S. quarter or smaller, and before stem elongation.</p> <p>For postemergence applications, use 0.25 to 0.5% NIS concentration (1 to 2 quarts per 100 gal of spray solution) for broadcast applications. For high volume applications, do not exceed 1 quart of surfactant per acre. Use only NIS which contains at least 80% active material. Refer to the surfactant label and observe all precautions, mixing and application instructions.</p> <p>When applied as directed under the conditions described, the following established grasses are tolerant to application of this product:</p> <table border="1"> <thead> <tr> <th colspan="2">Established Cool-Season Grasses</th> </tr> </thead> <tbody> <tr> <td>Bentgrass, creeping (<i>Agrostis stolonifera</i>)</td> <td>Fescue, fine (<i>Festuca rubra</i>)</td> </tr> <tr> <td>Blue Grass, Kentucky (<i>Poa pratensis</i>)</td> <td>Fescue, tall (<i>Festuca arundinacea</i>)</td> </tr> <tr> <td>Ryegrass, perennial (<i>Lolium perenne</i>)</td> <td>Orchardgrass (<i>Dactylis glomerata L.</i>)</td> </tr> </tbody> </table> <p>TALL FESCUE GROWN FOR SEED</p> <p>For postemergence control of listed broadleaf weeds, apply 2/3 to 1 1/3 oz by weight of this product per acre (0.031 to 0.062 lb a.i./acre) after the crop is well established.</p> <p>PRECAUTIONS:</p> <ul style="list-style-type: none"> For best results, do not mow grasses for 2 days before or 2 days after application. 	Established Cool-Season Grasses		Bentgrass, creeping (<i>Agrostis stolonifera</i>)	Fescue, fine (<i>Festuca rubra</i>)	Blue Grass, Kentucky (<i>Poa pratensis</i>)	Fescue, tall (<i>Festuca arundinacea</i>)	Ryegrass, perennial (<i>Lolium perenne</i>)	Orchardgrass (<i>Dactylis glomerata L.</i>)
Established Cool-Season Grasses										
Bentgrass, creeping (<i>Agrostis stolonifera</i>)	Fescue, fine (<i>Festuca rubra</i>)									
Blue Grass, Kentucky (<i>Poa pratensis</i>)	Fescue, tall (<i>Festuca arundinacea</i>)									
Ryegrass, perennial (<i>Lolium perenne</i>)	Orchardgrass (<i>Dactylis glomerata L.</i>)									

CROP	OZ/ACRE	DIRECTIONS FOR USE
GRASSES GROWN FOR SEED (Cont'd)		<ul style="list-style-type: none"> • This product is effective if no rainfall occurs within 3 hours, but best results are obtained with no rainfall or irrigation for at least 8 hours. • This product may be used on labeled grass seed crops that are well established. Allow grass to develop a good root system and uniform stand before application. *See specific use directions for spring planted tall fescue. • Avoid application of SANDEA when grass seed crops or weeds are under stress since crop injury and poor weed control may result. • Applications made in late fall or spring when grass seed crops are actively growing may result in injury. • Certain perennial ryegrass varieties have shown sensitivity to sulfonyleurea herbicides. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Do not apply as an over the top spray to desirable shrubs or trees. • Do not exceed the recommended amount of surfactant due to the potential for crop injury at higher rates. • Do not apply more than 2 applications or 2 2/3 oz/A of product by weight (0.125 lb a.i./acre) per 12 month period. • Minimum of 14 days between applications. • Do not apply by rope-wick wiper application.
FENCE ROWS, FUEL STORAGE AREAS, LUMBER-YARDS, TANK FARMS, RIGHT-OF WAY AND ROADSIDES	2/3 - 1 1/3	<p>Broadcast Applications: Apply SANDEA as a postemergence spray at 2/3 - 1 1/3 oz by weight of this product per acre (0.031 to 0.062 lb ai/A) to roadsides and other industrial sites. A second treatment can be applied 6 to 10 weeks after the initial treatment.</p> <p>Spot Treatments: Mix 1/4 oz to 1 oz of SANDEA per 1 gal of water. For best results, when using a hand held applicator, spray the desired target weeds in a back and forth motion to ensure proper contact and coverage.</p> <p>This product will control purple and yellow nutsedge and control and/or suppress listed broadleaf weeds (see weeds controlled chart for additional information).</p> <p>NOTE: This product can be tank mixed with Glyphosate herbicide. It is the pesticide user's responsibility to ensure that all products in the listed mixtures are registered for the intended use. Users must follow the most restrictive directions for use and precautionary statements of each product in the tank mixture.</p>

CROP	OZ/ACRE	DIRECTIONS FOR USE
FENCE ROWS, FUEL STORAGE AREAS, LUMBER-YARDS, TANK FARMS, RIGHT-OF-WAY AND ROADSIDES (Cont'd)	PRECAUTIONS:	<ul style="list-style-type: none"> • When using a surfactant refer to the adjuvants section of the label. • Consult "Use Precautions" and "For Optimum Results" for important usage information. • SANDEA may not control ALS resistant weeds. • Consult your local Gowan Sales Representative for more information.
	RESTRICTIONS:	<ul style="list-style-type: none"> • Do not apply more than 2 applications or 2 2/3 oz/A of product by weight (0.125 lb a.i./acre) per 12 month period. • Do not apply by rope-wick wiper application.

ROTATIONAL CROP RESTRICTIONS

Rotation intervals below may need to be extended if drought or cool conditions prevail. Rotation intervals may need to be extended on drip irrigated crops in Arizona and California. Gowan Company recommends that the end user test this product in order to determine its suitability for such intended use. When using SANDEA in tank mixes, refer to the individual product labels being tank mixed. To determine rotational crop restrictions follow the longest rotational limitation of the product being tank mixed.

TIME INTERVAL BEFORE PLANTING

CROP	MONTHS	EXCEPTIONS
CROPS NOT SPECIFICALLY LISTED	36	
Alfalfa	9	
Apples*	9	
Barley (winter)	2	
Beans, Dry	0	
Beans, Snap	9	2 months in the Northeast, Midwest, and Southeast, 3 months in TX
Blueberry*	9	
Broccoli	18	3 months for muck soils in FL
Cabbage	15	3 months for muck soils in FL
Caneberry*	9	
Canola	15	
Carrot	15	
Cauliflower	18	3 months for muck soils in FL

CROP	MONTHS	EXCEPTIONS
Cereal crops, Spring	2	
Clovers	9	
Collards	18	
Corn, IR/IMR Field	0	
Corn, Normal Field and IT Field	1	
Corn, Seed	2	
Corn, Sweet and Pop	3	
Cotton	4	
Cucumbers	9	2 months in the Northeast, Midwest, and Southeast, 3 months in TX
Eggplant	12	4 months for FL Transplants
Forage Grasses	2	
Grapes*	9	
Lettuce crops	18	3 months for muck soils in FL
Melons	9	2 months in the Southeast and TX
Mint	15	
Oats	2	
Onions and Leeks	18	
Peanuts	6	
Pears*	9	
Peas	9	
Peas, Field	9	
Peppers	10	4 months FL Transplants and 3 months in TX
Potatoes	9	
Pumpkins	9	2 months in the Southeast
Proso Millet	2	
Radish	12	3 months for muck soils in FL
Rice	0	
Rye (winter)	2	
Sorghums	2	
Soybeans	9	Where soil pH is less than 7.5 the interval is 5 months
Spinach	24	3 months for muck soils in FL
Squash	9	2 months in the Southeast

CROP	MONTHS	EXCEPTIONS
Strawberries	36	6 months for annual FL Transplants
Sugarbeet (Michigan only)	21	
Sugarbeet (ND, MN, Red River Valley)	36	
Sugarbeet and Red Beet	24	Where rainfall is sparse or irrigation is required, the time interval is 36 months.
Sugarcane	0	
Sunflowers	18	
Tomato	8	2 months in the Northeast, Midwest, and Southeast, 3 months in TX
Tree Nut*	9	
Wheat (winter)	2	

* After a SANDEA application, the soil must be plowed and cross disked.

STORAGE AND DISPOSAL

DO NOT contaminate water, food, feed or seed by storage or disposal.

PESTICIDE STORAGE: Store under cool, dry conditions (below 120 F). Do not store under moist conditions.

PESTICIDE DISPOSAL: Wastes resulting from the use of this product that cannot be used or chemically reprocessed should be disposed of in a landfill for pesticide disposal or in accordance with applicable Federal, state or local procedures.

CONTAINER DISPOSAL: Nonrefillable container. Do not reuse or refill this container. Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank. Fill the container 1/4 full with water and recap. Shake for 10 seconds. Pour rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Insert pressure rinsing nozzle in the side of the container, and rinse at about 40 PSI for at least 30 seconds. Then offer for recycling if available or puncture and dispose of in a sanitary landfill, or by incineration, or, if allowed by state and local authorities, by burning. If burned, stay out of smoke.

DISPOSAL AUTHORITIES: If none of the foregoing procedures is permitted by state and local authorities, then contact your State Pesticide or Environmental Control Agency, or your local Hazardous Waste Disposal office, or the Hazardous Waste Representative at the nearest EPA Regional Office for guidance.

**FOR 24-HOUR EMERGENCY ASSISTANCE (SPILL, LEAK OR FIRE),
CALL CHEMTREC® (800) 424-9300.**

For other product information, contact Gowan Company or see Safety Data Sheet.




NOTICE OF CONDITIONS OF SALE AND WARRANTY AND LIABILITY LIMITATIONS

Important: Read the entire Directions for Use and Notice of Conditions of Sale and Warranty and Liability Limitations before using this product. If terms are not acceptable return the unopened container for a full refund.


Our directions for use of this product are based on tests believed to be reliable. However, it is impossible to eliminate all risk associated with the use of this product. Crop injury, inadequate performance, or other unintended consequences may result due to soil or weather conditions, off target movement, presence of other materials, method of use or application, and other factors, all of which are beyond the control of Gowan Company. To the extent consistent with applicable law, all such risks shall be assumed by the Buyer and User.

Gowan Company warrants that this product conforms to the specifications on the label when used in strict conformance with Directions for Use, subject to the above stated risk limitations. TO THE EXTENT CONSISTENT WITH APPLICABLE LAW, GOWAN COMPANY MAKES NO OTHER EXPRESS OR IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE NOR ANY OTHER EXPRESS OR IMPLIED WARRANTY.

TO THE EXTENT CONSISTENT WITH APPLICABLE LAW, GOWAN COMPANY'S EXCLUSIVE LIABILITY FOR ANY AND ALL LOSSES, INJURIES OR DAMAGES RESULTING FROM THE USE OR HANDLING OF THIS PRODUCT WHETHER IN CONTRACT, WARRANTY, TORT, NEGLIGENCE, OR ANY OTHER LEGAL THEORY IS STRICTLY LIMITED TO THE PURCHASE PRICE PAID OR REPLACEMENT OF PRODUCT, AT GOWAN COMPANY'S SOLE DISCRETION.



Formulated in the United States using Active Ingredient made in Japan.
Manufactured by Nissan Chemical Industries, Ltd.
EPTAM® 7E and SANDEA® are trademarks of Gowan Company LLC.
YUKON® and TARGA® are trademarks of Nissan Chemical Industries, LTD
All other brands are registered trademarks of their respective owners.
© 2017 Gowan Company, L.L.C.





UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, DC 20460

OFFICE OF CHEMICAL SAFETY
AND POLLUTION PREVENTION

March 10, 2022

Dennese Flores
Registration Specialist
Canyon Group LLC
370 S. Main St.
Yuma, AZ 85364

Subject: Registration Review Label Mitigation for Halosulfuron-methyl
Product Name: SANDEA HERBICIDE
EPA Registration Number: 81880-18
Application Date: 3/9/22
Decision Number: 555026

Dear Ms. Flores:

The Agency, in accordance with the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), as amended, has completed reviewing all the information submitted with your application to support the Registration Review of the above referenced product in connection with the Halosulfuron-methyl Interim Decision, and has concluded that your submission is acceptable. The label referred to above, submitted in connection with registration under FIFRA, as amended, is acceptable.

Should you wish to add/retain a reference to the company's website on your label, then please be aware that the website becomes labeling under the Federal Insecticide Fungicide and Rodenticide Act and is subject to review by the Agency. If the website is false or misleading, the product would be misbranded and unlawful to sell or distribute under FIFRA section 12(a)(1)(E). 40 CFR 156.10(a)(5) list examples of statements EPA may consider false or misleading. In addition, regardless of whether a website is referenced on your product's label, claims made on the website may not substantially differ from those claims approved through the registration process. Therefore, should the Agency find or if it is brought to our attention that a website contains false or misleading statements or claims substantially differing from the EPA approved registration, the website will be referred to the EPA's Office of Enforcement and Compliance.

A stamped copy of your labeling is enclosed for your records. This labeling supersedes all previously accepted labeling. You must submit one copy of the final printed labeling before you release the product for shipment with the new labeling. In accordance with 40 CFR 152.130(c), you may distribute or sell this product under the previously approved labeling for 12 months from the date of this letter. After 12 months, you may only distribute or sell this product if it bears this new revised labeling or subsequently approved labeling. "To distribute or sell" is defined under FIFRA section 2(gg) and its implementing regulation at 40 CFR 152.3.

Page 2 of 2
EPA Reg. No. 81880-18
Decision No. 555026

If you have any questions about this letter, please contact DeMariah Koger by phone at (202)-566-2288, or via email at koger.demariah@epa.gov .

Sincerely,

A handwritten signature in blue ink, appearing to read "Linda Arrington", with a long horizontal flourish extending to the right.

Linda Arrington, Branch Chief
Risk Management and Implementation Branch 4
Pesticide Re-Evaluation Division
Office of Pesticide Programs

Enclosure

ACCEPTED

Mar 10, 2022

Under the Federal Insecticide, Fungicide and Rodenticide Act as amended, for the pesticide registered under EPA Reg. No. 81880-18

HALOSULFURON-METHYL GROUP 2 HERBICIDE

SANDEA® Herbicide

SANDEA® is a selective herbicide for control of listed broadleaf weeds and nutsedge

ACTIVE INGREDIENT:

Halosulfuron-methyl, methyl 3-chloro-5-(4,6-dimethoxypyrimidin-2-ylcarbamoylsulfamoyl)

-1-methylpyrazole-4-carboxylate 75.0%

OTHER INGREDIENTS 25.0%

TOTAL 100.0%

KEEP OUT OF REACH OF CHILDREN CAUTION

Si usted no entiende la etiqueta, busque a alguien para que se las explique a usted en detalle.
(If you do not understand the label, find someone to explain it to you in detail.)

FIRST AID	
IF IN EYES	<ul style="list-style-type: none"> Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after 5 minutes, then continue rinsing eye. Call poison control center or doctor for treatment advice.
IF SWALLOWED	<ul style="list-style-type: none"> Call poison control center or doctor immediately for treatment advice. Have person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by the poison control center or doctor. Do not give anything to an unconscious person.
HOT LINE NUMBER	
Have the product container or label with you when calling poison control center, doctor or going for treatment. For emergency information concerning this product, call toll free 1-888-478-0798.	

PRECAUTIONARY STATEMENTS HAZARDS TO HUMANS AND DOMESTIC ANIMALS CAUTION

Causes moderate eye irritation. Harmful if swallowed. Avoid contact with eyes or clothing.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Applicators and other handlers must wear:

- Long-sleeved shirt and long pants
- Shoes plus socks

Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

ENGINEERING CONTROLS STATEMENTS: When handlers use closed systems or enclosed cabs in a manner that meets the requirements listed in the Worker Protection Standard (WPS) for agricultural pesticides [40 CFR 170.240 (d) (4-6)], the handler PPE requirements may be reduced or modified as specified in the WPS.

USER SAFETY RECOMMENDATIONS

Users should:

- Wash hands before eating, drinking, chewing gum, using tobacco or using the toilet.
- Remove clothing immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.

ENVIRONMENTAL HAZARD SECTION OF PRECAUTIONARY STATEMENTS GROUND WATER ADVISORY

Halosulfuron-methyl is known to leach through soil into groundwater under certain conditions as a result of label use. This chemical may leach into groundwater if used in areas where soils are permeable, particularly where the water table is shallow.

SURFACE WATER ADVISORY

This product may impact surface water quality due to runoff of rainwater. This is especially true for poorly draining soils and soils with shallow ground water. This product is classified as having high potential for reaching surface water via runoff for several months or more after application. A level, well-maintained vegetative buffer strip between areas to which this product is applied and surface water features such as ponds, streams, and springs will reduce the potential loading of halosulfuron-methyl from runoff water and sediment. Runoff of this product will be greatly reduced by avoiding applications when rainfall or irrigation is expected to occur within 48 hours.

NET CONTENTS _____ OUNCES



Produced For:
Canyon Group LLC.
C/O Gowan Company
PO Box 5569
Yuma, Arizona 85364

PHYSICAL AND CHEMICAL HAZARDS

Do not mix or allow coming in contact with water. Hazardous chemical reaction may occur.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling. Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application. For any requirements specific to your State or Tribe, consult the agency responsible for pesticide regulation.

WINDBLOWN SOIL PARTICLES

Sandea has the potential to move off-site due to wind erosion. Soils that are subject to wind erosion usually have a high silt and/or fine to very fine sand fractions and low organic matter. Other factors which can affect the movement of windblown soil include the intensity and direction of prevailing winds, vegetative cover, site slope, rainfall, and drainage patterns. Avoid applying Sandea if prevailing local conditions may be expected to result in off-site movement.

NON-TARGET ORGANISM ADVISORY

This product is toxic to plants and may adversely impact the forage and habitat of non-target organisms, including pollinators, in areas adjacent to the treated area. Protect the forage and habitat of non-target organisms by minimizing spray drift. For further guidance and instructions on how to minimize spray drift, refer to the Spray Drift Management section of this label.

AGRICULTURAL USE REQUIREMENTS

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR Part 170. This standard contains requirements for the protection of agricultural workers on farms, forests, nurseries and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment (PPE) and restricted-entry interval. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard. Do not enter or allow worker entry into treated areas during the restricted entry interval (REI) of 12 hours. PPE required for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil, or water is:

- Coveralls
- Chemical-resistant gloves made of any waterproof material
- Shoes plus socks

PRODUCT INFORMATION

SANDEA is a dry flowable formulation that selectively controls certain broadleaf weeds and nutsedges in selected crops. SANDEA is effective both preemergence and postemergence. SANDEA can be absorbed through roots, shoots and foliage and is translocated within the plant.

WEED RESISTANCE STATEMENT

SANDEA contains a (Group 2) herbicide. Any weed population may contain or develop plants naturally resistant to (Group 2) Halosulfuron-methyl herbicides. Weed species with acquired resistance to (Group 2) Halosulfuron-methyl may eventually dominate the weed population if (Group 2) Halosulfuron-methyl herbicides are used repeatedly in the same field or in successive years as the primary method of control for targeted species. This may result in partial or total loss of control of those species by SANDEA or other (Group 2) herbicides.

Suspected herbicide-resistant weeds may be identified by these indicators:

- Failure to control a weed species normally controlled by the herbicide at the dose applied, especially if control is achieved on adjacent weeds;
- A spreading patch of non-controlled plants of a particular weed species; and
- Surviving plants mixed with controlled individuals of the same species.

To delay herbicide resistance consider:

- Rotate the use of SANDEA Herbicide or other Group (2) herbicides within a growing season sequence or among growing seasons with different herbicide groups that control the same weeds in a field.
- Use tank mixtures with herbicides from a different group if such use is permitted; where information on resistance in target weed species is available, use the less resistance-prone partner at a rate that will control the target weed(s) equally as well as the more resistance-prone partner.
- Consult your local extension service or certified crop advisor if you are unsure as to which active ingredient is currently less prone to resistance.
- Adopt an integrated weed-management program for herbicide use that includes scouting and uses historical information related to herbicide use and crop rotation, and that considers tillage (or other mechanical control methods), cultural (e.g., higher crop seeding rates; precision fertilizer application method and timing to favor the crop and not the weeds), biological (weed-competitive crops or varieties) and other management practices.
- Scout before and after herbicide application to monitor weed populations for early signs of resistance development. Indicators of possible herbicide resistance include:
 - (1) failure to control a weed species normally controlled by the herbicide at the dose applied, especially if control is achieved on adjacent weeds;
 - (2) a spreading patch of non-controlled plants of a particular weed species;
 - (3) surviving plants mixed with controlled individuals of the same species.
- If resistance is suspected, prevent weed seed production in the affected area by an alternative herbicide from a different group or by a mechanical method such as hoeing or tillage. Prevent movement of resistant weed seeds to other fields by cleaning harvesting and tillage equipment when moving between fields, and planting clean seed.
- If a weed pest population continues to progress after treatment with this product, discontinue use of this product, and switch to another management strategy or herbicide with a different mode of action, if available.

Contact your local extension specialist or certified crop advisors for additional pesticide resistance-management and/or integrated weed-management recommendations for specific crops and weed biotypes. For further information or to report suspected resistance or lack of performance, you may contact Gowan Company at 1-800-883-1844.

APPLICATION EQUIPMENT AND INSTRUCTIONS

Applications may be made by ground or aerial equipment to healthy, actively growing weeds. For best results, avoid applications when weeds are under stress due to weather, disease, insect damage, or combinations of these factors. Sandea is rainfast after 4 hours; rainfall or irrigation occurring within 4 hours after application may reduce effectiveness. Avoid streaking, skips, overlaps, and spray drift during application.

Thoroughly clean application equipment prior to mixing Sandea Herbicide spray solutions, after SANDEA Herbicide use, and prior to spraying a crop other than those listed on the label. Refer to the "SPRAYER TANK CLEANOUT" section of the label for more detailed information.

Ground Applications:

Apply SANDEA as a broadcast or band application with properly calibrated ground equipment in 15 or more gallons of water per acre unless otherwise directed in the "Application Instructions" section. Choose nozzles that provide optimum spray distribution and coverage to the target weed at the appropriate pressure (psi). For band applications, use proportionally less spray mixture based on the area actually sprayed. Do not concentrate the band. Consult the "Application Instructions" section of this label for the rates and procedures that are appropriate for your growing region.

Aerial Applications:

Apply this product or approved tank mixtures with properly calibrated equipment in 3 to 15 gallons of water per acre.

Rope-wick or Wiper Applications:

Apply by wiping SANDEA to the weeds using an absorbent material made of burlap, canvas, rope, sponge, or absorbent pad plumbed into a pipe reservoir filled with SANDEA. The absorbent material must maintain consistent moisture to allow for leaf wetness on targeted weeds, but not to a moisture level that allows for excess moisture to drip from the absorbent material. Selected equipment must be maintained and capable of preventing all contact of the herbicide solution with the crop or soil.

Adjust the height of the wiper applicator to ensure adequate contact with the weeds and so that no wiper contact point is at least 2 inches above the desirable vegetation. Optimum performance can be obtained when more of the weed is exposed to the herbicide solution and weeds are a minimum of 6 inches above the desirable vegetation. Weeds that do not come in contact with SANDEA will not be affected. Poor contact occurs when weeds are growing in dense clumps, in areas of severe weed infestation, when weed height varies dramatically or when operator speeds are too great. Terrain must be considered when making wiper applications. Sloping ground can cause herbicide solution to migrate to one side, causing dripping on the lower end and drying of the wiper on the upper end of the applicator. Due to decreased efficacy do not apply this product when weeds are wet.

Mix only the amount of product that will be used during a 1-day application, as reduced product performance can occur from solutions held longer than 24 hours. Avoid leaks or dripping of the herbicide solution onto the crop as contact of this product to desirable vegetation could result in plant injury or destruction. Keep wiper surfaces clean. Clean wiper parts promptly after using SANDEA by thoroughly flushing with water.

When Using Motorized Ground Equipment:

Prior to application determine the per acre output of your applicator. If the output rate is unknown it may be obtained by evaluating the output at ~100% weed density. Apply a minimum of 1 oz SANDEA per acre by mixing the desired per acre rate of SANDEA, in ratio with your determined per acre output. Do not exceed the maximum labeled rate for your crop.

The applicator device will physically wipe this product directly onto the weed in between rows of crop plants (row middles) or over the top of crops for selectively controlling weeds. Operate wiper applicators at a ground speed of no greater than 5 miles per hour. To maintain performance applicator should control chemical application rate by adjusting travel speed to match weed density. In areas of dense weeds better results can be obtained when two applications are made in opposite directions. Refer to the specific crop section of this label for rates and directions for use.

Spot Treatment:

For spot treatment or application with a hand held device, mix 1/4 oz – 1 oz SANDEA per 1 gallon of water. For best results, when using a hand held applicator, wipe the desired target weeds in a back and forth motion to ensure proper contact and coverage.

NOTE: When using a surfactant refer to the adjuvants section of this label.

SPRAY DRIFT**Ground Boom Applications:**

- Apply with the nozzle height recommended by the manufacturer, but no more than 3 feet above the ground or crop canopy unless making a turf, pasture, or rangeland application, in which case applicators may apply with a nozzle height no more than 4 feet above the ground.
- For applications prior to the emergence of crops and target weeds, applicators are required to use a Coarse or coarser droplet size (ASABE S572.1).
- For all other applications, applicators are required to use a Medium or coarser droplet size (ASABE S572.1).
- Do not apply when wind speeds exceed 10 miles per hour at the application site.
- Do not apply during temperature inversions.

Boom-less Ground Applications:

- Applicators are required to use a Medium or coarser droplet size (ASABE S572.1) for all applications.
- Do not apply when wind speeds exceed 10 miles per hour at the application site.
- Do not apply during temperature inversions.

Aerial Applications:

- Do not release spray at a height greater than 10 ft above the vegetative canopy, unless a greater application height is necessary for pilot safety.
- For applications prior to the emergence of crops and target weeds, applicators are required to use a Coarse or coarser droplet size (ASABE S572.1).
- For all other applications, applicators are required to use a Medium or coarser droplet size (ASABE S572.1).
- The boom length must not exceed 65% of the wingspan for airplanes or 75% of the rotor blade diameter for helicopters.
- Applicators must use 1/2 swath displacement upwind at the downwind edge of the field.
- Nozzles must be oriented so the spray is directed toward the back of the aircraft.
- Do not apply when wind speeds exceed 10 miles per hour at the application site.
- Do not apply during temperature inversions.

SPRAY DRIFT ADVISORIES:**Handheld Technology Applications:**

- Take precautions to minimize spray drift.

Boom-less Ground Applications:

- Setting nozzles at the lowest effective height will help to reduce the potential for spray drift.

THE APPLICATOR IS RESPONSIBLE FOR AVOIDING OFF-SITE SPRAY DRIFT. BE AWARE OF NEARBY NON-TARGET SITES AND ENVIRONMENTAL CONDITIONS.

Importance of droplet size:

An effective way to reduce spray drift is to apply large droplets. Use the largest droplets that provide target pest control. While applying larger droplets will reduce spray drift, the potential for drift will be greater if applications are made improperly or under unfavorable environmental conditions.

Controlling Droplet Size - Ground Boom

- Volume - Increasing the spray volume so that larger droplets are produced will reduce spray drift. Use the highest practical spray volume for the application. If a greater spray volume is needed, consider using a nozzle with a higher flow rate.
- Pressure - Use the lowest spray pressure recommended for the nozzle to produce the target spray volume and droplet size.
- Spray Nozzle - Use a spray nozzle that is designed for the intended application. Consider using nozzles designed to reduce drift.

Controlling Droplet Size - Aircraft

- Adjust Nozzles - Follow nozzle manufacturers recommendations for setting up nozzles. Generally, to reduce fine droplets, nozzles should be oriented parallel with the airflow in flight.

BOOM HEIGHT - Ground Boom - Use the lowest boom height that is compatible with the spray nozzles that will provide uniform coverage. For ground equipment, the boom should remain level with the crop and have minimal bounce.

RELEASE HEIGHT - Aircraft - Higher release heights increase the potential for spray drift. When applying aerially to crops, do not release spray at a height greater than 10 ft above the crop canopy, unless a greater application height is necessary for pilot safety.

SHIELDED SPRAYERS - Shielding the boom or individual nozzles can reduce spray drift. Consider using shielded sprayers. Verify that the shields are not interfering with the uniform deposition of the spray on the target area.

TEMPERATURE AND HUMIDITY - When making applications in hot and dry conditions, use larger droplets to reduce effects of evaporation.

TEMPERATURE INVERSIONS - Drift potential is high during a temperature inversion. Temperature inversions are characterized by increasing temperature with altitude and are common on nights with limited cloud cover and light to no wind. The presence of an inversion can be indicated by ground fog or by the movement of smoke from a ground source or an aircraft smoke generator. Smoke that layers and moves laterally in a concentrated cloud (under low wind conditions) indicates an inversion, while smoke that moves upward and rapidly dissipates indicates good vertical air mixing. Avoid applications during temperature inversions.

WIND - Drift potential generally increases with wind speed. AVOID APPLICATIONS DURING GUSTY WIND CONDITIONS. Applicators need to be familiar with local wind patterns and terrain that could affect spray drift.

Sensitive areas:

Pesticides should only be applied when the potential for drift to adjacent sensitive areas (e.g. residential areas, bodies of water, known habitat for threatened or endangered species, non-target crops) is minimal (e.g. when wind is blowing away from the sensitive areas).

Thoroughly clean application equipment immediately after the use of SANDEA. Prepare a tank cleaning solution that consists of a 1% solution of household ammonia (one quart of ammonia for every 25 gal of water). Use sufficient cleaning solution to thoroughly rinse all surfaces and to flush all hoses. Repeat the procedure with the ammonia solution. Complete the cleaning process by rinsing with clean water.

MIXING INSTRUCTIONS

Fill the spray tank to about three-fourths of the desired volume and begin agitation. Add the labeled amount of SANDEA. Complete the filling process while maintaining agitation. Remove the hose from the mixing tank immediately after filling to avoid siphoning back into the carrier source. Add nonionic surfactant (NIS) and other adjuvants as the last ingredients in the tank. Spray solutions should be applied within 24 hours after mixing.

ADJUVANTS

Unless otherwise stated, a NIS is recommended in the spray solution for postemergence applications or for preemergence applications where susceptible weeds are present prior to crop emergence. Use only nonionic-type surfactants that are approved for use on food crops and contain at least 80% active ingredients. Use 0.25 to 0.50% nonionic-type surfactant concentration (1 to 2 quarts per 100 gal of spray solution). Use of SANDEA without an adjuvant when weeds are present may result in reduced efficacy. Use of crop oil concentrate (COC) or silicone-based adjuvants can result in increased crop injury and reduced yields and are not recommended for postemergence applications over the crop, unless stated otherwise.

TANK MIXES

Unless stated in the "Application Instructions" section or allowed by supplemental labeling, tank mix combinations have not been evaluated and are the user's responsibility. It is the pesticide user's responsibility to ensure that all products in the listed mixtures are registered for the intended use (For Example: first aid from one product, spray drift management from another). Users must follow the most restrictive directions and precautionary language of the products in the mixture. It is recommended that tank mixtures should be evaluated for miscibility and crop safety on a small test area prior to use. Tank mixtures should not be applied when the plants are under stress due to drought, water saturated soils, low fertility (especially low nitrogen levels) or other poor growing conditions.

SPRAYER TANK CLEANOUT

To avoid injury to desirable crops, clean all mixing and spray equipment before and immediately following applications of SANDEA as follows:

1. Drain tank; thoroughly rinse spray tank, boom, and hoses with clean water. Remove the nozzles and screens and clean separately in a bucket containing agent and water. Loosen and physically remove any visible deposits.
2. Fill the tank with clean water and 1 gal of household ammonia* (containing 3% ammonia) for every 100 gal of water. Flush the hoses, boom, and nozzles with the cleaning solution. Then add more water to completely fill the tank. Circulate the cleaning solution through the tank and hoses for at least 15 minutes. Again flush the hoses, boom, and nozzles with the cleaning solution and then drain the tank.
3. Remove the nozzles and screens and clean separately in a bucket containing agent and water.
4. Repeat step 2.
5. Rinse the tank, boom, and hoses with clean water.
6. The rinsate may be disposed of on-site or at an approved disposal facility.

* Equivalent amount of an alternate strength ammonia solution can be used in the clean out procedure. Carefully read and follow the individual cleaner instructions.

USE PRECAUTIONS

- Excessive amounts of water (greater than 1 inch) from rainfall or sprinkler irrigation soon after a preemergent application may cause crop injury. This potential injury can be enhanced if seeding depth is too shallow.
- Within 4 hours of a SANDEA application, avoid using overhead sprinkler irrigations or making applications when conditions favor rainfall.
- Properly crowned beds may minimize the potential for injury when broadcast applications of SANDEA are made over plastic mulch. Significant crop injury could result when spray residue is concentrated in the plant hole by irrigation or rainfall.
- SANDEA can cause injury or crop failure under cool and wet growing conditions that delay early seedling emergence, vigor or growth. Be especially cautious during the first planting of the season when these conditions are likely to occur.
- SANDEA may delay maturity of treated crops.
- SANDEA should not be applied if the crop or target weeds are under stress due to drought, water saturated soils, low fertility (especially low nitrogen levels) or other poor growing conditions.
- Use of soil or foliar-applied organophosphate insecticides on SANDEA treated crops may increase the potential for crop injury and/or the severity of the crop injury.
- Avoid spray drift outside of targeted area.
- SANDEA may be applied to labeled crops (including cultivars and/or hybrids of these) and used according to labeled directions. Not all hybrids/varieties have been tested for sensitivity to SANDEA. For untested varieties, a small amount of the field should be sprayed to determine potential sensitivity to its use.
- Thoroughly clean application equipment immediately after SANDEA use and prior to spraying another crop.
- Temporary yellowing or stunting of the crop may occur following SANDEA applications.
- Under certain environmental conditions, SANDEA applied over the top of a blooming crop may result in some bloom loss.
- Use of SANDEA without an adjuvant can result in reduced efficacy.

USE RESTRICTIONS

- Do not apply SANDEA using air assisted (air blast) field crop sprayers.
- Do not apply this product through any type of irrigation system.
- Do not apply more than 2 oz of SANDEA per acre per 12 month period (includes applications to the crop and to row middles/furrows).
- Do not make more than the maximum number of applications per year for each crop.
- CALIFORNIA ONLY SENSITIVE CROP:

PRUNES

Buffer Zones:

1. Aerial applications shall not be made closer than 4 miles.
2. Ground applications shall not be made closer than 1 mile from prunes unless wind direction during the application is away from prunes. When wind direction during the ground application is away from prunes, ground applications shall not be made closer than 1/2 mile from prunes.

COTTON

Buffer Zones:

1. Aerial applications shall not be made closer than 1 mile from cotton.
2. Ground applications shall not be made closer than 1 mile from cotton unless wind direction during the application is away from cotton. When wind direction during the ground application is away from cotton, ground applications shall not be made closer than 1/2 mile from cotton.

FOR OPTIMUM RESULTS

Control typically occurs within 7 to 14 days depending on the weed size, species and growing conditions. Heavy weed infestations should be treated early before the weeds become too competitive with the crop. Good coverage with SANDEA is essential. When applying SANDEA follow "Weed Controlled Chart" and "Application Timing" sections of the label for improved control. When adding approved adjuvant follow mixing instructions regarding adjuvant.

- For best results, wait to cultivate treated soil area for 7 to 10 days after a postemergence application of SANDEA unless otherwise specified. (Cultivation may be necessary to control suppressed weeds, weeds that were bigger than the maximum recommended size at application, weeds that emerge after an application, or weed species not on the SANDEA label).
- To maximize control of annual weeds, it may be necessary to use sequential applications of SANDEA, but do not make more than the maximum number of applications per year for each crop. (Multiple flushes of seedlings, or treated perennials may sometimes re-grow from underground stems or roots).

For preemergence applications:

- Use a surfactant as directed in the "Adjuvants" section of this label to control susceptible weeds prior to crop emergence.
- Preemergent weed control may be improved by incorporating SANDEA with irrigation (1/4 to 1/2 inch maximum).
- Preemergence applications of SANDEA when weed coverage prevents contact with the soil will result in reduced or no residual activity.

For postemergence applications:

- Treat young actively growing broadleaf weeds 1 to 3 inches in height.
- Treat actively growing nutsedge plants at the 3 to 5 leaf stage.
- Wait 2 - 3 days after postemergent applications for to overhead irrigation.
- Avoid applications when crops are under drought, stress, disease, or insect damage.

WEEDS CONTROLLED BY SANDEA ALONE

C = Control, S = Suppression, NA = No Activity

WEED SPECIES	PREEMERGE NT ACTIVITY	POSTEMERGENT ACTIVITY	WEED HEIGHT (IN) 1 OZ/ACRE	WEED HEIGHT (IN) 2 OZ/ACRE
Amaranth, spiny ² <i>Amaranth spinosus</i>	C ²	C ²	1 to 3	1 to 6
Bindweed, hedge <i>Calystegia sepium</i>	NA	S	1 to 2	1 to 4
Burcucumber <i>Sicyos angulatus</i>	NA	S	1 to 3	1 to 12
California arrowhead ³ <i>Sagittaria montevidensis</i>	NA	C ³	1 to 2	1 to 4
Chickweed, common <i>Stellaria media</i>	C	NA	1 to 3	1 to 5
Cocklebur, common <i>Xanthium strumarium</i>	C	C	1 to 9	1 to 14
Corn spurry <i>Spergula arvensis</i>	C	C	1 to 2	1 to 4
Dayflower* <i>Commelina erecta</i>	C	S	1 to 2	1 to 4
Deadnettle, purple <i>Lamium purpureum</i>	C	NA	----	----
Devils Claw <i>Proboscidea louisianica</i>	NA	C	1 to 6	1 to 10
Eclipta* <i>Ecilpta prostrata</i>	C	S	1 to 2	1 to 4
Flatsedge, rice* ² <i>Cyperus iria</i>	S ²	C ²	1 to 9	1 to 12
Fleabane, Philadelphia <i>Erigeron philadelphicus</i>	NA	C	1 to 3	1 to 3
Galinsoga <i>Galinsoga</i>	C	C	1 to 2	1 to 4
Golden crownbeard* <i>Verbesina encelioides</i>	NA	C	1 to 2	1 to 4
Goosefoot <i>Chenopodium</i>	C	C	1 to 2	1 to 4
Groundsel, common <i>Senecio vulgaris</i>	C	NA	----	----
Horseweed/Marestail ² <i>Erigeron canadensis</i>	C ²	NA	1 to 3	1 to 6
Horsetail <i>Equisetum</i>	NA	S	1 to 2	1 to 4
Jimsonweed <i>Datura stramonium</i>	C	NA	1 to 4	1 to 8
Jointvetch <i>Aeschynomene virginica</i>	NA	C	1 to 2	1 to 4
Kochia ² <i>Kochia scoparia</i>	C ²	S ²	1 to 3	1 to 6
Ladysthumb <i>Polygonum persicaria</i>	C	C	1 to 3	1 to 6
Lambsquarter, common <i>Chenopodium album</i>	C	NA	1 to 3	1 to 5
Lettuce, prickly <i>Lactuca serriola</i>	C	NA	1 to 4	1 to 6
Mallow, common <i>Malva neglecta</i>	C	NA	1 to 3	1 to 5
Mallow, Venice <i>Hibiscus trionum</i>	C	C	1 to 3	1 to 12
Mayweed chamomile (dog fennel) <i>Anthemis cotula</i>	C	NA	----	----
Milkweed, common <i>Asclepias syriaca</i>	NA	S	1 to 5	1 to 12

WEED SPECIES	PREEMERGE NT ACTIVITY	POSTEMERGENT ACTIVITY	WEED HEIGHT (IN) 1 OZ/ACRE	WEED HEIGHT (IN) 2 OZ/ACRE
Milkweed, honeyvine <i>Ampelamus albidus</i>	NA	S	1 to 3	1 to 6
Morningglory, ivyleaf ³ <i>Ipomoea hederacea</i>	NA	S ³	1 to 3	1 to 4
Morningglory, tall ³ <i>Ipomoea purpurea</i>	NA	S ³	1 to 3	1 to 4
Mustard, wild <i>Sinapis arevensis</i>	C	C	1 to 6	1 to 10
Nutsedge, yellow ¹ <i>Cyperus esculentus</i>	S	C ¹	3 to 6	3 to 12
Nutsedge, purple ¹ <i>Cyperus rotundus</i>	S	C ¹	3 to 6	3 to 12
Passionflower, maypop <i>Passiflora incarnata</i>	NA	C	1 to 3	1 to 3
Pigweed, redroot ² <i>Amaranthus retrofiexus</i>	C ²	C ²	1 to 3	1 to 6
Pigweed, smooth ² <i>Amaranthus hybridus</i>	C ²	C ²	1 to 3	1 to 6
Plantain <i>Plantago major</i>	C	NA	----	----
Pokeweed, common <i>Phytolacca Americana</i>	NA	C	1 to 3	1 to 6
Purslane <i>Portulaca oleracea</i>	S	NA	----	----
Radish, wild <i>Raphanus raphanistrum</i>	C	C	1 to 4	1 to 8
Ragweed, common ² <i>Ambrosia artemisiifolia</i>	C ²	C ²	1 to 9	1 to 12
Ragweed, giant ² <i>Ambrosia trifida</i>	NA	C ²	1 to 3	1 to 6
Redstem ³ <i>Ammania auriculata</i>	NA	C ³	1 to 2	1 to 4
Ricefield Bulrush ² <i>Scirpus mucronatus</i>	NA	C ²	1 to 2	1 to 4
Sesbania, hemp <i>Sesbania exaltata</i>	S	C	1 to 3	1 to 6
Sharppoint fluvellin ^{.4} <i>Kickxia elatine</i>	C	C ⁴	----	----
Shepherdspurse <i>Capsella bursa-pastoris</i>	C	S	1 to 3	1 to 6
Sida, prickly* <i>Sida spinosa</i>	NA	S	1 to 2	1 to 4
Smallflower umbrella sedge ² <i>Cyperus difformis</i>	NA	C ²	1 to 2	1 to 4
Smartweed, Pennsylvania <i>Polygonum pensylvanicum</i>	C	S	1 to 3	1 to 6
Sunflower <i>Helianthus</i>	C	C	1 to 12	1 to 15
Velvetleaf <i>Abutilon theophrasti</i>	C	C	1 to 9	1 to 12
Willowherb <i>Epilobium ciliatum</i>	C	NA	----	----
Yellowcress, creeping <i>Rorippa sylvestris</i>	C	C	1 to 2	1 to 4

* Except California

1. Heavy infestations of nutsedge may require sequential applications. An earlier treatment may be required to prevent nutsedge from competing with the crop.
2. Certain biotypes of this weed species are known to be resistant to ALS herbicides. Where these ALS-resistant biotypes are known to exist, an appropriate registered herbicide, active against the weed and with another mode of action, should be used alone or in tank mixtures with SANDEA to control these biotypes.
3. Use maximum label rates for best results.
4. Postemergence applications must be made when the basal diameter of the weed is the size of a U.S. quarter or smaller, and before stem elongation.

Table of Contents			
CROP	PAGE #	CROP	PAGE #
Alfalfa	"-"	Honeydews	"-"
Artichokes	"-"	Millet	"-"
Asparagus	"-"	Okra	"-"
Beans, Dry	"-"	Pasture, Rangeland, & Forage	"-"
Beans, Succulent	"-"	Peas, Succulent	"-"
Bell peppers	"-"	Pome Fruit Group	"-"
Blueberries	"-"	Pumpkins	"-"
Caneberries	"-"	Rhubarb	"-"
Cantaloupes	"-"	Rice	"-"
Chile peppers	"-"	Small Fruit Vine Climbing Group	"-"
Corn, Field	"-"	Sorghum	"-"
Corn, Pop	"-"	Sugarcane	"-"
Corn, Seed	"-"	Summer Squash	"-"
Corn, Sweet	"-"	Tomatoes	"-"
Cotton	"-"	Tree Nuts	"-"
Crenshaw Melons	"-"	Turfgrass/Sod	"-"
Cucumbers	"-"	Watermelons	"-"
Fallow Ground	"-"	Winter Squash	"-"

**APPLICATION INSTRUCTIONS
PREHARVEST INTERVAL**

The required days between last application and harvest (PHI) are given in () after each crop name.

CUCURBIT CROPS

CROP	OZ/ACRE	DIRECTIONS FOR USE
CUCUMBERS (14) <i>(including pickles)</i> MUSKMELON <i>(including cantaloupes)</i> (57), HONEYDEWS (57), AND CRENSHAW MELONS (57)	1/2 - 1	<p>Apply uniformly with ground equipment in a minimum of 15 gal of water per acre.</p> <p>Direct-seeded: Bare ground (no mulch)</p> <ul style="list-style-type: none"> • Preemergence - Apply SANDEA after planting, but prior to soil cracking. Use the lower rate on lighter textured soils with low organic matter. • Postemergence - Apply SANDEA after the crop has reached at least 3 to 5 true leaves but before first female flowers appear. SANDEA can be applied as an over-the-top application, a directed spray application, or with crop shields to minimize contact of the herbicide with the crop. <p>Direct-seeded: Plastic mulch</p> <ul style="list-style-type: none"> • Pre-seeding - Apply SANDEA following final bed shaping and just prior to the installation of the plastic mulch. Crop may be seeded into this treated area no sooner than 7 days after application and the installation of the plastic mulch unless local conditions demonstrate safety at an earlier interval. Use the lower rate on lighter textured soils with low organic matter. • Postemergence - Apply SANDEA after the crop has at least 3 to 5 true leaves but before first female flowers appear. SANDEA can be applied as an over-the-top application, a directed spray application, or with crop shields to minimize contact of the herbicide with the crop. Additional phytotoxicity may occur when applications are made over plastic due to concentration of product in the planting hole. NOTE: Over-the-top applications on plastic are not allowed in Northeastern and Midwestern states. <p>Transplanted: Bare ground (no mulch)</p> <ul style="list-style-type: none"> • Pre-transplant - Apply SANDEA as a pre-transplant application. Crop may be transplanted into this treated area no sooner than 7 days after application unless local conditions demonstrate safety at an earlier interval. Use the lower rate on lighter textured soils with low organic matter. Care should be taken to limit movement of SANDEA-treated surface soil during the transplanting process since if treated soil is moved into the transplant hole injury can occur. • Post-transplant - Apply SANDEA to transplants that are established and actively growing. Applications should not be made until plants are actively growing and in the 3 to 5 true leaf stage or no sooner than 14 days after transplanting unless local conditions demonstrate safety at an earlier interval, but before first female flowers appear. SANDEA may be applied as an over-the-top application, a directed spray application, or with crop shields to minimize contact of the herbicide with the crop. <p>Transplanted: Plastic mulch</p> <ul style="list-style-type: none"> • Pre-transplant - Apply SANDEA following final bed shaping and just prior to the installation of the plastic mulch. Crop may be transplanted into this treated area no sooner than 7 days after the application and the installation of the plastic mulch unless local conditions demonstrate safety at an earlier interval. Use the lower rate on lighter textured soils with low organic matter. Care should be taken to limit movement of SANDEA-treated surface soil during the transplanting process since if treated soils is moved into the transplant hole injury can occur. • Post-transplant - Apply SANDEA to transplants that are established, actively growing and in the 3 to 5 true leaf stage or no sooner than 14 days after transplanting unless local conditions demonstrate safety at an earlier interval, but before first female flowers appear. Apply SANDEA as an over-the-top application, a directed spray application, or with crop shields to minimize contact of the herbicide with the crop. Additional phytotoxicity can occur when applications are made over plastic due to concentration of product in the transplant hole. NOTE: Over-the-top applications on plastic are not allowed in Northeastern and Midwestern states. <p>Direct-seeded and Transplant:</p> <ul style="list-style-type: none"> • Row Middle/Furrow Applications - Apply SANDEA between rows of direct-seeded or transplanted crop. Avoid contact of the herbicide with the planted crop. If plastic is used on the planted row, adjust equipment to keep the application off the plastic. Reduce rate and spray volume in proportion to area actually sprayed. <p>Split Applications for Nutsedge:</p> <ul style="list-style-type: none"> • Preemergence followed by postemergence for nutsedge control To maximize control of nutsedge, it may be necessary to use a postemergence application to those areas where the nutsedge has emerged later following a preemergence application. For these situations, use a spot treatment method treating only those areas of emerged nutsedge. Application rate should not exceed 1.0 oz product per treated acre in these areas. Use a water volume that will allow for good coverage of the plants. Avoid contact of the herbicide with the planted crop. • Postemergence followed by postemergence for nutsedge control To maximize control of nutsedge, it may be necessary to use a second postemergence spot application to those areas where the nutsedge has emerged or re-grown. For these situations, use a spot treatment method treating only those areas of emerged nutsedge. Allow a minimum of 21 days between applications. Application rate should not exceed 1.0 oz product per treated acre in these areas. Use a water volume that will allow for good coverage of the plants. Avoid contact of the herbicide with the planted crop. Rope-wick or
	1	<p>Rope-wick or Wiper Applications:</p> <ul style="list-style-type: none"> • Row Middle/Furrow Application – Apply using a minimum of 1 oz per acre.
<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • Runners that come in contact with the plastic can pick up residual SANDEA and may exhibit a visual crop response. • Consult "Use Precautions" and "For Optimum Results" for important usage information. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Do not apply more than 2 applications or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period. (includes applications to the crop and to row middle/furrows) 		

CROP	OZ/ACRE	DIRECTIONS FOR USE
PUMPKINS and WINTER SQUASH (30)	1/2 - 3/4	Apply uniformly with ground equipment in a minimum of 15 gal of water per acre. For all applications where possible, apply 1/2 to 3/4 inch of sprinkler irrigation to settle the soil after planting and prior to application. Direct-seeded: <ul style="list-style-type: none"> • Preemergence - Apply SANDEA after planting, but prior to soil cracking. Use the lower rates on lighter textured soils with low organic matter. • Postemergence - Apply SANDEA after the crop has reached the 2 to 5 true leaf stage, preferably 4 to 5 true leaves, but before first female flowers appear. Use lower rates on lighter textured soils with low organic matter. Transplanted: <ul style="list-style-type: none"> • Pre-transplant - Apply SANDEA prior to transplant. Crop may be transplanted into this treated area no sooner than 7 days after application unless local conditions demonstrate safety at an earlier interval. Use the lower rate on lighter textured soils with low organic matter. Care should be taken to limit movement of SANDEA-treated surface soil during the transplanting process since if treated soil is moved into the transplant hole injury can occur. • Post-transplant - Apply SANDEA to transplants that are established, actively growing and in the 3 to 5 true leaf stage or no sooner than 14 days after transplanting unless local conditions demonstrate safety at an earlier interval, but before first female flowers appear. SANDEA can be applied as an over-the-top application, a directed spray application or with crop shields to minimize contact of the herbicide with the crop.
	1/2 - 1	Apply uniformly as a broadcast spray with ground equipment in a minimum of 15 gal of water per acre. FOR PROCESSING ONLY - Direct-seeded: <ul style="list-style-type: none"> • Preemergence - Apply SANDEA after planting, but prior to soil cracking. Use the lower rates on lighter textured soils with low organic matter. • Postemergence - Apply SANDEA after the crop has reached the 2 to 5 true leaf stage, but before first female flowers appear. Use lower rates on lighter textured soils with low organic matter.
	1/2 - 1	Direct-seeded and Transplant: <ul style="list-style-type: none"> • Row Middle/Furrow Applications - Apply SANDEA between rows of direct-seeded or transplanted crop while avoiding contact of the herbicide with the planted crop. If plastic is used on the planted row, adjust equipment to keep the application off the plastic. Reduce rate and spray volume in proportion to area actually sprayed.
	1	Rope-wick or Wiper Applications: <ul style="list-style-type: none"> • Row Middle/Furrow Application – Apply using a minimum of 1 oz per acre.
	PRECAUTIONS: <ul style="list-style-type: none"> • When rainfall or irrigation in excess of 3/4 inch occurs following a preemergence application and the crop is in the germination to early-seedling stage, there is the potential for significant plant stunting to occur. • Consult “Use Precautions” and “For Optimum Results” for important usage information. RESTRICTIONS: <ul style="list-style-type: none"> • Do not apply more than 2 applications of 1 oz/A or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period. (includes applications to the crop and to row middles). 	
SUMMER SQUASH FOR PROCESSING (30) (AR, OK and MO only)	2/3 - 1	Apply uniformly with ground equipment in a minimum of 20 gal of water per acre. Direct-seeded: <ul style="list-style-type: none"> • Preemergence - Apply SANDEA after planting, but prior to cracking. Use the lower rate on lighter textured soils with low organic matter.
	1/2 - 1	Direct-seeded and Transplant: <ul style="list-style-type: none"> • Row Middle/Furrow Applications - Apply SANDEA between rows of direct-seeded or transplanted summer squash. If plastic is used on the planted row, adjust equipment to keep the application off the plastic. Reduce rate and spray volume in proportion to area actually sprayed. Avoid contact of the herbicide with the planted crop.
	1	Rope-wick or Wiper Applications: <ul style="list-style-type: none"> • Row Middle/Furrow Application – Apply using a minimum of 1 oz per acre.
PRECAUTIONS: <ul style="list-style-type: none"> • Consult “Use Precautions” and “For Optimum Results” for important usage information. RESTRICTIONS: <ul style="list-style-type: none"> • Do not apply more than 2 applications of 1 oz/A or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period. (includes applications to the crop and to Row Middle/Furrows) 		
WATERMELONS (57) Only: AL, AR, AZ, CA, CT, DE, FL, GA, IL, IN, KS, KY, LA, MA, MD, ME, MI, MO, MS, NC, NH, NJ, NY, OH, OK, OR, PA, RI, SC, TN, TX, VA, VT, WA, WV, WI	1/2 - 3/4	Apply uniformly with ground equipment in a minimum of 20 gal of water per acre. Direct-seeded: Bare ground <ul style="list-style-type: none"> • Preemergence - Apply SANDEA after planting, but prior to soil cracking. Use the lower rate on lighter textured soils with low organic matter. Where soil is fumigated prior to planting, allow at least five days after soil fumigation before an application of SANDEA. Direct Seeded: Plastic mulch <ul style="list-style-type: none"> • Pre-seeding - Apply SANDEA following final bed shaping and just prior to the installation of the plastic mulch. Watermelons should be seeded into this treated area no sooner than 7 days after the application and the installation of the plastic mulch unless local conditions demonstrate safety at an earlier interval. Use the lower rate on lighter textured soils with low organic matter. SANDEA treated soil from the soil surface into the planting hole can result in crop injury. Care should be taken to limit movement of SANDEA treated surface soil during the transplant process.

CROP	OZ/ACRE	DIRECTIONS FOR USE
WATERMELONS (57) Only: AL, AR, AZ, CA, CT, DE, FL, GA, IL, IN, KS, KY, LA, MA, MD, ME, MI, MO, MS, NC, NH, NJ, NY, OH, OK, OR, PA, RI, SC, TN, TX, VA, VT, WA, WV, WI (continued)		Transplanted: Bare ground <ul style="list-style-type: none"> • Pre-transplant - Apply SANDEA pre-transplant. Watermelons should be transplanted into this treated area no sooner than 7 days after application unless local conditions demonstrate safety at an earlier interval. Use the lower rate on lighter textured soils with low organic matter. Care should be taken to limit movement of SANDEA-treated surface soil during the transplanting process since if treated soils is moved into the transplant hole injury can occur.
	1/2 - 3/4	Transplanted: Plastic mulch <ul style="list-style-type: none"> • Pre-transplant - Apply SANDEA following final bed shaping and just prior to the installation of the plastic mulch. Watermelons should be transplanted into this treated area no sooner than 7 days after the application and the installation of the plastic mulch unless local conditions demonstrate safety at an earlier interval. Use the lower rate on lighter textured soils with low organic matter. Care should be taken to limit movement of SANDEA treated surface soil during the transplanting process since if treated soils is moved into the transplant hole injury can occur.
	1/2 - 1	Direct-seeded and Transplant: <ul style="list-style-type: none"> • Row Middle Applications - Apply SANDEA between rows of direct-seeded or transplanted crop, while avoiding contact of the herbicide with the planted crop. If plastic is used on the planted row, adjust equipment to keep the application off the plastic. Reduce rate and spray volume in proportion to area actually sprayed.
	1	Rope-wick or Wiper Applications: <ul style="list-style-type: none"> • Row Middle/Furrow Application – Apply using a minimum of 1 oz per acre.
	PRECAUTIONS: <ul style="list-style-type: none"> • Runners that come in contact with the plastic can pick up residual SANDEA and may exhibit a visual crop response. • Consult "Use Precautions" and "For Optimum Results" for important usage information. RESTRICTIONS: <ul style="list-style-type: none"> • Do not apply more than 2 applications or 1 oz/A of product by weight (0.047 lb a.i./acre) per 12 month period. (includes applications to the crop and to row middle) 	
OTHER COMMODITIES IN THE CUCURBIT VEGETABLES GROUP <i>Including but not limited to summer squash, gourd, watermelon (See text for PHI)</i>	1/2 - 1	Direct-seeded and Transplant: <ul style="list-style-type: none"> • Row Middle/Furrow Applications - Apply SANDEA between rows of direct-seeded or transplanted cucurbit vegetables while avoiding contact of the herbicide with the planted crop. If plastic is used on the planted row, adjust equipment to keep the application off the plastic. Reduce rate and spray volume in proportion to area actually sprayed.
	1	Rope-wick or Wiper Applications: <ul style="list-style-type: none"> • Row Middle/Furrow Application – Apply using a minimum of 1 oz per acre.
	PRECAUTIONS: <ul style="list-style-type: none"> • Consult "Use Precautions" and "For Optimum Results" for important usage information. RESTRICTIONS: <ul style="list-style-type: none"> • Do not apply within 30 days of harvest for squash/cucumber subgroup. • Do not apply within 57 days of harvest for melon subgroup. • Do not apply more than 2 applications or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period. 	

FRUITING VEGETABLE CROPS

CROP	OZ/ACRE	DIRECTIONS FOR USE
PEPPERS, BELL/CHILE (30) AZ, CA, NM, TX and OK Only	1/2 - 1	Apply uniformly with ground equipment in a minimum of 20 gal of water per acre. Direct-seeded: <ul style="list-style-type: none"> • Postemergence - Apply SANDEA as a directed spray 28 days after planting or when the plants have reached a minimum of six inches in height, but prior to flowering. Use lower rates on lighter textured soils with low organic matter. Transplanted: <ul style="list-style-type: none"> • Post-transplant - Apply SANDEA as a directed spray 21 days after transplanting or when the plants have reached a minimum of six inches in height, but prior to flowering.
	1/2 - 1	Direct-seeded and Transplant: <ul style="list-style-type: none"> • Row Middle/Furrow Applications - Apply SANDEA between rows of direct-seeded or transplanted peppers while avoiding contact of the herbicide with the planted crop. If plastic is used on the planted row, adjust equipment to keep the application off the plastic. Reduce rate and spray volume in proportion to area actually sprayed.
	1	Rope-wick or Wiper Applications: <ul style="list-style-type: none"> • Row Middle/Furrow Application – Apply using a minimum of 1 oz per acre.
	PRECAUTIONS: <ul style="list-style-type: none"> • Not all pepper varieties have been tested. • Consult "Use Precautions" and "For Optimum Results" for important usage information. RESTRICTIONS: <ul style="list-style-type: none"> • Do not apply more than 2 applications or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period. (includes applications to the crop and to row middle/furrows). 	

TOMATOES (30)	1/2 - 1	<p>Apply uniformly with ground equipment in a minimum of 20 gal of water per acre.</p> <p>Direct-seeded:</p> <ul style="list-style-type: none"> • Postemergence - Apply SANDEA over-the-top once tomatoes have reached the 4 leaf stage through 30 days prior to harvest. Applications following bloom could cause some bloom drop under certain environmental conditions. Apply as a directed spray or with crop shield when these conditions are present. <p>Transplanted:</p> <ul style="list-style-type: none"> • Pre-transplant on Bareground - Apply SANDEA as a pre-plant application to bareground. Tomatoes can be transplanted into this treated area 7 days after the application unless local conditions demonstrate safety at an earlier interval. Use lower rate on lighter textured soils with low organic matter. SANDEA treated soil from the soil surface into the transplant hole can result in crop injury. Care should be taken to limit the movement of treated surface soil during the transplant process. • Pre-transplant Under Plastic Mulch Applications - Apply SANDEA following final bed shaping and just prior to the installation of the plastic mulch. Tomatoes can be transplanted into this treated area 7 days after the application and the installation of the plastic mulch unless local conditions demonstrate safety at an earlier interval. SANDEA treated soil from the soil surface into the transplant hole can result in crop injury. Care should be taken to limit movement of SANDEA treated surface soil during the transplant process. • Post-transplant - Apply SANDEA over-the-top, post directed or with crop shields to tomato transplants that are established, actively growing and a minimum of 14 days after transplanting unless local conditions demonstrate safety at an earlier interval. Applications following bloom could cause some bloom drop under certain environmental conditions. Application as a directed spray or with crop shields should be considered when conditions are present. <p>Direct-seeded and Transplant:</p> <ul style="list-style-type: none"> • Row Middle/Furrow Applications - Apply SANDEA between rows for the control of nutsedge and listed broadleaf weeds. Avoid contact of the herbicide with the planted crop. If plastic is used on the planted row, adjust equipment to keep the application off the plastic. Reduce rate and spray volume in proportion to area actually sprayed. <p>Split Applications for Nutsedge</p> <p>Direct-seeded and Transplant:</p> <ul style="list-style-type: none"> • Pre-transplant followed by postemergence for nutsedge control To maximize control of nutsedge, it may be necessary to use a postemergence application to those areas where the nutsedge has broken through the plastic mulch. For these situations, use a spot treatment method treating only those areas of emerged nutsedge. Application rate should not exceed 3/4 oz product per treated acre in these areas. Use a water volume that will allow for good coverage of the plants. SANDEA treated soil in the transplant hole may result in crop injury. If transplanting after herbicide application, care should be taken to limit movement of SANDEA treated soil during the transplant process. • Postemergence followed by postemergence for nutsedge control To maximize control of nutsedge, it may be necessary to use a postemergence spot application to those areas where the nutsedge has germinated or regrown. Allow a minimum of 21 days between applications. Application rate should not exceed 1 oz product per treated acre in these areas.
	1	<p>Rope-wick or Wiper Applications:</p> <ul style="list-style-type: none"> • Row Middle/Furrow Application – Apply using a minimum of 1 oz per acre.
	<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • Consult “Use Precautions” and “For Optimum Results” for important usage information. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Do not apply more than 2 applications or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period. (Includes applications to the crop and to row middles/furrows). 	
FRUITING VEGETABLES GROUP (30) <i>Including but not limited to eggplant, peppers, tomatoes</i>	1/2 - 1	<p>Direct-seeded and Transplant:</p> <ul style="list-style-type: none"> • Row Middle/Furrow Applications - Apply SANDEA between rows of direct-seeded or transplanted fruiting vegetables while avoiding contact of the herbicide with the planted crop. If plastic is used on the planted row, adjust equipment to keep the application off the plastic. Reduce rate and spray volume in proportion to area actually sprayed.
	1	<p>Rope-wick or Wiper Applications:</p> <ul style="list-style-type: none"> • Row Middle/Furrow Application – Apply using a minimum of 1 oz per acre.
	<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • Consult “Use Precautions” and “For Optimum Results” for important usage information. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Do not apply more than 2 applications or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period. 	

PERMANENT CROPS

CROP	OZ/ACRE	DIRECTIONS FOR USE
<p>13-07B BUSHBERRY SUBGROUP (14) (excluding lowbush blueberries)</p>	<p>1/2 - 2/3 1 - 4 year bushes</p> <p>1/2 - 1 >4 year bushes</p>	<p>Apply uniformly with ground equipment in a minimum of 15 gal of water per acre. Apply as a directed spray application to the ground on either side of the row.</p> <ul style="list-style-type: none"> • Preemergence and Postemergence directed application for control of labeled weeds: Apply SANDEA as a single or sequential directed spray application. If small weeds are present tank mix with a postemergence broad-spectrum type herbicide to maximize and enhance the spectrum of broadleaf and grass control. Preemergence applications of SANDEA when ground cover prevents contact with the soil will result in reduced or no residual activity • Postemergence directed application for control of nutsedge: Apply SANDEA as a single directed spray application when nutsedge is fully emerged. Alternatively, two directed spray applications can be made. Apply first directed spray application to the initial nutsedge flush when it has reached the 3 to 5 leaf stage. If a second treatment is needed, it may be applied later in the season directed to secondary nutsedge emergence. To maximize control, apply SANDEA when nutsedge plants are in the 3 to 5 leaf stage. For best results, use a minimum of 0.75 oz/A of SANDEA. SANDEA may not control ALS resistant weeds. <p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • Contact of SANDEA with the blueberry bushes should be avoided. Contact will result in temporary chlorosis of treated leaves. • Use of a shielded boom is recommended. • Consult "Use Precautions" and "For Optimum Results" of label for important usage information. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Minimum of 45 days between applications. • Do not concentrate the application rate into the treated swath. • Do not apply to bushes established less than one year or to plants under stress. • Do not apply to 'Elliott' variety bushes established less than four years. • Do not apply to areas where water is known to pond for periods of time following rainfall. • Do not contact foliage or green wood renewal canes with SANDEA. Herbicide uptake via contacted foliage or green canes will result in plant injury. • Do not apply more than 2 applications or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period. • Do not apply by rope-wick wiper application.
<p>13-07B LOWBUSH BLUEBERRIES (14)</p>	<p>1/2 - 1</p>	<p>Apply uniformly with ground equipment in a minimum of 15 gal of water per acre. SANDEA should be tank mixed with products such as Velpar® or Sinbar® to broaden the spectrum of weeds controlled.</p> <ul style="list-style-type: none"> • Vegetative (Non-Crop) Year • Broadcast application prior to breaking dormancy for control of labeled weeds <p>Apply SANDEA as a single broadcast spray application. If small weeds are present tank mix with a postemergence herbicide to maximize and enhance the spectrum of broadleaf and grass control. Applications applied 1 to 2 months prior to breaking dormancy will allow for better weed control.</p> <p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • Overlapping boom swaths increases the potential for phytotoxicity including leaf yellowing, reddening, and/or stunting • Consult "Use Precautions" and "For Optimum Results" of label for important usage information. • Preemergence applications of SANDEA when ground cover prevents contact with the soil will result in reduced or no residual activity. • SANDEA may not control ALS resistant weeds. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Do not apply to bushes established less than one year or to plants under stress. • Do not apply to areas where water is known to pond for periods of time following rainfall. • Do not apply SANDEA after the crop has progressed into budbreak or significant injury will occur. • Do not apply more than 1 application or 1 oz/A of product by weight (0.047 lb a.i./acre) per 12 month period. • Do not apply by rope-wick wiper application.
<p>13-07A CANEBERRY SUBGROUP (14) (Blackberry; loganberry; raspberry, black and red; wild raspberry; cultivars, varieties and/or hybrids of these)</p> <p>(For use in Oregon and Washington only)</p>	<p>3/4 – 1 1/3</p>	<p>Apply SANDEA uniformly with ground equipment in a minimum of 15 gal of water per acre.</p> <ul style="list-style-type: none"> • Apply as a broadcast directed spray application to the ground on either side of the row. Applications of SANDEA should be made pre-emergence up to and including primocane burndown. Do not apply to developing primocanes in season until hardened off. • Preemergence and Postemergence directed application for control of labeled weeds: Apply a single or sequential application based on weed pressure. If small weeds are present tank mix with a postemergence broad-spectrum type herbicide to maximize and enhance the spectrum of broadleaf and grass control. <p>For preemergence control, do not apply SANDEA if excessive weed growth prevents contact with the ground.</p> <ul style="list-style-type: none"> • Postemergence directed application for control of nutsedge: Apply SANDEA as a single directed spray application when nutsedge is fully emerged. Alternatively, two directed spray applications can be made. Apply first directed spray application to the initial nutsedge flush when it has reached the 3 to 5 leaf stage. If a second treatment is needed, it may be applied later in the season directed to secondary nutsedge emergence. To maximize control, apply SANDEA when nutsedge plants are in the 3 to 5 leaf stage. For best results, use a minimum of 0.75 oz/A of SANDEA.
	<p>1</p>	<p>Rope-wick or Wiper Applications:</p> <ul style="list-style-type: none"> • Row Middle/Furrow Application – Apply using a minimum of 1 oz per acre.

	<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • For best results, use a non-ionic surfactant (NIS) with applications. • Consult "Use Precautions" and "For Optimum Results" for important usage information. • Contact of SANDEA with the caneberry bushes should be avoided. Contact will result in temporary chlorosis of treated leaves. • Use of a shielded boom is recommended. • SANDEA may not control ALS resistant weeds. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Minimum of 45 days between applications. • Do not concentrate the application rate into the treated swath. • Do not apply to areas where water is known to pond for periods of time following rainfall. • Do not apply to bushes established less than one year or to plants under stress. • Do not contact foliage or green wood renewal canes with SANDEA. Herbicide uptake via contacted foliage or green canes will result in plant injury. • Do not apply more than 2 applications or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period. • Do not apply by air. • Do not apply to developing primocanes in season until hardened off. 	
<p>13-07F SMALL FRUIT VINE CLIMBING SUBGROUP EXCEPT FUZZY KIWIFRUIT (14) (East of the Rockies) Amur river grape; gooseberry; grape; kiwifruit, hardy; maypop; schisandra berry; cultivars, varieties, and/or hybrids of these</p>	<p>1/2 - 1</p>	<p>Apply uniformly with ground equipment in a minimum of 15 gal of water per acre.</p> <ul style="list-style-type: none"> • Preemergence and Postemergence directed application for control of labeled weeds: Apply SANDEA as a single or sequential directed spray application to the ground on either side of the row. If small weeds are present, tank mix with a postemergence broad-spectrum type herbicide to maximize and enhance the spectrum of broadleaf and grass control. Preemergence applications of SANDEA when ground cover prevents contact with the soil will result in reduced or no residual activity. • Postemergence directed application for control of nutsedge: Apply SANDEA as a single directed spray application to the ground on either side of the row when nutsedge is fully emerged. Alternatively, two directed spray applications can be made. Apply first directed spray application to the initial nutsedge flush when it has reached the 3-5 leaf stage. If a second treatment is needed, it may be applied later in the season directed to secondary nutsedge emergence. To maximize control, apply SANDEA when nutsedge plants are in the 3-5 leaf stage. For best results, use a minimum of 0.75 ounces per acre of SANDEA. <p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • For best results, use a NIS with postemergence applications. • Consult "Use Precautions" and "For Optimum Results" sections of label for important usage information. • Contact of SANDEA with the grape vines should be avoided. Contact will result in leaf chlorosis and distortion with possible shortening of shoot internodes. • Use of a shielded boom is recommended. • SANDEA may not control ALS-resistant weeds. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Minimum of 45 days between applications. • Do not concentrate the application rate into the treated swath. • Do not apply to vines established in a permanent vineyard for less than one year or to plants under stress. • Do not apply to areas where water is known to pond for periods of time following rainfall. • Do not contact foliage with SANDEA Herbicide. Uptake via contacted foliage will result in plant injury. • Do not apply to nursery stock. • Do not apply more than 2 applications or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period. • Do not apply by rope-wick wiper application.
<p>11-10 POME FRUIT GROUP (14) (West of the Rockies) Apple; azarole; crabapple; loquat; mayhaw; medlar; pear; pear, Asian; quince; quince, Chinese; quince, Japanese; tejocote; cultivars, varieties, and/or hybrids of these</p>	<p>3/4 - 2</p>	<p>Apply uniformly with ground equipment in a minimum of 15 gal of water per acre.</p> <ul style="list-style-type: none"> • Postemergence application for control of nutsedge: Apply SANDEA as a single broadcast application to orchard floor on either side of the row when nutsedge is fully emerged (early – midsummer). Alternatively, two applications can be made. Apply first application to the initial nutsedge flush when it has reached the 3-5 leaf stage. If a second treatment is needed, apply SANDEA later in the season directed to secondary nutsedge emergence. To maximize nutsedge control, do not apply if nutsedge has exceeded 12 inches in height. • Preemergence and Postemergence application for control of labeled broadleaf weeds: Apply SANDEA as a single or sequential broadcast application to orchard floor on either side of the row based on weed pressure. If small weeds are present, to maximize and enhance the spectrum of broadleaf control tank mix with a postemergence broad spectrum type herbicide. Preemergence applications of SANDEA when ground cover prevents contact with the soil will result in reduced or no residual activity. <p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • For best results, use a NIS or penetrating type surfactant. • Avoid spray contact with tree foliage and fruit with spray or drift. • Consult "Use Precautions" and "For Optimum Results" sections for important usage information. • SANDEA may not control ALS resistant weeds. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Do not apply when orchard temperatures exceed 85°F at the time of application. • Do not concentrate the application rate into the treated swath. • Do not apply to trees established in a permanent orchard less than one calendar year. • Do not apply to nursery stock. • Minimum of 45 days between applications. • Do not apply more than 2 applications or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period. • Do not apply by rope-wick wiper application

<p>11-10 POME FRUIT GROUP (14) (East of the Rockies) (Apple; azarole; crabapple; loquat; mayhaw; medlar; pear; pear, Asian; quince; quince, Chinese; quince, Japanese; tejocote; cultivars, varieties, and/or hybrids of these)</p>	<p>1/2 - 1</p>	<p>Apply uniformly with ground equipment in a minimum of 15 gal of water per acre.</p> <ul style="list-style-type: none"> • Postemergence application for control of nutsedge: Apply SANDEA as a single broadcast application to orchard floor on either side of the row when nutsedge is fully emerged. Alternatively, two applications can be made. Apply first application to the initial nutsedge flush when it has reached the 3-5 leaf stage. If a second treatment is needed, it may be applied later in the season directed to secondary nutsedge emergence. To maximize nutsedge control, apply SANDEA when nutsedge plants are in the 3-5 leaf stage. For best results, use a minimum of 0.75 oz/A of SANDEA. • Preemergence and Postemergence application for control of labeled broadleaf weeds: Apply SANDEA as a single or sequential broadcast application to orchard floor on either side of the row based on weed pressure. For best results, apply to bare ground. If small weeds are present, to maximize and enhance the spectrum of broadleaf control tank when ground cover prevents contact with the soil will result in reduced or no residual activity. Mix with a postemergence broad-spectrum type herbicide. <p>Preemergence applications of SANDEA when ground cover prevents contact with the soil will result in reduced or no residual activity.</p>
<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • For best results, use a NIS with postemergence applications. • Avoid spray or drift contact with tree foliage and fruit. • Consult "Use Precautions" and "For Optimum Results" sections for important usage information. • SANDEA may not control ALS resistant weeds. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Do not apply when orchard temperatures exceed 85°F at the time of application. • Do not concentrate the application rate into the treated swath. • Do not apply to trees established in a permanent orchard less than one calendar year. • Do not apply to nursery stock. • Minimum of 45 days between applications. • Do not apply more than 2 applications or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period. • Do not apply by rope-wick wiper application. 		
<p>TREE NUT CROP GROUP 14 including PISTACHIOS (1)</p>	<p>2/3 - 1 1/3</p>	<p>Apply SANDEA as a directed spray to established tree nut crops. Established tree nut crops are defined as those that have been transplanted into their final growing location for a period of at least 12 months, and where the soil has firmly settled around the roots from packing and rainfall or irrigation.</p> <ul style="list-style-type: none"> • Extreme care must be exercised to avoid contact of spray containing SANDEA with trunk, stems, roots, or foliage of tree nut crops, or severe damage or death may result. • Labeled rates are based on broadcast treatment. For band applications reduce the broadcast rate of SANDEA in proportion to the area actually sprayed. For all applications, adjust the rate of SANDEA to account for high volume output nozzles, such as off-center nozzles, and overlaps in the spray pattern. Use of controlled droplet application, spot application, irrigation, or chemigation equipment for application of this product is not recommended due to variations in the actual application rate. Excessive application rates can result in severe tree injury or death. • Use a maximum of 1 oz by weight (0.047 lb active ingredient) SANDEA per acre on coarse textured soils classified as sands, loamy sands, and sandy loams with less than 18% clay and more than 65% sand, or on soils with less than 1% organic matter. Do not apply to gravelly soils. For the best results apply SANDEA in the spring when nutsedge is not drought stressed and maximize the interval between application and subsequent irrigation. • Mechanical cultivation or mowing may be required to control weed species not on the SANDEA label. If so, a sequential treatment may be required to control weeds in areas of disturbed soil. • If SANDEA is applied to trees that have been weakened by or recovering from stress caused by, but not limited to, excessive fertilizer or soil salts, disease, nematodes, frost, wind injury, drought, flooding, previously applied pesticides, insects, winter injury, soil pan of any type, nutrient deficiency, or mechanical damage, severe injury or death may result. Application of SANDEA to weakened or stressed trees as described, especially in soils with less than 1% organic matter, significantly increases the probability of severe injury or death. • SANDEA may be applied at 2/3 to 1 1/3 oz by weight per acre in combination with glyphosate agricultural herbicides for control of emerged annual grasses, broadleaf weeds and nutsedge.
<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • Consult "Use Precautions" and "For Optimum Results" for important usage information. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Refer to the "Rotational Crop Restrictions" for applicable rotational crop information. • Do not apply more than 2 applications or 2 2/3 oz/A of product by weight (0.125 lb active ingredient) per 12 month period. On coarse textured soils classified as sand, loamy sand, and sandy loam with less than 18% clay and more than 65% sand, or on soils with less than 1% organic matter, do not apply more than 2 applications or 2 oz/A of product by weight (0.094 lb ai/acre) per 12 month period. • Do not apply by rope-wick wiper application. 		

FIELD CROPS

CROP	OZ/ACRE	DIRECTIONS FOR USE
BEANS, DRY (30)	1/2 - 2/3	<p>Apply uniformly with ground equipment in a minimum of 15 gal of water per acre.</p> <p>Direct-seeded:</p> <ul style="list-style-type: none"> • Preemergence - Apply SANDEA after planting but prior to soil cracking. Use the lower rate on lighter textured soils with low organic matter. • Postemergence - Apply SANDEA when plants have 1 to 3 trifoliolate leaves, but before flowering. Applications with a weed size of 6 inches or below will allow for the greatest control. Make only one broadcast application per season. • Only apply as a post directed row middle or furrow application in the state of California. <p style="text-align: center;"><u>Tank Mixtures for Dry Beans:</u></p> <ul style="list-style-type: none"> • It is the pesticide user's responsibility to ensure that all products in the listed mixtures are registered for the intended use. Users must follow the most restrictive directions and precautionary language of the products in the mixture. • Tank mixtures for additional broadleaf weed control can be added. • Tank mixtures for postemergent grass control, including but not limited to TARGA® or other graminicides can be added.
	<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • Consult "Use Precautions" and "For Optimum Results" sections for important usage information. • Not all varieties have been tested for tolerance. Under adverse growing conditions (dry or excessive moisture, cool weather, etc.), maturity of the treated crop may be delayed which can influence harvest date, yield, and quality. • Use of COC or MSO adjuvant may cause temporary crop response when plants are under stress. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • COC or MSO adjuvants can only be used in the states of CO, MN, NE, ND, and SD. • Do not apply more than 2 applications of 2/3 OZ/A per crop cycle, not to exceed 2 OZ/A of product by weight (0.094 lb a.i./acre) per 12 month period. • Do not apply by rope-wick wiper application. 	
	1/2 - 1	<ul style="list-style-type: none"> • Row Middle/Furrow Applications for Dry Beans - Apply SANDEA between crop rows while avoiding contact of the herbicide with the planted crop. Reduce rate and spray volume in proportion to area actually sprayed.
	<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • Consult "Use Precautions" and "For Optimum Results" for important usage information. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Do not apply more than 2 applications or 1 oz/A of product by weight (0.047 lb a.i./acre) per crop-cycle, not to exceed 2 oz/A (0.094 lb a.i./acre) per 12 month period (includes applications to the crop and to row middles/furrows). • Do not apply by rope-wick wiper application. 	
BEANS, SUCCULENT SNAP (30) <i>(including lima beans)</i>	1/2 - 1	<p>Direct-seeded:</p> <ul style="list-style-type: none"> • Preemergence - Apply SANDEA after planting but prior to soil cracking. Use the lower rate on lighter textured soils with low organic matter. • Apply uniformly with ground equipment in a minimum of 15 gal of water per acre.
	1/2 - 2/3	<p>Direct-seeded:</p> <ul style="list-style-type: none"> • Postemergence - Apply SANDEA over-the-top after the crop has reached the 2 to 4 trifoliolate leaf stage, but before flowering. Use the lower rate on lighter textured soils with low organic matter. Directed sprays may limit crop injury.
	1/2 - 1	<ul style="list-style-type: none"> • Row Middle/Furrow Applications - Apply SANDEA between crop rows while avoiding contact of the herbicide with the planted crop. Reduce rate and spray volume in proportion to area actually sprayed.
	<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • Application of SANDEA may cause temporary stunting. • Consult "Use Precautions" and "For Optimum Results" for important usage information. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Do not apply more than 2 applications or 1 oz/A of product by weight (0.047 lb a.i./acre) per crop-cycle, not to exceed 2 oz/A (0.094 lb a.i./acre) per 12 month period (includes applications to the crop and to row middles/furrows). • Do not apply by rope-wick wiper application. 	
1/2 - 1	<p>Preplant or At Planting:</p> <p>Apply uniformly with ground equipment in a minimum of 15 gal of water per acre.</p> <ul style="list-style-type: none"> • Incorporation: Apply and incorporate 1/2 to 1 oz SANDEA with EPTAM 7-E at a depth of approximately 2 inches just before planting. Use lower rate on lighter textured soils with low organic matter. Refer to EPTAM 7-E label for specific incorporation directions. Rotary hoe lightly during or shortly after emergence of the beans to break any crust that occurs. 	

CROP	OZ/ACRE	DIRECTIONS FOR USE
6B SUCCULENT SHELLED PEA AND BEAN SUBGROUP (30) (Any succulent shelled cultivar of bean (Phaseolus) including lima bean, green; broad bean, succulent; (vigna) including blackeyed pea, cowpea, southern pea	1/2	<p>Preemergence application for control of labeled broadleaf weeds - Apply SANDEA as a single broadcast application after planting but before crop emergence.</p> <p>Application of SANDEA may cause significant, temporary stunting and delay maturity of peas resulting in delayed harvest. This product is available to the end-user /grower solely to the extent that the benefit and utility, in the sole opinion of the end-user/grower, outweigh the extent of potential injury associated with the use of this product.</p>
		<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • Consult "Use Precautions" and "For Optimum Results" for important usage information. • SANDEA may not control ALS resistant weeds. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Do not apply more than 1 application or 1/2 oz/A of product by weight (0.023 lb a.i./acre) per 12 month period. • Do not feed to livestock. • Do not apply SANDEA to English peas and garden peas. • Do not apply by rope-wick wiper application.
	1/2 - 1	<p>Postemergence – Apply SANDEA uniformly with ground equipment in a minimum of 15 gal of water per acre. Apply as a directed spray when plants have 2 to 4 trifoliolate leaves and before flowering. Make one broadcast application. Directed sprays are recommended to limit crop injury.</p> <p>Not all varieties have been tested for tolerance. Under adverse growing conditions (dry or excessive moisture, cool weather, etc.), maturity of the treated crop may be delayed which can influence harvest date, yield, and quality. For untested varieties, a small area of the field should be sprayed to determine potential sensitivity to its use.</p>
		<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • For best results, use a NIS with applications. • Consult "Use Precautions" and "For Optimum Results" for important usage information. • SANDEA may not control ALS resistant weeds. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Do not apply more than 2 applications or 1 oz/A of product by weight (0.047 lb a.i./acre) per crop cycle, not to exceed 2 oz/A (0.094 lb a.i./acre) per 12 month period. • Do not feed to livestock. • Do not apply SANDEA to Adzuki beans, English peas and garden peas. • Do not apply by rope wick wiper application.
CORN, FIELD AND FIELD CORN GROWN FOR SEED (30)	2/3 - 1 1/3	<p>Postemergence - Apply SANDEA over-the-top or with drop nozzles from the spike-through layby stage of field corn.</p> <p style="text-align: center;"><u>Tank Mixtures for Corn Only</u></p> <p>It is the pesticide user's responsibility to ensure that all products in the listed mixtures are registered for the intended use. Users must follow the most restrictive directions and precautionary language of the products in the mixture.</p> <p>Ensure that spray equipment is set up to avoid applying an excessive rate directly over the rows and into the whorl of the cornstalk. To insure good spray coverage of weeds and to reduce the risk of spraying directly into the whorl, tank mix applications made after corn is 24 inches tall should be directed or semi-directed using drop nozzles.</p> <p style="text-align: center;"><u>SANDEA Post Field Corn Applications</u></p> <p>It is the pesticide user's responsibility to ensure that all products in the listed mixtures are registered for the intended use. Users must follow the most restrictive directions and precautionary language of the products in the mixture.</p>

CROP	OZ/ACRE	DIRECTIONS FOR USE
CORN, FIELD AND FIELD CORN GROWN FOR SEED (30) (continued)	2/3 - 1 1/3	<p>Before mixing in the spray tank, it is recommended that compatibility be tested by mixing all components in a small container in proportionate quantities. For tank mixtures, add individual formulations to a spray tank in the following sequence: water soluble bags, dry flowables, emulsifiable concentrates, drift control additive, water soluble liquids followed by NIS or COC.</p> <p>Tank mixtures should not be applied if the crop is under severe stress due to drought, water-saturated soils, poor fertility (especially low nitrogen levels), hail, frost, insects or when the maximum daytime temperature is above 92° F at time of application. Tank mix applications under these conditions may cause temporary crop injury.</p> <p>Tank mixtures for additional broadleaf weed control, including but not limited to 2,4-D, Armezon™, atrazine, Buctril®, Callisto®, dicamba, Impact®, Laudis® or YUKON® can be added.</p> <p>Tank mixtures for postemergence grass control, including but not limited to Accent®, Beacon®, Option® or Steadfast® can be added.</p> <p>Tank mixtures for additional postemergence grass and broadleaf control, including but not limited to Roundup® brands or glyphosate (glyphosate-tolerant corn only) or Ignite® and Liberty® (LibertyLink® hybrids only) can be added.</p> <p style="text-align: center;">SANDEA and SOIL RESIDUALS in emerged corn</p> <p>Alachlor, acetochlor, metolachlor and dimethenamid may be tank mixed with SANDEA for residual control of foxtails and other grass weeds in field corn.</p> <p style="text-align: center;"><u>SANDEA Soil Applications</u></p> <p>When used exclusively with Pioneer IR field corn hybrids, SANDEA may be soil applied at the rate of 1 1/3 to 2 oz per acre (0.062 to 0.094 lb of active ingredient per acre) for residual control of velvetleaf, common cocklebur, common lambsquarters, common ragweed, pigweed, smartweed, sunflower and other difficult to control weeds.</p> <p>This product is labeled as an early pre-plant surface-applied, pre-plant incorporated, or preemergence treatment. SANDEA offers effective broadleaf control across all tillage systems and is intended for use in tank mixtures with preemergence grass herbicides, including but not limited to: alachlor, acetochlor, metolachlor and dimethenamid active ingredient materials</p> <p>Refer to the labels for these products, or any other grass preemergence herbicide used for use instructions, weeds controlled, and application restrictions.</p>
<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> Refer to "Mixing Instructions" and "Use Rate Guides" for detailed information on SANDEA application. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> Do not apply more than 2 applications or 2 2/3 oz/A of product by weight (0.125 lb a.i./acre) per 12 month period. Refer to the "Rotational Crop Restrictions" for applicable rotational crop information. Following application to foliage, allow 30 days before grazing domestic livestock, harvesting forage, or harvesting silage. Do not apply by rope-wick wiper application. 		
CORN, SWEET AND POPCORN (30)	2/3 - 1	<p>Apply SANDEA over-the-top or with drop nozzles from the spike through layby stage of the corn. If necessary, a sequential treatment of this product at 2/3 oz per acre may be applied only with drop nozzles semi-directed or directed to avoid application into the corn plant whorl.</p> <p>PRECAUTIONS:</p> <ul style="list-style-type: none"> Consult "Use Precautions" and "For Optimum Results" for important usage information. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> Do not apply more than 2 applications of SANDEA per 12 month period in sweet corn or popcorn. Following application to foliage, allow 30 days before grazing domestic livestock, harvesting forage, or harvesting silage. Do not use SANDEA on "Jubilee" sweet corn. All varieties have not been tested for sensitivity to SANDEA. Do not apply by rope-wick wiper application.
COTTON (28)	2/3 - 1 1/3	<p>Apply SANDEA as a directed spray in hooded equipment for postemergent weed control in emerged cotton. Applications may be made anytime after cotton emergence until row closure inhibits use of hooded spray equipment. The applicator is responsible for maintaining proper spray speed and equipment position so spray mist does not contact cotton plants.</p> <p>PRECAUTIONS:</p> <ul style="list-style-type: none"> Consult "Use Precautions" and "For Optimum Results" for important usage information. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> Do not apply more than 2 applications or 1 1/3 oz/A of product by weight (0.062 lb a.i./acre) per 12 month period. Refer to the "Rotational Crop Information" for applicable rotational crop restrictions. Do not apply by rope-wick wiper application.

CROP	OZ/ACRE	DIRECTIONS FOR USE																							
MILLET, PROSO (0 Millet Forage) (50 Millet Grain and Straw) (37 Millet Hay)	1/2 - 2/3	<p>Millet Growth Stage: SANDEA, alone, can be applied from the 2 leaf through layby stage (before grain head emergence).</p> <p>Temporary stature reduction may occur to the crop following application of SANDEA if the proso millet is under stress. This effect will be most evident 7 to 10 days after application. The crop will quickly recover under normal growing conditions. Applications should be made after weed emergence and actively growing. If adding a tank mix, refer to the tank mix section of this label.</p> <p style="text-align: center;">TANK MIXTURES</p> <p>It is the pesticide user's responsibility to ensure that all products in the listed mixtures are registered for the intended use. Users must follow the most restrictive directions and precautionary language of the products in the mixture.</p> <p>Tank mixtures for additional broadleaf weed control, including but not limited to 2,4-D, and dicamba can be added.</p> <p>Insecticide and fungicide products can be tank mixed with SANDEA. Listed day intervals following an application of SANDEA.</p> <table border="1"> <thead> <tr> <th rowspan="2">CROP</th> <th colspan="3">All Animals (Lactating and Non-lactating)</th> </tr> <tr> <th>Pre-Grazing Interval (PGI)</th> <th>Pre-Harvest Interval (PHI)</th> <th>Pre-Slaughter Interval (PSI)</th> </tr> </thead> <tbody> <tr> <td>Millet Forage</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>Millet Grain</td> <td>N/A</td> <td>50</td> <td>0</td> </tr> <tr> <td>Millet Straw</td> <td>N/A</td> <td>50</td> <td>0</td> </tr> <tr> <td>Millet Hay</td> <td>N/A</td> <td>37</td> <td>0</td> </tr> </tbody> </table>	CROP	All Animals (Lactating and Non-lactating)			Pre-Grazing Interval (PGI)	Pre-Harvest Interval (PHI)	Pre-Slaughter Interval (PSI)	Millet Forage	0	0	0	Millet Grain	N/A	50	0	Millet Straw	N/A	50	0	Millet Hay	N/A	37	0
CROP	All Animals (Lactating and Non-lactating)																								
	Pre-Grazing Interval (PGI)	Pre-Harvest Interval (PHI)	Pre-Slaughter Interval (PSI)																						
Millet Forage	0	0	0																						
Millet Grain	N/A	50	0																						
Millet Straw	N/A	50	0																						
Millet Hay	N/A	37	0																						
<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> Consult "Use Precautions" and "For Optimum Results" for important usage information. Refer to "Mixing Instructions" and "Use Rate Guides" for detailed information on SANDEA application. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> Do not apply more than 1 application or 2/3 oz/A of product by weight (0.031 lb a.i./acre) per 12 month period. 0 Day Pre grazing interval for grass forage for ALL animals (lactating and non-lactating). Do not apply by rope-wick wiper application. 																									
RICE (48, CA 69)	2/3 - 1 1/3	<p>Pre-plant, at planting, preemergence and postemergence applications to rice</p> <ul style="list-style-type: none"> Pre-plant: Apply SANDEA at 2/3 oz per acre in combination with glyphosate or other suitable agricultural herbicides for burn down of emerged annual grasses, broadleaf weeds and nutsedge. If this product is applied pre-plant burn down, refer to "TIME INTERVAL BEFORE PLANTING" table in complete directions for use. Preemergence and Postemergence: Apply SANDEA for postemergent weed control from prior to the emergence of rice until after permanent flood is established. Apply SANDEA at 2/3 to 1 1/3 oz/A, with the total application rate not to exceed 1 1/3 oz/A of product (0.062 lb a.i./acre) per 12 month period. <p>SANDEA can be applied as a foliar spray or dry broadcast.</p> <p>SANDEA can be tank mixed with propanil containing rice herbicides (e.g. Stam and propanil 4E) at 2/3 to 1 1/3 oz per acre of this herbicide and labeled rates of the tank mix products.</p> <p>Foliar applications of SANDEA can be made at the 3 to 5 leaf stage of rice when weeds have 2 to 4 leaves. Dry broadcast applications can be made at the 1 to 2 leaf stage of rice when weeds have two leaves or less.</p> <p>SANDEA can also be applied post flood with dry broadcast applications of SANDEA at 2/3 to 1 1/3 oz with the total application rate not to exceed 1 1/3 oz/A of product (0.062 lb a.i./acre) per 12 month period.</p> <p>With all foliar applications of SANDEA use a minimum 3 to 15 gal of water per acre for aerial equipment and a minimum of 10 gal of water per acre for ground equipment. It is best to apply spray solutions the day they are mixed.</p> <p>Water levels in rice fields and checks should remain static (3 to 6 inch depth) following dry broadcast applications of SANDEA. Do not reintroduce water into rice fields or checks for at least five days following dry broadcast applications of SANDEA. Rice fields and checks may be irrigated to maintain water level, but this may reduce weed control.</p> <p>Control of emerged weeds with foliar applications is best when 70% to 80% of the weed foliage is exposed. Control of submerged weeds is best when weeds have 2 leaves or less. Do not reintroduce water into rice fields or checks for at least 24 hours following foliar applications of SANDEA.</p> <p style="text-align: center;">SANDEA Tank Mixture Options in Rice</p> <p>It is the pesticide user's responsibility to ensure that all products in the listed mixtures are registered for the intended use. Users must follow the most restrictive directions and precautionary language of the products in the mixture.</p>																							

CROP	OZ/ACRE	DIRECTIONS FOR USE
RICE (48, CA 69) (continued)		<p>Before mixing in the spray tank, it is recommended that compatibility be tested by mixing all components in a small container in proportionate quantities. For tank mixtures, add individual formulations to a spray tank in the following sequence: water soluble bags, dry flowables, emulsifiable concentrates, drift control additive, water soluble liquids followed by NIS or COC.</p> <p>Tank mixtures should not be applied if the crop is under severe stress due to drought, poor fertility (especially low nitrogen levels), hail, frost and insects. Tank mix applications under these conditions may cause temporary crop injury.</p> <ul style="list-style-type: none"> • Preemergence & Pre-Plant Applications: Tank mixtures for additional preemergence weed control, including but not limited to Bolero®, Command® 3ME, glyphosate, pendimethalin or quinclorac can be added. • Postemergence Applications: Tank mixtures for additional broadleaf weed control, including but not limited to Grandstand®, propanil and propanil products, Aim®, Facet®, Basagran®, Londax®, Grasp®, Regiment®, NewPath®, Beyond® and 2-4-D can be added. <p>Tank mixtures for postemergence grass control, including but not limited to Newpath®, Beyond®, propanil, Facet®, Grasp®, and Regiment® can be added.</p> <p>Insecticide and fungicide products can be tank mixed with SANDEA®.</p> <p>Sequential Applications - SANDEA can be applied sequentially with Ordram®, Bolero®, Clincher®, Regiment® and Shark®. Read the Ordram, Bolero, Clincher, Regiment and Shark labels for application information, restrictions and precautions.</p> <p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • Avoid using SANDEA on rice fields which have a history of weed biotypes resistant to ALS herbicides. • For best results, use 0.25 to 0.5% NIS which contains at least 80% active ingredient with foliar applications of SANDEA. • Refer to "Application Equipment and Instructions" for spray drift management techniques. • Refer to "Mixing Instructions" and "Use Rate Guides" sections of this label for detailed information on SANDEA application. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Do not apply within 48 days of harvest. • Do not apply within 69 days of harvest in California. • Do not exceed more than 2 applications per 12 month period. • Do not apply by rope-wick wiper application.
SORGHUM, GRAIN (MILO) (30)	2/3 - 1	<p>Postemergence - Apply SANDEA from the 2 leaf through layby stage (before grain head emergence).</p> <p>Temporary stature reduction may occur to the crop following application of SANDEA if the grain sorghum is under stress. This effect will be most evident 7 to 10 days after application. The crop will quickly recover under normal growing conditions.</p> <p style="text-align: center;"><u>Tank Mixtures for Grain Sorghum</u></p> <p>Tank mixtures with SANDEA can include, but are not limited to atrazine, Buctril® or 2,4-D. It is the pesticide user's responsibility to ensure that all products in the listed mixtures are registered for the intended use. Users must follow the most restrictive directions and precautionary language of the products in the mixture.</p> <p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • Consult "Use Precautions" and "For Optimum Results" for important usage information. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Do not apply more than 1 application or 1 oz/A of product by weight (0.047 lb a.i./acre) per 12 month period. • Following application to foliage, allow 30 days before grazing domestic livestock, harvesting forage, or harvesting silage. • Do not apply by rope-wick wiper application.
SUGARCANE (30)	2/3 - 1 1/3	<p>When used alone, apply SANDEA prior to planting, prior to emergence or after the emergence of the sugarcane, and until row closure. Mechanical cultivation may be required to control weed species not on the label. If so, a sequential treatment may be required to control weeds in areas of disturbed soil.</p> <p>Apply SANDEA at 2/3 to 1 1/3 oz by weight per acre (0.031 to 0.062 lb active ingredient per acre) in combination with glyphosate agricultural herbicides for pre-plant burn down of emerged annual grasses, broadleaf weeds and nutsedge in sugarcane.</p> <p style="text-align: center;"><u>Tank Mixtures for Sugarcane</u></p> <p>Tank mixtures with SANDEA can include, but are not limited to Asulox®, atrazine, Callisto®, Envoke®, Evik®, glyphosate, or 2,4-D.</p> <p>It is the pesticide user's responsibility to ensure that all products in the listed mixtures are registered for the intended use. Users must follow the most restrictive directions and precautionary language of the products in the mixture.</p> <p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • Consult "Use Precautions" and "For Optimum Results" for important usage information. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Refer to the "Rotational Crop Restrictions" for applicable rotational crop information. • Do not apply more than 3 applications (including pre-plant applications) or 2 2/3 oz/A (0.125 lb a.i./acre) per 12 month period. • Following application to foliage allow 30 days before grazing domestic livestock, harvesting forage, or harvesting silage. • Do not apply by rope-wick wiper application.

OTHER CROPS AND APPLICATIONS

CROP	OZ/ACRE	DIRECTIONS FOR USE
<p>ALFALFA (14) AZ, CA & NM</p>	<p>2/3 - 1</p>	<p>Established Fields</p> <ul style="list-style-type: none"> • Postemergence Broadcast - Apply SANDEA as a broadcast application to established alfalfa. Alfalfa should be well established in the field for a minimum of 6 months prior to application of SANDEA. Apply uniformly with ground equipment in a minimum of 20 gal of water per acre. Use a water volume that will provide uniform coverage of plants. It is recommended to make an application as soon as possible after removal of hay from the field and prior to an irrigation to minimize crop injury. Wait for at least 48 hours after application before irrigation. • Postemergence Spot Treatment - Apply SANDEA as a spot treatment application to only those areas of emerged nutsedge. Application rate should not exceed 3/4 oz product per treated acre in these areas. Use a water volume that will allow for good coverage of the plants. • Postemergence followed by Postemergence - To maximize control of nutsedge, it may be necessary to use a second postemergence spot application to those areas where the nutsedge has emerged or re-grown. For these situations, use a spot treatment method treating only those areas of emerged nutsedge. Application rate must not exceed 3/4 oz product per treated acre in these areas. Use a water volume that will allow for good coverage of the plants. This use pattern will result in greater potential of growth and yield reduction. <p>Research has shown that alfalfa growth and yields will be reduced for one or more cuttings after a SANDEA application. Application of SANDEA to alfalfa where re-growth exceeds 6" will result in greater yield reduction. Symptoms may be temporary. Follow all directions carefully to minimize potential reduced plant growth and yield. Apply uniformly with ground equipment in a minimum of 20 gal of water per acre. Use a water volume that will provide uniform coverage of plants.</p> <p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • Consult "Use Precautions" and "For Optimum Results" for important usage information. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Do not apply more than 2 applications or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period. • Do not apply by rope-wick wiper application.
<p>ARTICHOKE (5)</p>	<p>1 – 2</p>	<p>Apply SANDEA uniformly with ground equipment in a minimum of 15 gal of water per acre. Apply as a broadcast application to the ground on either side of the row and winter ditches while avoiding crop foliage.</p> <ul style="list-style-type: none"> • Row Middle - Apply SANDEA between rows of perennial artichokes for the control of nutsedge and listed broadleaf weeds. Applications should be made when oxalis is in full bloom. Avoid contact of the herbicide with the planted crop. If plastic is used on the planted row, adjust equipment to keep the application off the plastic. To maximize nutsedge control, apply when plants are in the 3 to 5 leaf stage. <p>Application of SANDEA may cause significant, temporary stunting and delay maturity of artichokes if sprayed directly. This product is available to the end-user/grower solely to the extent that the benefit and utility, in the sole opinion of the end-user/grower, outweigh the extent of potential injury associated with the use of this product.</p> <p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • For best results, use a NIS with applications. • Consult "Use Precautions" and "For Optimum Results" for important usage information. • Use rates are broadcast per acre. Reduce rate and spray volume in proportion to area actually sprayed. • SANDEA may not control ALS resistant weeds. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Do not apply by air. • Do not apply more than 2 applications or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period. • Do not apply by rope-wick wiper application.
<p>ASPARAGUS (1)</p>	<p>1/2 - 1 1/2</p>	<p>Apply uniformly with ground equipment in a minimum of 15 gal per acre.</p> <p>Nursery, Transplanted Crowns and Established Beds</p> <ul style="list-style-type: none"> • Postemergence/Post transplant - Apply SANDEA to asparagus before or during the harvesting season. SANDEA may cause a temporary stunting or twisting of fern on certain asparagus varieties when applied during spear emergence. The addition of surfactants and postemergent grass herbicides may accentuate the crop response. Spectrum and degree of weed control may be reduced where SANDEA is used without a surfactant. • Post-harvest - Apply SANDEA at the end of the harvest season. Under heavy nutsedge pressure, split applications are recommended. Contact with the fern may cause temporary yellowing. A NIS or COC should be used with post-harvest applications. Crop injury will be minimized and weeds control will be more effective when applications are made with drop nozzles as a directed spray below the ferns to allow for more complete coverage of target weeds. • Split application for enhanced control of nutsedge - Apply a split application with 3/4 to 1 oz product per acre during the cutting/harvesting season when the first flush of nutsedge is in the 3 to 5 leaf stage, followed by a second application of 3/4 to 1 oz product per acre at least 21 to 30 days later up to lay-by to control later flushes of nutsedge. SANDEA can be applied post-harvest during the fern stage. Contact with the fern may cause temporary yellowing. Crop injury will be minimized and nutsedge more effectively controlled when applications are made with drop nozzles directing the spray below the ferns allowing for more complete coverage of nutsedge.

	<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> For first year transplants, apply no sooner than six weeks after fern emergence. NIS can be used east of the Rockies to enhance weed control. Consult "Use Precautions" and "For Optimum Results" for important usage information. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> Do not use NIS west of the Rockies. Do not apply more than 2 applications or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period. Do not apply by rope-wick wiper application. 													
FALLOW GROUND	2/3 - 1 1/3	Applications of SANDEA to fallow ground.												
	<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> Refer to the "Weeds Controlled" section of this label for weed control recommendations. Consult "Use Precautions" and "For Optimum Results" for important usage information. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> Do not apply more than 2 applications or 2 2/3 oz of product by weight (0.125 lb a.i./acre) per 12 month period. Refer to the "Rotational Crop Restrictions" for applicable rotational crop information. Do not apply by rope-wick wiper application. 													
OKRA (30)	1/2 - 1	<ul style="list-style-type: none"> Direct-seeded and Transplant: Row Middle/Furrow Applications/Shielded Spray - Apply SANDEA between rows of direct-seeded or transplanted okra, while avoiding contact of the herbicide with the planted crop. If plastic is used on the planted row, adjust equipment to keep the application off the plastic. Reduce rate and spray volume in proportion to area actually sprayed. 												
	<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> Consult "Use Precautions" and "For Optimum Results" sections for important usage information. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> Do not apply more than 2 applications or 2 oz/A of product by weight (0.094 lb a.i./acre) per 12 month period. Do not apply by rope-wick wiper application. 													
CROP GROUP 17 PASTURE, RANGELAND & CRP FORAGE GRASSES/HAY (37)	2/3 - 1 1/3	<p>Established Fields</p> <ul style="list-style-type: none"> Postemergence Broadcast – Apply SANDEA as a broadcast application to established Pasture & Rangeland. Apply uniformly with ground equipment in a minimum of 10 gal of water per acre. Use a water volume that will provide uniform coverage of plants. It is recommended to make an application as soon as possible after removal of hay or before weeds exceed label height restriction. Wait for at least 48 hours after application before irrigation. Postemergence Spot Treatment – Apply SANDEA as a spot treatment application to only those areas of emerged nutsedge. Application rate should not exceed 3/4 oz product per treated acre in these areas. Use a water volume that will allow for good coverage of the plants. Postemergence followed by Postemergence - To maximize control of nutsedge, it may be necessary to use a second postemergence spot application to those areas where the nutsedge has emerged or re-grown. For these situations, use a spot treatment method treating only those areas of emerged nutsedge. Application rate should not exceed 3/4 oz product per treated acre in these areas. Use a water volume that will allow for good coverage of the plants. This use pattern will result in greater potential of growth and yield reduction. <p style="text-align: center;">TANK MIXTURES</p> <p>It is the pesticide user's responsibility to ensure that all products in the listed mixtures are registered for the intended use. Users must follow the most restrictive directions and precautionary language of the products in the mixture.</p> <p>Tank mixtures for additional broadleaf weed control, including but not limited to 2,4-D, dicamba and, Grazon® can be added.</p> <p>Labeled insecticides, including CONFIRM® and labeled fungicide products can be tank mixed with SANDEA.</p> <p>Listed day intervals following an application of SANDEA.</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th rowspan="2">CROP</th> <th colspan="3">Lactating and Non-lactating Animals</th> </tr> <tr> <th>Pre-Grazing Interval (PGI)</th> <th>Pre-Harvest Interval (PHI)</th> <th>Pre-Slaughter Interval (PSI)</th> </tr> </thead> <tbody> <tr> <td>Pasture, Rangeland, CRP and Forage Grasses/Hay</td> <td style="text-align: center;">0</td> <td style="text-align: center;">37</td> <td style="text-align: center;">0</td> </tr> </tbody> </table>		CROP	Lactating and Non-lactating Animals			Pre-Grazing Interval (PGI)	Pre-Harvest Interval (PHI)	Pre-Slaughter Interval (PSI)	Pasture, Rangeland, CRP and Forage Grasses/Hay	0	37	0
CROP	Lactating and Non-lactating Animals													
	Pre-Grazing Interval (PGI)	Pre-Harvest Interval (PHI)	Pre-Slaughter Interval (PSI)											
Pasture, Rangeland, CRP and Forage Grasses/Hay	0	37	0											
	<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> Consult "Use Precautions" and "For Optimum Results" for important usage information. Refer to "Mixing Instructions" and "Use Rate Guides" for detailed information on SANDEA application. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> Do not apply more than 2 applications or 1 1/3 oz/A of product by weight (0.062 lb a.i./acre) per 12 month period. 0 Day pre grazing interval for lactating and non-lactating animals. Do not apply by rope-wick wiper application. 													
RHUBARB (60)	1/2 - 1	Apply uniformly with ground equipment in a minimum of 15 gal of water per acre. Apply SANDEA as a single broadcast application to <u>dormant</u> rhubarb. The timing of the application should be as late as possible, or just prior to the breaking of rhubarb dormancy. Application of SANDEA may cause significant crop stunting. It is recommended that the user begin with a the lower rate to determine potential sensitivity to its use along with speed and degree of recovery.												

		<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • Consult "Use Precautions" and "For Optimum Results" for important usage information. • For best results use a NIS if labeled weeds are emerged. • SANDEA may not control ALS resistant weeds. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Do not apply more than 2 applications or 1 oz/A of product by weight (0.047 lb a.i./acre) per 12 month period. • Do not apply by rope-wick wiper application. 																					
<p>CROP GROUP 1C TUBEROUS AND CORM VEGETABLES SUBGROUP (Arracacha; arrowroot; artichoke, Chinese; artichoke, Jerusalem; canna, edible; cassava, bitter and sweet; chayote (root); chufa; dasheen (taro); ginger; leren; potato; sweet potato; tanier; turmeric; yam bean; yam, true. (45))</p>	1/2 - 1	<ul style="list-style-type: none"> • Preemergence and Postemergence applications for control of labeled broadleaf weeds and nutsedge: <p>Apply a single broadcast application after planting but prior to crop emergence. If needed, make a second postemergence foliar application 45 days before harvest.</p> <p>Second application, add NIS (1 to 2 quarts) per 100 gal of spray solution.</p> <p>Application of SANDEA may cause significant, temporary stunting and delay maturity of potatoes resulting in delayed harvest. This product is available to the end-user/grower solely to the extent that the benefit and utility, in the sole opinion of the end-user/grower, outweigh the extent of potential injury associated with the use of this product.</p> <p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • Consult "Use Precautions" and "For Optimum Results" for important usage information. • SANDEA may not control ALS resistant weeds. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Do not apply more than 2 applications or 1 oz/A of product by weight (0.047 lb a.i./acre) per 12 month period. • Do not apply by rope-wick wiper application. 																					
TURFGRASS SOD	2/3 - 1 1/3	<p>SANDEA is a selective herbicide for postemergence control of sedges such as purple and yellow nutsedge in sod farms. This product will not injure nearby established ornamentals, trees, and shrubs when used according to label directions.</p> <p>For postemergence control of purple or yellow nutsedge found in established turfgrass, apply 2/3 to 1 1/3 oz by weight of this product per acre (0.031 to 0.062 lbs. a.i./acre) after nutsedge has reached the 3 to 5 leaf stage of growth. Use the lower rate in light infestations and the higher rate in heavy infestations.</p> <p>A second treatment may be required 6 to 10 weeks after the initial treatment. As a sequential treatment, when new purple or yellow nutsedge plants have reached the 3 to 5 leaf stage of growth, apply 2/3 to 1 1/3 oz by weight of this product per acre (0.031 to 0.062 lb a.i./acre). Use the lower rate in light infestations and the higher rate in heavy infestations.</p> <p>Use 0.25 to 0.5% NIS concentration (1 to 2 quarts per 100 gal of spray solution) for broadcast applications. For high volume applications, Do not exceed 1 quart of surfactant per acre. Use only NIS which contains at least 80% active material. Refer to the surfactant label and observe all precautions, mixing and application instructions.</p> <p>When applied as directed under the conditions described, the following established turfgrasses are tolerant to application of this product:</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="3" style="text-align: center;">Established Cool-Season Grasses</th> </tr> </thead> <tbody> <tr> <td style="width: 33%;">Bentgrass, creeping (<i>Agrostis stolonifera</i>)</td> <td style="width: 33%;">Fescue, fine (<i>Festuca rubra</i>)</td> <td style="width: 33%;">Ryegrass, perennial (<i>Lolium perenne</i>)</td> </tr> <tr> <td>Blue Grass, Kentucky (<i>Poa pratensis</i>)</td> <td>Fescue, tall (<i>Festuca arundinacea</i>)</td> <td></td> </tr> <tr> <th colspan="3" style="text-align: center;">Established Warm-Season Grasses</th> </tr> <tr> <td>Bahiagrass (<i>Paspalum notatum</i>)</td> <td>Centipedegrass (<i>Eremochloa ophiuroides</i>)</td> <td>Kikuyugrass (<i>Pennisetum clandestinum</i>)</td> </tr> <tr> <td>Bermudagrass (<i>Cynodun dactylon</i>)</td> <td>Seashore paspalum (<i>Paspalum vaginatum</i>)</td> <td>Zoysiagrass (<i>Zoysia japonica</i>)</td> </tr> <tr> <td>Buffalograss (<i>Buchloe dactyloides</i>)</td> <td>St. Augustinegrass (<i>Stenotaphrum secundatum</i>)</td> <td></td> </tr> </tbody> </table>	Established Cool-Season Grasses			Bentgrass, creeping (<i>Agrostis stolonifera</i>)	Fescue, fine (<i>Festuca rubra</i>)	Ryegrass, perennial (<i>Lolium perenne</i>)	Blue Grass, Kentucky (<i>Poa pratensis</i>)	Fescue, tall (<i>Festuca arundinacea</i>)		Established Warm-Season Grasses			Bahiagrass (<i>Paspalum notatum</i>)	Centipedegrass (<i>Eremochloa ophiuroides</i>)	Kikuyugrass (<i>Pennisetum clandestinum</i>)	Bermudagrass (<i>Cynodun dactylon</i>)	Seashore paspalum (<i>Paspalum vaginatum</i>)	Zoysiagrass (<i>Zoysia japonica</i>)	Buffalograss (<i>Buchloe dactyloides</i>)	St. Augustinegrass (<i>Stenotaphrum secundatum</i>)	
Established Cool-Season Grasses																							
Bentgrass, creeping (<i>Agrostis stolonifera</i>)	Fescue, fine (<i>Festuca rubra</i>)	Ryegrass, perennial (<i>Lolium perenne</i>)																					
Blue Grass, Kentucky (<i>Poa pratensis</i>)	Fescue, tall (<i>Festuca arundinacea</i>)																						
Established Warm-Season Grasses																							
Bahiagrass (<i>Paspalum notatum</i>)	Centipedegrass (<i>Eremochloa ophiuroides</i>)	Kikuyugrass (<i>Pennisetum clandestinum</i>)																					
Bermudagrass (<i>Cynodun dactylon</i>)	Seashore paspalum (<i>Paspalum vaginatum</i>)	Zoysiagrass (<i>Zoysia japonica</i>)																					
Buffalograss (<i>Buchloe dactyloides</i>)	St. Augustinegrass (<i>Stenotaphrum secundatum</i>)																						

<p>TURFGRASS SOD (continued)</p>		<p align="center">Fallow Treatments in Turfgrass Seed and Sod Production Areas</p> <p>This product may be used on fallow areas prior to establishing turfgrass plants. Allow 4 weeks between application and seeding or sodding of turfgrass.</p> <p align="center">Tank Mixtures for Turfgrass Renovation</p> <p align="center">SANDEA plus GLYPHOSATE AGRICULTURAL HERBICIDES plus NIS</p> <p>For non-selective control of all vegetation prior to turfgrass renovation, SANDEA may be applied at 2/3 oz by weight per acre in combination with glyphosate agricultural herbicides for pre-plant burndown of emerged annual grasses, broadleaf weeds and nutsedge.</p> <p>Refer to the glyphosate agricultural herbicide label for use instructions, weeds controlled, and application restrictions.</p> <p>It is the pesticide user's responsibility to ensure that all products in the listed mixtures are registered for the intended use. Users must follow the most restrictive directions and precautionary language of the products in the mixture.</p> <p>PRECAUTIONS:</p> <ul style="list-style-type: none"> For best results, do not mow turf for 2 days before or 2 days after application. This product is effective if no rainfall occurs within 3 hours, but best results are obtained with no rainfall or irrigation for at least 8 hours. This product may be used on seeded, sodded, or sprigged turfgrass that is well established. Allow the turf to develop a good root system and uniform stand before application. Avoid application of SANDEA when turfgrass or nutsedge is under stress since turf injury and poor nutsedge control may result. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> Do not apply as an over the top spray to desirable shrubs or trees. Do not exceed the recommended amount of surfactant due to the potential for turf injury at higher rates. Do not apply more than 2 applications or 2 2/3 oz/A of product by weight (0.125 lb a.i./acre) per 12 month period. Do not apply by rope-wick wiper application. 									
<p>GRASSES GROWN FOR SEED</p>	<p>2/3 – 1 1/3</p>	<p>ESTABLISHED GRASSES</p> <p>For postemergence control of listed broadleaf weeds and nutsedge found in established grasses grown for seed, apply 2/3 to 1 1/3 oz by weight of this product per acre (0.031 to 0.062 lbs. a.i./acre). Postemergence applications for control of sharpshooters must be made when the basal diameter of the weed is the size of a U.S. quarter or smaller, and before stem elongation.</p> <p>For postemergence applications, use 0.25 to 0.5% NIS concentration (1 to 2 quarts per 100 gal of spray solution) for broadcast applications. For high volume applications, do not exceed 1 quart of surfactant per acre. Use only NIS which contains at least 80% active material. Refer to the surfactant label and observe all precautions, mixing and application instructions.</p> <p>When applied as directed under the conditions described, the following established grasses are tolerant to application of this product:</p> <table border="1"> <thead> <tr> <th colspan="3">Established Cool-Season Grasses</th> </tr> </thead> <tbody> <tr> <td>Bentgrass, creeping (<i>Agrostis stolonifera</i>)</td> <td>Fescue, fine (<i>Festuca rubra</i>)</td> <td>Ryegrass, perennial (<i>Lolium perenne</i>)</td> </tr> <tr> <td>Blue Grass, Kentucky (<i>Poa pratensis</i>)</td> <td>Fescue, tall (<i>Festuca arundinacea</i>)</td> <td>Orchardgrass (<i>Dactylis glomerata L.</i>)</td> </tr> </tbody> </table> <p>TALL FESCUE GROWN FOR SEED</p> <p>For postemergence control of listed broadleaf weeds, apply 2/3 to 1 1/3 oz by weight of this product per acre (0.031 to 0.062 lb a.i./acre) after the crop is well established.</p> <p>PRECAUTIONS:</p> <ul style="list-style-type: none"> For best results, do not mow grasses for 2 days before or 2 days after application. This product is effective if no rainfall occurs within 3 hours, but best results are obtained with no rainfall or irrigation for at least 8 hours. This product may be used on labeled grass seed crops that are well established. Allow grass to develop a good root system and uniform stand before application. *See specific use directions for spring planted tall fescue. Avoid application of SANDEA when grass seed crops or weeds are under stress since crop injury and poor weed control may result. Applications made in late fall or spring when grass seed crops are actively growing may result in injury. Certain perennial ryegrass varieties have shown sensitivity to sulfonylurea herbicides. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> Do not apply as an over the top spray to desirable shrubs or trees. Do not exceed the recommended amount of surfactant due to the potential for crop injury at higher rates. Do not apply more than 2 applications or 2 2/3 oz/A of product by weight (0.125 lb a.i./acre) per 12 month period. Minimum of 14 days between applications. Do not apply by rope-wick wiper application. 	Established Cool-Season Grasses			Bentgrass, creeping (<i>Agrostis stolonifera</i>)	Fescue, fine (<i>Festuca rubra</i>)	Ryegrass, perennial (<i>Lolium perenne</i>)	Blue Grass, Kentucky (<i>Poa pratensis</i>)	Fescue, tall (<i>Festuca arundinacea</i>)	Orchardgrass (<i>Dactylis glomerata L.</i>)
Established Cool-Season Grasses											
Bentgrass, creeping (<i>Agrostis stolonifera</i>)	Fescue, fine (<i>Festuca rubra</i>)	Ryegrass, perennial (<i>Lolium perenne</i>)									
Blue Grass, Kentucky (<i>Poa pratensis</i>)	Fescue, tall (<i>Festuca arundinacea</i>)	Orchardgrass (<i>Dactylis glomerata L.</i>)									

FENCE ROWS, FUEL STORAGE AREAS, LUMBERYARDS, TANK FARMS, RIGHT-OF WAY AND ROADSIDES	2/3 – 1 1/3	<p>Broadcast Applications: Apply SANDEA as a postemergence spray at 2/3 - 1 1/3 oz by weight of this product per acre (0.031 to 0.062 lb ai/A) to roadsides and other industrial sites.</p> <p>A second treatment can be applied 6 to 10 weeks after the initial treatment.</p> <p>Spot Treatments: Mix 1/4 oz to 1 oz of SANDEA per 1 gal of water. For best results, when using a hand held applicator, spray the desired target weeds in a back and forth motion to ensure proper contact and coverage.</p> <p>This product will control purple and yellow nutsedge and control and/or suppress listed broadleaf weeds (see weeds controlled chart for additional information).</p> <p>NOTE: This product can be tank mixed with Glyphosate herbicide. It is the pesticide user's responsibility to ensure that all products in the listed mixtures are registered for the intended use. Users must follow the most restrictive directions for use and precautionary statements of each product in the tank mixture.</p>
	<p>PRECAUTIONS:</p> <ul style="list-style-type: none"> • When using a surfactant refer to the adjuvants section of the label. • Consult "Use Precautions" and "For Optimum Results" for important usage information. • SANDEA may not control ALS resistant weeds. • Consult your local Gowan Sales Representative for more information. <p>RESTRICTIONS:</p> <ul style="list-style-type: none"> • Do not apply more than 2 applications or 2 2/3 oz/A of product by weight (0.125 lb a.i./acre) per 12 month period. • Do not apply by rope-wick wiper application. 	

ROTATIONAL CROP RESTRICTIONS

Rotation intervals below may need to be extended if drought or cool conditions prevail. Rotation intervals may need to be extended on drip irrigated crops in Arizona and California. Canyon Group recommends that the end user test this product in order to determine its suitability for such intended use. When using SANDEA in tank mixes, refer to the individual product labels being tank mixed. To determine rotational crop restrictions follow the longest rotational limitation of the product being tank mixed.

TIME INTERVAL BEFORE PLANTING

CROP	MONTHS	EXCEPTIONS
CROPS NOT SPECIFICALLY LISTED	36	
Alfalfa	9	
Apples*	9	
Barley (winter)	2	
Beans, Dry	0	
Beans, Snap	9	2 months in the Northeast, Midwest, and Southeast, 3 months in TX
Blueberry*	9	
Broccoli	18	3 months for muck soils in FL
Caneberry*	9	
Cabbage	15	3 months for muck soils in FL
Canola	15	
Carrot	15	
Cauliflower	18	3 months for muck soils in FL
Cereal crops, Spring	2	
Clovers	9	
Collards	18	
Corn, IR/IMR Field	0	
Corn, Normal Field and IT Field	1	
Corn, Seed	2	
Corn, Sweet and Pop	3	
Cotton	4	
Cucumbers	9	2 months in the Northeast, Midwest, and Southeast, 3 months in TX
Eggplant	12	4 months for FL Transplants
Forage Grasses	2	
Grapes*	9	
Lettuce crops	18	3 months for muck soils in FL
Melons	9	2 months in the southeast and TX
Mint	15	
Oats	2	
Onions and Leeks	18	
Peanuts	6	
Pears*	9	
Peas	9	
Peas, Field	9	
Peppers	10	4 months FL Transplants and 3 months in TX
Potatoes	9	

Pumpkins	9	2 months in the Southeast
Proso Millet	2	
Radish	12	3 months for muck soils in FL
Rice	0	
Rye (winter)	2	
Sorghums	2	
Soybeans	9	Where soil pH is less than 7.5 the interval is 5 months
Spinach	24	3 months for muck soils in FL
Squash	9	2 months in the Southeast
Strawberries	36	6 months for annual FL Transplants
Sugarbeet (Michigan only)	21	
Sugarbeet (ND, MN, Red River Valley)	36	
Sugarbeet and Red Beet	24	Where rainfall is sparse or irrigation is required, the time interval is 36 months.
Sugarcane	0	
Sunflowers	18	
Tomato	8	2 months in the Northeast, Midwest, and Southeast, 3 months in TX
Tree Nut*	9	
Wheat (winter)	2	

* After a SANDEA application, the soil must be plowed and cross disked.

STORAGE AND DISPOSAL

DO NOT contaminate water, food, feed or seed by storage or disposal.

PESTICIDE STORAGE: Store under cool, dry conditions (below 120 F). Do not store under moist conditions.

PESTICIDE DISPOSAL: Wastes resulting from the use of this product that cannot be used or chemically reprocessed should be disposed of in a landfill for pesticide disposal or in accordance with applicable Federal, state or local procedures.

CONTAINER DISPOSAL: Nonrefillable container. Do not reuse or refill this container. Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank. Fill the container 1/4 full with water and recap. Shake for 10 seconds. Pour rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Insert pressure rinsing nozzle in the side of the container, and rinse at about 40 PSI for at least 30 seconds. Then offer for recycling if available or puncture and dispose of in a sanitary landfill, or by incineration, or, if allowed by state and local authorities, by burning. If burned, stay out of smoke.

DISPOSAL AUTHORITIES: If none of the foregoing procedures is permitted by state and local authorities, then contact your State Pesticide or Environmental Control Agency, or your local Hazardous Waste Disposal office, or the Hazardous Waste Representative at the nearest EPA Regional Office for guidance.

FOR 24-HOUR EMERGENCY ASSISTANCE (SPILL, LEAK OR FIRE), CALL CHEMTREC® (800) 424-9300.

For other product information, contact Canyon Group or see Material Safety Data Sheet.

NOTICE OF CONDITIONS OF SALE AND WARRANTY AND LIABILITY LIMITATIONS

Important: Read the entire Directions for Use and Notice of Conditions of Sale and Warranty and Liability Limitations before using this product. If terms are not acceptable return the unopened container for a full refund.

Our directions for use of this product are based on tests believed to be reliable. However, it is impossible to eliminate all risk associated with the use of this product. Crop injury, inadequate performance, or other unintended consequences may result due to soil or weather conditions, off target movement, presence of other materials, method of use or application, and other factors, all of which are beyond the control of Canyon Group. To the extent consistent with applicable law, all such risks shall be assumed by the Buyer and User.

Canyon Group warrants that this product conforms to the specifications on the label when used in strict conformance with Directions for Use, subject to the above stated risk limitations. CANYON GROUP MAKES NO OTHER EXPRESS OR IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE NOR ANY OTHER EXPRESS OR IMPLIED WARRANTY.

TO THE FULLEST EXTENT PERMITTED BY LAW, CANYON GROUP'S EXCLUSIVE LIABILITY FOR ANY AND ALL LOSSES, INJURIES OR DAMAGES RESULTING FROM THE USE OR HANDLING OF THIS PRODUCT WHETHER IN CONTRACT, WARRANTY, TORT, NEGLIGENCE, OR ANY OTHER LEGAL THEORY IS STRICTLY LIMITED TO THE PURCHASE PRICE PAID OR REPLACEMENT OF PRODUCT, AT CANYON GROUP'S SOLE DISCRETION.

Formulated in the United States using Active Ingredient made in Japan.
 Manufactured by Nissan Chemical Industries, Ltd.
 EPTAM® 7E and SANDEA® are trademarks of Gowan Company LLC.
 YUKON® and TARGA® are trademarks of Nissan Chemical Industries, LTD
 All other brands are registered trademarks of their respective owners.
 © 2017 Gowan Company, L.L.C.

EPA Text SANDEA (To EPA 11-30-2021)



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

Memorandum

To: Board of Pesticides Control
 From: Pamela J. Bryer, Ph.D. | Pesticides Toxicologist
 Subject: Sandea Special Local Need 24c Registration 2022 Review

January 11, 2023

Summary:

Halosulfuron-methyl, the active ingredient in Sandea, is a low-toxicity herbicide that is unlikely to cause undue risk to people or the environment from the proposed uses in this Special Local Need 24c registration.

Rationale:

Background: Halosulfuron-methyl is a systemic sulfonylurea (SU) herbicide that acts by inhibiting amino acid synthesis selectively in plants.

Risk is a function of hazard and exposure and both elements must be considered to understand and predict potential effects. Halosulfuron-methyl has generally low toxicity to organisms in acute exposure scenarios. Chronic exposure to mammals has the potential for moderate toxic effects. Label rates and use patterns are dictated by EPA to prevent exposure at levels likely to cause toxic effects in mammals. The generally short half-life and frequency of allowed applications is how exposure is maintained at acceptable levels. The changes to the primary label accounted for in this 24(c) registration are consistent with several other allowable uses; the total annual usage allowed under this registration (1 oz/ A/ yr) is half of the annual usage allowed under the primary label (2 oz/ A/ yr).

MEGAN PATTERNSON, DIRECTOR
 90 BLOSSOM LANE, DEERING BUILDING



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



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

Hazard:

Hazard Test System	Hazard Categorization	Measured Level of Toxic Effect
Mammals acute	LOW	7,758 mg/kg
Mammals chronic	MODERATE	50 mg/kg
Birds acute	LOW	>2,250 mg/kg
Birds chronic	LOW	>5,620 mg/kg
Earthworms acute	LOW	>1,000 mg/kg
Honeybees contact	LOW	>100 mg/kg
Honeybees oral	LOW	>100 mg/kg
Fish acute	LOW	>118 mg/L
Fish chronic	LOW	34 mg/L
Aquatic invertebrates acute	LOW	>107 mg/L
Aquatic invertebrates chronic	MODERATE	>6.9 mg/L
Sediment dwelling invertebrates chronic	MODERATE	5 mg/kg

Cancer:

US EPA’s 2020 Cancer Classification for halosulfuron-methyl is:

Not Likely To Be Carcinogenic To Humans

Tolerances:

Tolerances are set for halosulfuron-methyl on a range of commodities: hay, nuts, green vegetables, beans, corn, small grains, and pome fruits. For foods eaten directly by humans the allowable values range from 0.01 ppm to 0.8 ppm (<https://www.ecfr.gov/current/title-40/chapter-I/subchapter-E/part-180/subpart-C/section-180.479>).

MEGAN PATTERNSON, DIRECTOR
 90 BLOSSOM LANE, DEERING BUILDING



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



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

Exposure:

Environmental fate and transfer metric	Categorization	Measured value describing movement in environment
Solubility	Low	10.2 mg/L
Persistence as measured as half-life		
Lab soil half-life	Non-persistent	26.7 days
Field soil half-life	Non-persistent	14 days
On/In plant tissue half-life		3 days
Sunlit water half-life	Stable	Stable
Water half-life	Non-persistent	14 days
Sediment half-life	Fast	10.4 days
Octanol-water partition coefficient (LogP)	Low	-0.02
Soil horizon travel	Moderately mobile	No data
Bioconcentration factor	Low	Calculated < 3
Volatility	Low	0.035 mPa

Maine patterns:

USE: There were 270.5 pounds reported by commercially licensed applicators in Maine for 2018 and 26.6 pounds reported for the same in 2019.

WATER QUALITY: There were no detections of halosulfuron-methyl in the 2021 water quality surveys performed by BPC. The survey sampled 186 wells adjacent to active agricultural land in Maine. This study involved 57 sites located directly adjacent to actively managed blueberry barrens. The laboratory reporting limit for halosulfuron-methyl was 0.01 µg/L (ppb).

National use patterns:

In agriculture, halosulfuron-methyl is commonly used for corn, vegetables, rice, and hay as seen in the estimates modeled by USGS (in the map and chart following). Additionally, EPA estimated, “The annual usage averaged approximately 30,000 pounds a.i. for 1,000,000 acres from 2008-2010.” (<https://www.regulations.gov/document/EPA-HQ-OPP-2011-0745-0056>)

For Non-agricultural usage EPA found:

- non-agricultural use sites: recreational areas, race tracks, non-crop areas, tennis courts, playgrounds, right of way areas, and golf courses;
- use in golf courses increased from less than 500 lbs. a.i. in 2002 to 2,000 lbs. a.i. in 2004 and then declined to 1,000 lbs. a.i. in 2006;

MEGAN PATTERNSON, DIRECTOR
 90 BLOSSOM LANE, DEERING BUILDING



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

- for turf farms, use was almost 1,000 lbs a.i. in 2004 and 2006. There were less than 500 lbs a.i. used on institutional turf and for landscape in 2004 and 2006;
- Licensed Commercial Operators used less than 500 lbs. a.i. in 2002 and 2004, and about 3,000 lbs. a.i. in 2006.

(<https://www.regulations.gov/document/EPA-HQ-OPP-2011-0745-0056>)

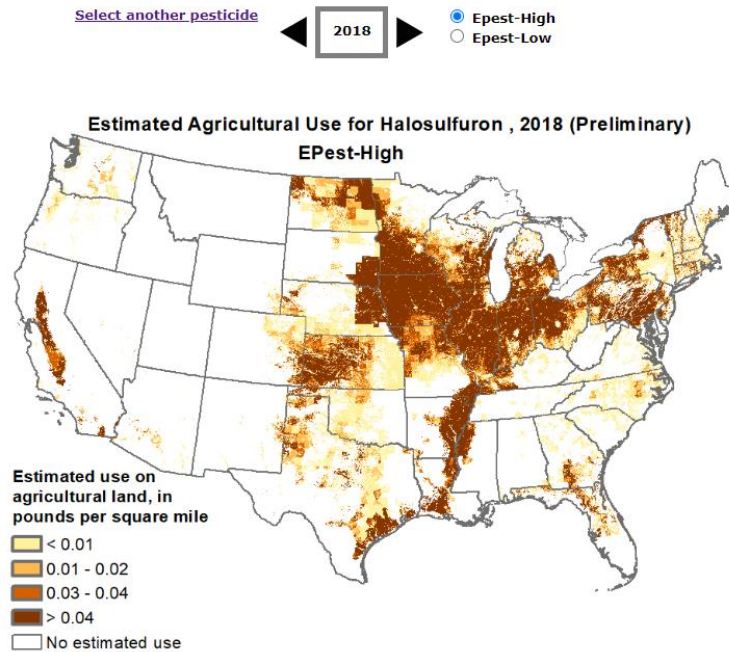


Figure 1. Estimated agricultural use nationally for halosulfuron in 2018, data sourced from USGS Pesticide National Synthesis Project.

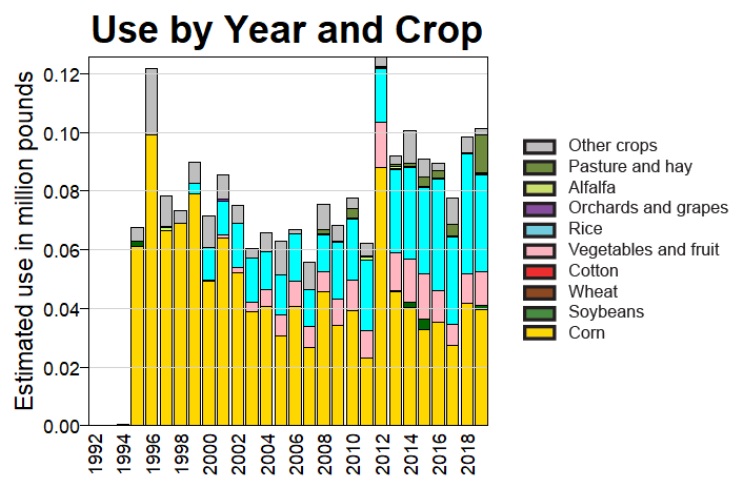


Figure 2. Estimated use by year and crop nationally for halosulfuron between 1992 and 2018, data sourced from USGS Pesticide National Synthesis Project.

Overview of the Massachusetts Glyphosate Commission's Activities

History

"This Commission was established by the legislature to conduct a scientific review of the potential impacts of glyphosate and its most common alternative herbicides on the environment and public health, including a review, undertaken in collaboration with the natural heritage and endangered species program, of the potential impacts of glyphosate and most common alternative herbicides. Members of the Commission include the Commissioner of MassDEP (chair); the Commissioner of Massachusetts Department of Agricultural Resources; the Commissioner of the Department of Public Health; the Director of the Division of Fish and Game; and a representative of a Land Trust Organization appointed by the legislature....

to determine whether current uses of glyphosate pose unreasonable adverse effects to the environment, and whether current registered uses of glyphosate should be altered or suspended; provided further, that the department shall submit the results of both the scientific review and individual review to the joint committee on environment, natural resources and agriculture no later than December 31, 2021;"

<https://www.mass.gov/service-details/glyphosate-commission>

Deliverables

Phase One: identifying all resources to consider for the scientific review

Phase Two: collects, researches, and reviews resources identified in phase one

Timeline

Initial Legislative action called for a report deadline December 31st, 2021

Phase One Completed June 2022

Phase Two Estimated: six months from funding discussed at September 2022 meeting

Budget

Total current allocation for total project cost: \$186,700

Status

The funding for phase two was secured and phase two has started. Additional funding was added to the budget to accommodate the additional work generated from public comment. Two accompanying documents share the process the commission has undergone. The first five pages of the RFP document show the commission's plan for this investigation and the Phase One document shows what the contractor discovered for information sources to include in Phase Two. The Phase Two report is due mid-spring 2023.

Glyphosate Scientific Review Phase 1 Report

Prepared for:

Massachusetts Department of Agricultural Resources
251 Causeway Street #500
Boston, MA 02114

Prepared by:



Eastern Research Group, Inc.
110 Hartwell Avenue
Lexington, MA 02421

June 6, 2022

CONTENTS

1.0 Introduction2

2.0 Summary of Available Information on Uses of Glyphosate and Alternatives2

 2.1 Background Information on Glyphosate 3

 2.2 Glyphosate Uses in Massachusetts..... 3

 2.3 Glyphosate Alternatives..... 4

3.0 Key Assessments to Review6

 3.1 Assessments of Glyphosate’s Human Health Impacts 7

 3.1.1 *Recent and Ongoing Assessments Published by Recognized Authorities* 7

 3.1.2 *Peer-reviewed Publications*..... 8

 3.1.3 *Precedential Judicial Decisions*..... 9

 3.2 Assessments of Glyphosate’s Environmental Impacts..... 10

 3.2.1 *Recent and Ongoing Assessments Published by Recognized Authorities* 10

 3.2.2 *Peer-reviewed Publications*..... 11

 3.2.3 *Precedential Judicial Decisions*..... 12

 3.3 Assessments of Glyphosate Alternatives 12

4.0 Key Stakeholders to Consult12

5.0 References14

6.0 Abbreviations Used in the Report18

1.0 Introduction

In 2021, the Massachusetts legislature enacted the Acts of 2021. Chapter 24 of this legislation established budgets for many state government activities, including the formation of a commission charged with conducting “a scientific review of the potential impacts of glyphosate and its most common alternative herbicides on the environment and public health” (Commonwealth of Massachusetts, 2021).

The legislation further states that: “...the pesticide subcommittee established under section 3A of chapter 132B of the General Laws shall use said scientific review as part of an individual review conducted under 333 C.M.R. 8.03 to determine whether current uses of glyphosate pose unreasonable adverse effects to the environment, and whether current registered uses of glyphosate should be altered or suspended” (Commonwealth of Massachusetts, 2021).

Pursuant to the Acts, the Glyphosate Commission was formed, and the Commission opted to use contractor support to conduct the glyphosate scientific review. The Massachusetts Department of Agricultural Resources (MDAR), on behalf of the Glyphosate Commission, issued a Request for Quotes to seek contractor support for this project. After an open bidding process, MDAR issued a contract to Eastern Research Group, Inc. (ERG) to conduct the scientific review of glyphosate and its alternatives. The review is to consider uses, restrictions, public health impacts, and environmental impacts of glyphosate. The results of the review will be presented to the Glyphosate Commission and then submitted to the joint Committee of Environment, Natural Resources and Agriculture.

MDAR split the glyphosate scientific review project into two phases. In Phase One, MDAR tasked ERG with identifying all resources to consider for the scientific review, and ERG will then review those resources in Phase Two. ERG, with assistance from its subcontractor Tetra Tech, Inc., prepared this Phase One report, which is organized into the following sections. The list quotes text from the scope of work from this project’s original Request for Quotes.

- [Section 2.0](#) presents “a summary of available information on the use of glyphosate in the Commonwealth and key herbicide agent alternatives,” including available information on “use restrictions and requirements to minimize impacts.”
- [Section 3.0](#) lists “key assessments (e.g., recent assessments by recognized authorities including, for example, the U.S. Environmental Protection Agency; peer reviewed publications; precedential judicial decisions), of the potential public health and environmental impacts of glyphosate and its alternatives.” This section presents the requested information separately for glyphosate’s public health impacts (Section 3.1) and environmental impacts (Section 3.2) and impacts of glyphosate alternatives (Section 3.3).
- [Section 4.0](#) lists “key stakeholders to be consulted” by ERG and Tetra Tech as part of the broader glyphosate scientific review.
- [Section 5.0](#) lists the references cited throughout this report.
- [Section 6.0](#) provides a list of abbreviations.

ERG anticipates that the Glyphosate Commission (and potentially other stakeholders) will review and comment on this Phase One report. Those comments might include recommendations for additional resources to include in this report. After receiving all feedback on the current version, ERG will prepare and submit a final Phase One report.

Once MDAR authorizes ERG to proceed with Phase Two, ERG and Tetra Tech will begin compiling, researching, and synthesizing information from the resources identified in this Phase One report. That work will culminate with ERG submitting the Phase Two report, which will include a scientific review of human health and ecological impacts of glyphosate and selected alternatives.

2.0 Summary of Available Information on Uses of Glyphosate and Alternatives

This section presents background information on glyphosate ([Section 2.1](#)); summarizes categories of glyphosate uses in the Commonwealth and, where data are available, the quantities of glyphosate used ([Section 2.2](#)); and identifies glyphosate alternatives that have been reported in the literature and the subset of herbicide alternatives that will be evaluated in Phase Two ([Section 2.3](#)).

During Phase Two of this project, the ERG Team will contact key stakeholders on glyphosate use in Massachusetts (see [Section 4.0](#)). Through those stakeholder contacts, ERG will seek additional Massachusetts-specific input on glyphosate uses, glyphosate usage quantities, and glyphosate alternatives.

2.1 Background Information on Glyphosate

Glyphosate is a synthetic, non-selective systemic herbicide that controls a wide variety of plants including grasses, annuals, perennials, and woody plants. Since it is non-selective and acts systemically, it has been frequently used in commercial farming, transportation right of ways (such as highway borders and railways), residential applications, and for habitat management. Both nationally and in Massachusetts, glyphosate usage has increased dramatically over the past 30 years (Benbrook, 2016 and references therein). The increase is due at least in part to the availability of commonly produced crops (e.g., corn, soybeans) genetically modified to be resistant to glyphosate. As a result, at farms that grow glyphosate-resistant crops, a wide variety of weeds can be controlled using glyphosate without harming crop production.

Glyphosate is the active ingredient in many herbicide formulations that have been registered by the U.S. Environmental Protection Agency (EPA) and approved by Massachusetts authorities for use in the Commonwealth. ERG searched the Massachusetts Pesticide Product Registration Information website (Kelly Solutions, 2022) for details on the herbicides that contain glyphosate or glyphosate salts (e.g., ammonium glyphosate, potassium glyphosate, the isopropylamine salt of glyphosate). As of May 1, 2022, the database includes records for ten active ingredients for glyphosate or glyphosate compounds, and these records pertain to 156 unique EPA registration numbers. The glyphosate concentrations across these 156 herbicides range from 0.14 percent to 95.2 percent, with a median active ingredient concentration of 41 percent. Like other herbicide active ingredients, manufacturers formulate a mixture of glyphosate and other ingredients, such as carriers, solvents, and surfactants, to maintain efficient application and maximum effectiveness. While manufacturers must disclose the identities and concentrations of active ingredients on product labels, no such requirement applies for other ingredients.

The Kelly Solutions database also includes information on weeds controlled by the various products, sites where the herbicides may be used, and links to the EPA stamped labels for the products. The specific weeds controlled by the registered glyphosate-containing herbicides vary. Many glyphosate-containing herbicides registered in Massachusetts include more than 100 weeds that the products control—and some registered herbicides list more than 300 weeds that are controlled. The sites to which the products can be applied also vary. Some registrations list only one site where products may be applied (e.g., some products are only used in corn fields) but others list more than 500 sites.

The EPA-accepted product labels include extensive information about the herbicides, and most labels reviewed were at least 50 pages long. These labels have information on application methods and rates, formulation details, precautionary statements, steps to prevent resistance, and other topics. Glyphosate products are applied to target areas using a variety of mechanical devices, including hand-held or backpack sprayers and other methods. The most appropriate application method depends on the size of the target area, the density of plant pests, concerns about impacts to surrounding areas, and other factors. The EPA-accepted labels provide further details on application methods for individual products. In most cases, labels warn users not to apply glyphosate-containing herbicides directly to water and outline steps users should take to prevent contamination of water resources; however, some glyphosate-containing herbicides can be used to control emergent aquatic weeds in certain circumstances.

2.2 Glyphosate Uses in Massachusetts

As noted previously, the Massachusetts Pesticide Product Registration Information website lists the approved uses of every glyphosate-containing herbicide registered in the Commonwealth, and these lists include hundreds of entries. Based on this information, most glyphosate uses in Massachusetts fall under the following categories:

- Weed control for row crops (e.g., corn, soybeans, alfalfa)
- Weed control in orchards (e.g., apples)
- Weed control at nurseries

- Control of problematic plants (e.g., dodder, dewberries) in cranberry farming (UMass, 2008)
- Control of nuisance plants in and along transportation rights of way (e.g., highways, railways)
- Residential and commercial landscape management to control weeds and unwanted plants
- Aquatic weed control as a restricted use herbicide in MassDEP-permitted applications
- Habitat management for wildlife and unique ecosystems to control invasive plant species

The ERG Team also sought data on the amounts of glyphosate-containing herbicides used in Massachusetts for different purposes, but quantitative usage information was only available for row crop applications. Specifically, the most recent agricultural herbicide usage data reported by the United States Geological Survey (Wieben, 2021) indicates the following glyphosate usage quantities in 2019 for row crops in Massachusetts:

- 5,381 kg for corn
- 520 kg for fruits and vegetables
- 78 kg for soybeans
- 77 kg for orchards
- 51 kg for alfalfa

The ERG Team searched for estimates of glyphosate usage quantities for the various non-agricultural uses noted above, but no reports were identified that include this information. ERG is aware that licensed applicators must submit annual reports on pesticide applications to MDAR, and glyphosate usage quantities for certain applications can be derived from information in these reports. However, the applicators' annual reports are only available in paper form and must be reviewed individually to estimate statewide usages. In Phase Two, ERG will assess whether the reports can be reviewed with available project resources. Note that the licensed applicators' annual reports do not account for glyphosate applied by non-licensed users (e.g., homeowners who use Roundup).

2.3 Glyphosate Alternatives

This contract's scope of work calls for the ERG Team to not only summarize available information on glyphosate uses in the Commonwealth, but also to summarize use of "key herbicide agent alternatives." ERG interprets this requirement as referring to chemical alternatives to glyphosate, but for completeness, ERG initially searched for a broader range of glyphosate alternatives.

ERG first identified resources that identify glyphosate alternatives. These include, but are not limited to: a University of Massachusetts (UMass) Extension Turf Program website on glyphosate alternatives (UMass CAFE, 2020); an herbicide alternatives research study that UMass researchers conducted for the Massachusetts Executive Office of Transportation (Barker and Prostack, 2008; 2009); the latest Massachusetts Department of Transportation (MassDOT) Vegetation Management Plan (MassDOT, 2021); a North Carolina State University Extension website on glyphosate alternatives for landscapers (Neal and Senesac, 2022); a technical committee report on glyphosate alternatives for vegetation management in the Los Angeles area (Chiotti et al., 2010); and multiple weed control manuals issued by various state agencies nationwide.

These resources group glyphosate alternatives into multiple categories. For purposes of this project, ERG will consider four categories of alternatives. The list below demonstrates the range of alternatives that are currently available, without consideration for what alternatives are most viable for specific uses in the Commonwealth. Whether a given alternative is feasible will depend on the use, and preferred alternatives might vary between farmers, organic farmers, orchard owners, roadside applicators, nursery owners, habitat managers, landscapers, and homeowners. The feasibility of alternatives and preferred application methods will depend on other factors, like target species, desired effectiveness, potential environmental impacts, area of application, site access, applicable regulations and restrictions, and cost.

Phase Two will consider the following four categories of alternatives. ERG will seek stakeholder input (see [Section 4.0](#)) on preferred alternatives in Massachusetts.

- Chemical methods are use of chemical herbicides. A wide range of chemical formulations available is available, as discussed below.
- Mechanical methods include use of mechanical devices to control weeds. Examples include tilling soils, mowing weeds, burning weeds, or killing them with steam (with or without foam).
- Physical methods are options for controlling weeds manually, whether by removing weeds from the soil (e.g., hand-picking weeds, hoeing weeds) or by applying materials to suppress weed growth (e.g., mulch, weed mats).
- Biological methods include use of other organisms to remove weeds or inhibit their growth. These include use of herbivores (e.g., sheep, goats, cattle) to consume weeds and use of other plants (e.g., clover) to compete with weeds.

The ERG Team will consider multiple chemical methods in Phase Two. The chemical herbicide alternatives exhibit a range of properties relevant to weed control (e.g., systemic vs. contact herbicides; selective vs. non-selective herbicides; pre-emergent vs. post-emergent herbicides) and may require multiple applications to achieve the desired effectiveness. The Phase Two evaluation will consider two groups of chemical methods as alternatives:

- EPA-registered herbicides. The resources that the ERG Team reviewed (Barker and Prostack, 2008; 2009; Chiotti et al., 2010; MassDOT, 2021; Neal and Senesac, 2022; UMass CAFE, 2020) list EPA-registered herbicide products that researchers have proposed or investigated as glyphosate alternatives for certain uses. Table 1 lists the alternative active ingredients for selected products. These alternatives contain various active ingredients, including both synthetic chemicals and substances derived from natural sources. Note: Just because Table 1 lists potential alternatives does not mean they have been demonstrated to serve as effective glyphosate substitutes in Massachusetts or elsewhere.

Table 1. Potential Chemical Herbicide Alternatives to Be Considered in Phase Two

Active Ingredient ^a	Number of Unique Pesticide Registrations Containing Active Ingredient in Massachusetts	Concentration Range of Active Ingredient in Products Registered in Massachusetts
2,4-D	47	0.146% – 38.87%
Aminopyralid compounds ^b	6	2.22% – 71.01%
Caprylic acid	14	0.099% – 47%
Chlorsulfuron	6	15% – 75%
Clethodim	19	12.6% – 26.4%
Clopyralid compounds ^b	21	0.071% – 60%
Diquat compounds ^b	44	0.04% – 37.3%
Dithiopyr	82	0.08% – 40%
Fluazifop-P-butyl	22	0.06% – 24.5%
Glufosinate compounds ^b	29	0.36% – 45.9%
Imazapyr compounds ^b	44	0.16% – 63.2%
Imazethapyr compounds ^b	12	1.38% – 50.2%
Indaziflam	13	0.0061% – 24.3%
Isoxaben	14	0.0008% – 93.5%
d-Limonene	9	1% – 70%
Metsulfuron compounds ^b	20	0.75% – 60%
Oryzalin	9	1% – 41%
Pelargonic acid	23	2% – 57%
Pendimethalin	37	0.81% – 39%
Prodiamine	69	0.2% – 65%
Sethoxydim	7	13% – 18%
Simazine	9	41.9% – 90%

Active Ingredient ^a	Number of Unique Pesticide Registrations Containing Active Ingredient in Massachusetts	Concentration Range of Active Ingredient in Products Registered in Massachusetts
Sulfometuron methyl	8	6.5% – 75%
Triclopyr compounds ^b	84	0.084% – 83.9%

Notes:

Data compiled from queries of the Massachusetts Pesticide Product Registration Information website (Kelly Solutions, 2022).

^a Certain formulations have multiple active ingredients, which may include glyphosate.

^b Where active ingredients are in multiple chemical forms, Table 1 collapses the various active ingredients into one entry labeled with “compounds.” For example, Table 1 lists the multiple salts of aminopyralid as “aminopyralid compounds.”

In Phase Two of the project, the ERG Team will narrow the list of alternative chemical options based on input from the Glyphosate Commission and from stakeholders (see [Section 4.0](#)). The ERG Team will ask stakeholders about current and prospective uses of chemical herbicide alternatives, including input on any viable alternatives not listed in Table 1 or elsewhere in this report; whether alternatives are better suited for specific uses (e.g., commercial agriculture, organic farming, roadside weed control, nurseries, residential landscaping); and information on alternatives’ effectiveness.

- **Minimum risk pesticides.** The other chemical alternatives to glyphosate-containing products are those that meet the criteria for “minimum risk pesticides” and therefore EPA does not register them under the Federal Insecticide, Fungicide, and Rodenticide Act. To be eligible for this designation, the products must contain active ingredients and inert ingredients from lists of substances developed by EPA (EPA, 2015a; 2016) and meet additional criteria for labeling, health claims, and other factors. Examples of active ingredients for “minimum risk pesticides” include citric acid, clove oil, coconut oil, corn gluten meal, garlic oil, and lauryl sulfate (EPA, 2015a). Formulations containing acetic acid at concentrations up to 8 percent are also eligible to be “minimum risk pesticides,” provide the other applicability criteria are met.

3.0 Key Assessments to Review

This section presents a list of “key assessments” that the ERG team proposes reviewing. Consistent with the contract scope of work, we consider “key assessments” to include (1) recent assessments published by selected government agencies and international bodies, (2) peer-reviewed publications in scientific journals, and (3) precedential judicial decisions. The ERG team compiled the list of assessments and relevant publications from a diverse set of resources, including state and federal government agencies, agencies from selected foreign countries, international bodies, non-governmental organizations, databases of judicial decisions, and the peer-reviewed literature.

This section identifies “key assessments” that the ERG team will review on glyphosate’s human health impacts (see [Section 3.1](#)) and glyphosate’s ecological impacts (see [Section 3.2](#)) and assessments on the most common alternative herbicides (see [Section 3.3](#)). After receiving approval to proceed to Phase Two, the ERG team will review the assessments listed throughout this section and relevant supporting documents, which may include interim assessments, final determinations, and responses to comments. In Phase Two, the ERG Team will acknowledge which findings pertain to technical grade glyphosate separately from findings that pertain to commercial formulations that contain glyphosate and other substances (adjuvants), to the extent this information is available.

It is important to note that the state of the science of glyphosate’s human health and environmental impacts continues to evolve. The following sub-sections include provisions to account for recently completed studies and for key assessments expected to be issued later this year.

3.1 Assessments of Glyphosate's Human Health Impacts

This section identifies the “key assessments” that the ERG team will consider on glyphosate's human health impacts.

3.1.1 Recent and Ongoing Assessments Published by Recognized Authorities

The ERG team proposes reviewing and summarizing the following publications in Phase Two, considering a range of cancer and non-cancer human health impacts. Importantly, the Phase Two review will consider the fact that the various assessments have different scopes, reviewed different sets of literature (i.e., the assessments were completed in different years), and followed different methodologies. These differences will factor into the ERG Team's synthesis of information on human health impacts.

The list is organized into three categories of authors. For purposes of this project, an assessment was considered either a publication that comprehensively reviews the literature on glyphosate toxicity and reaches conclusions on carcinogenicity, non-cancer toxicity, or both or an ongoing significant research study of glyphosate toxicity in humans.

Assessments Issued by Federal and State Authorities in the United States

- EPA first registered glyphosate as a pesticide in 1974 and has periodically reassessed health risks since. The ERG team will review multiple documents posted to the EPA [Glyphosate Registration Review](#) docket. These documents include the most recent Interim Registration Review Decision to continue to list glyphosate (EPA, 2020a) and the accompanying Draft Human Health Risk Assessment (EPA, 2018a); EPA's responses to comments (EPA, 2019; 2020b; 2020c); and other relevant supporting documents (EPA 2018b; 2018c). Note that the ERG Team will not review every entry in the EPA docket, because the docket contains more than 14,000 entries.
- Congress mandated the Agency for Toxic Substances and Disease Registry (ATSDR) to develop toxicological profiles for hazardous substances found at Superfund sites. ATSDR has prepared more than 180 toxicological profiles, including its [Toxicological Profile for Glyphosate](#) (ATSDR, 2020). The profile considered peer-reviewed literature published through September 2017.
- The National Toxicology Program (NTP) falls within the U.S. Department of Health and Human Services. NTP has previously issued cancer classifications for selected hazardous substances and the program's Report on Carcinogens is a widely cited resource for evidence of carcinogenicity. Although NTP has not yet classified glyphosate for carcinogenicity, the program is currently researching the toxicity of [glyphosate and selected glyphosate formulations](#). NTP has released limited results from *in vitro* and genetic toxicity tests and may issue additional publications in 2022 (NTP, 2022).
- The U.S. Forest Service (USFS) within the U.S. Department of Agriculture (USDA) has a mission to “sustain the health, diversity, and productivity of the Nation's forests and grasslands.” In support of that mission, USFS has evaluated the toxicity of various herbicides, including a 2011 contractor report that presented a [human health and ecological risk assessment](#) of glyphosate (USFS, 2011). A 2003 contractor report addressed the same topic (USFS, 2003).
- The [Agricultural Health Study](#) is an ongoing prospective epidemiological study that is examining adverse health effects among pesticide applicators and their spouses. The National Cancer Institute and the National Institute of Environmental Health Studies fund this study, which has included collaboration from EPA and the National Institute for Occupational Safety and Health. Westat, a government contractor, has been coordinating the study. Although the study is not specific to glyphosate, the investigators have published journal articles on relationships between cancer incidence and glyphosate use (Androtti et al., 2018; De Roos et al., 2005).
- California's Office of Environmental Health Hazard Assessment (OEHHA) sets “No Significant Risk Levels” (NSRLs) for toxic substances regulated under the state's Safe Drinking Water and Toxic Enforcement Act of 1986 (i.e., Proposition 65). In July 2017, OEHHA issued an [Initial Statement of Reasons](#) for glyphosate that proposed an NSRL for glyphosate based on cancer outcomes observed in laboratory animals. The state has also proposed changes to the wording of warnings on glyphosate-containing products used in

California. A final rulemaking on the updated warnings has not been issued, and the public comment period for that initiative ended earlier this month (CalEPA, 2022).

Assessments Issued by International Bodies (e.g., European Union and World Health Organization)

- The International Agency for Research on Cancer (IARC) is the agency within the World Health Organization that, among other functions, issues monographs to classify toxic substances by human carcinogenic potential. In 2017, IARC issued a [monograph](#) evaluating carcinogenicity for five pesticides and herbicides, including glyphosate. The monograph concludes that glyphosate is “probably carcinogenic to humans” (IARC, 2017).
- Other European Union agencies have completed assessments of glyphosate toxicity. In 2015, for example, the European Food Safety Authority (EFSA) completed an [assessment](#) that, among other findings, concluded that glyphosate is “unlikely to pose a carcinogenic hazard to humans” (EFSA, 2015). The European Union has approved the use of glyphosate, but that approval expires in December 2022. Another glyphosate assessment is currently being conducted by the Assessment Group on Glyphosate (AGG). In 2021, the AGG submitted both a draft Renewal Assessment Report (more than 10,000 pages) and an update to EFSA (AGG, 2021). The final Renewal Assessment Report, which will include final conclusions on human health impacts, is expected to be released in late 2022 or 2023.
- In May 2016, the Food and Agriculture Organization of the United Nations and the Core Assessment Group on Pesticide Residues of the World Health Organization (WHO) convened a panel to evaluate human health risks of consuming food products that contain pesticide residues; and a [summary report](#) was issued later in the year. This evaluation considered health risks for three pesticides, including glyphosate. The panel found that long-term exposures to glyphosate residues in food are “unlikely to present a human health concern” and that short-term exposures are “unlikely to present a risk to consumers” (FAO/WHO, 2016).

Assessments Issued by Selected Foreign Governments (Outside the European Union)

- In Canada, the Pest Management Regulatory Agency (PMRA) of Health Canada authorizes uses of pesticides. In 2017, PMRA re-authorized use of glyphosate and published an [assessment](#) that considered cancer risk and potential health impacts associated with dietary exposures, occupational exposures, and household uses. An advocacy group sued the agency regarding the re-authorization decision; and in February 2022, a Federal Court of Appeal in Canada issued a ruling that directed the PMRA to reconsider certain procedural aspects of the re-authorization. The court decision did not change the glyphosate authorization, however. In Phase Two, ERG will investigate whether PMRA has issued new assessment documents on glyphosate human health impacts, given the implications of the recent court decision.
- In 2016, the Food Safety Commission of Japan completed a human health risk assessment of different commercial grades of glyphosate. The complete assessment report is only available in Japanese, but ERG will review the [summary of conclusions](#), which is written in English (FSCJ, 2016). The human health risk assessment considered a range of cancer and non-cancer outcomes and derived an acceptable daily intake for glyphosate.
- The Australian Pesticide and Veterinary Medicines Authority (APVMA) has multiple mandates, including regulation of the use of pesticides in Australia. In 2016, APVMA issued a [regulatory position paper](#) that found no “scientific grounds for placing glyphosate and products containing glyphosate under formal reconsideration,” based both on human health and ecological considerations (APVMA, 2016).

3.1.2 Peer-reviewed Publications

The major assessments reviewed in the previous section were completed in different years, and they considered peer-reviewed literature issued up through different cutoff dates (e.g., the ATSDR 2020 Toxicological Profile is based on a literature search completed in September 2017). These assessments therefore do not consider findings from research published after the corresponding literature search cutoff dates. This is an important disconnect because scientists worldwide continue to study human health impacts associated with glyphosate exposure, and highly relevant publications have become available in recent years on glyphosate genotoxicity (e.g., Benbrook et

al., 2019), cancer (e.g., Leon et al., 2019; Zhang et al., 2019; Boffetta et al., 2021), reproductive effects (e.g., Mohammadi et al., 2021), and various other health outcomes.

To ensure this project's scientific review is complete and current, the ERG Team will perform a literature search to identify recent peer-reviewed publications on glyphosate's human health impacts. ERG will prepare a literature search methodology memorandum for review by the Glyphosate Commission before executing the search. We anticipate conducting this task using the PubMed search engine and focusing on the most recent 5 years of publications (2018-2022). Key words for the search will include terms related to the herbicide (e.g., glyphosate, Roundup), the various health outcomes under consideration (e.g., cancer, genotoxicity, reproductive toxicity, developmental toxicity, endocrine disruption), and others (e.g., epidemiology). ERG will select the key words in an iterative fashion, using approaches ERG has previously applied in literature review projects and considering key words that EPA used in a recent glyphosate literature search (EPA, 2018d).

Upon executing the search, ERG will compile potentially relevant publications in a reference management system (either EndNote or RefWorks), remove duplicate entries, and remove entries for publications not written in English. The next step will be reviewing the references' titles and abstracts for relevance, after which ERG will have a final list of the recent literature of relevance to glyphosate human health impacts. ERG will then obtain the publications that passed the initial title and abstract screening and again review publications for relevance. ERG then intends to review every publication that passed the different tiers of screening. However, should this search identify an unexpectedly substantial number of potentially relevant publications, ERG will discuss with the Glyphosate Commission options for synthesizing the literature within the bounds of the project budget (e.g., focusing on review articles and meta-analyses, focusing on health endpoints of greatest interest).

3.1.3 Precedential Judicial Decisions

To identify precedential judicial decisions, an attorney with ERG executed a search of a case law database using the Casetext Research software platform. The Casetext database includes cases for which a judicial order has been issued. This includes federal and state case law, with all 50 states considered. A judicial order could mean that a court or judicial officer issued a decision or that an order was issued after two parties reached agreement. Not all filed claims result in judicial orders. Selected details of the initial Casetext searches follow:

- Searching on "glyphosate" without a date range yielded 255 cases filed in state and federal courts, but no case law from Massachusetts state court. Of the cases identified, 108 were filed in the last 5 years. EPA was a party in five of the cases.
- Over the last 5 years, 49 glyphosate tort law cases were identified, most of which focused on cancer outcomes (particularly lymphoma); and 39 glyphosate regulatory law cases were identified. The two most litigated issues in the tort law cases include the causes of action on product liability and negligence. Upon initial review, the product liability cases are rooted in what information should be included in product labels and whether plaintiffs were properly warned about carcinogens, ecological concerns, and other issues. The negligence claims are centered around plaintiffs' ability to show that the products containing glyphosate are the actual cause of their health effects.
- 19 cases were identified that addressed ecological issues but did not address lymphoma. These cases related to product liability, the Endangered Species Act, and the Plant Protection Act.
- Ongoing legal proceeding pertain to EPA's January 2020 interim registration review decision to continue to register various forms of glyphosate as a pesticide. Multiple parties, including the Natural Resources Defense Council, the Rural Coalition, the National Family Farm Coalition, the Center for Biological Diversity, and the Pesticide Action Network, sued EPA over its interim decision. In May 2021, EPA submitted a filing to the U.S. Court of Appeals that sought permission to revise previously issued glyphosate assessment documents—but did not propose changing the glyphosate registration status.

In Phase Two, ERG will synthesize information in the 49 tort law cases referenced above and the status of the legal challenges to EPA's interim registration review decision. Further, recognizing that precedential cases on glyphosate are a changing landscape, ERG intends to conduct a more thorough legal review of all cases for relevance during

Phase Two. ERG seeks input from Glyphosate Commission members on whether any subset of court decisions are of greatest interest for the Phase Two review.

3.2 Assessments of Glyphosate’s Environmental Impacts

This section identifies the “key assessments” that the ERG team will consider on environmental impacts of glyphosate and glyphosate formulations. The content is organized into the three types of “key assessments” included in this contract’s scope of work. Assessments that reported on both human health and environmental impacts are listed both below and in [Section 3.1](#).

The ERG Team will consider a range of environmental impacts when reviewing publications listed in this section. These impacts include direct toxicity effects on non-target aquatic and terrestrial species due to contact with glyphosate, especially for species that may be rare or endangered in Massachusetts; sublethal effects on aquatic and terrestrial biota such as behavioral effects that may have ecological significance on particular species populations; indirect effects on pollinators (e.g., honeybees, monarch butterflies) due to potential habitat impacts; and indirect effects on other aquatic and terrestrial biota due to potential impacts on their habitats. The ERG Team will consider the various glyphosate-related environmental impacts that have been studied as well as the uncertainties associated with the assessments and their underlying publications.

As with the key assessments of human health impacts, the key assessments presented below were prepared to address different issues, employed different methodologies, and drew from different subsets of the peer-reviewed literature. The ERG Team will account for and explain these differences when preparing the Phase Two report.

3.2.1 Recent and Ongoing Assessments Published by Recognized Authorities

The ERG team proposes reviewing and summarizing the following assessments conducted by recognized authorities in Phase Two of the contract. The list is organized into three categories of authors.

Assessments Issued by Federal and State Authorities in the United States

- As noted previously, EPA originally registered glyphosate as a pesticide and has since reassessed the use as part of the statutorily mandated 15-year review cycle. The ERG team will review multiple documents that EPA and its contractors prepared (or reviewed) on glyphosate environmental risks, and most documents of interest are posted to the EPA [Glyphosate Registration Review](#) docket. These documents include but are not limited to: the “Final National Level Listed Species Biological Evaluation for Glyphosate” (EPA, 2021); the “Interim Registration Review Decision: Case Number 0178” (EPA, 2020a), which incorporates a relatively recent methodology for evaluating risks to honeybees, monarch butterflies, and other pollinators; and the 2015 “Preliminary Ecological Risk Assessment in Support of the Registration Review of Glyphosate and Its Salts” (EPA, 2015b). The ERG team will also review selected additional material posted to EPA’s docket, but as noted previously, a review of every docket entry is beyond the scope of this project.
- The ERG Team will review multiple publications issued by the USFS, including the 2003 and 2011 human health and ecological risk assessment cited in [Section 3.1](#) (USGS, 2003; 2011), articles in the peer-reviewed literature authored or co-authored by USFS and USDA scientists (e.g., Busse et al., 2001; Linz et al., 1999), and selected earlier profiles of glyphosate environmental impacts (e.g., USFS, 1997).
- The ERG Team will consult with MDAR for publicly available assessments that Massachusetts agencies have issued on glyphosate’s environmental impacts, beyond the updated summary fact sheet that MDAR has already issued (MDAR, 2022).

Assessments Issued by International Bodies and Agencies of Selected Foreign Countries

- In the European Union, glyphosate is currently being reevaluated for ecological effects and risk and this reevaluation is expected to be completed in late 2022 or 2023. EFSA and the European Chemical Agency are jointly reassessing glyphosate exposure and effects. Thus far, a working group has prepared a draft Renewal Assessment Report (dRAR), and that draft is currently being reviewed and will eventually be made public along with any modifications to the assessment. The ERG Team will review all available

information on the ongoing EFSA work, including: the Authority's summary of the dRAR (AGG, 2021); the Authority's evaluation of glyphosate residues in animal feed and potential impacts to animal health (EFSA, 2018); and the Authority's evaluation of glyphosate's endocrine disruption potential (EFSA, 2017).

- Recognizing that EFSA (and its AGG) has published more extensively on glyphosate's environmental impacts than other foreign government agencies, the ERG Team's review of assessments issued by international bodies will be limited to the EFSA publications. As the only exception, the ERG Team will also consider findings the Australian regulatory position paper on glyphosate, as that specifically addressed ecological impacts (APVMA, 2016).

Assessments Issued by Selected Non-Governmental Organizations (NGOs)

- In 2020, the Forest Stewardship Council (FSC), an NGO that advocates for forest management, issued environmental and social risk assessment guidance. The guidance includes appendixes that present information on six specific pesticides. The ERG Team will consider the contents of Appendix 1, which addresses glyphosate (FSC, 2020).
- In 2017, two organizations in Europe—Générations Futures and the Pesticide Action Network—issued a joint publication that, among other things, critiqued the literature search conducted by authors of a previous EFSA Renewal Assessment Report (GF and PAN, 2017). The report argued that the literature search should have been more inclusive of publications that reported various glyphosate-related impacts.
- In 2019, the Natural Resources Defense Council (NRDC) published a report raising concern about 10 species in the United States that are imperiled by pesticide use, and some of the concern centered on reported glyphosate impacts (NRDC, 2019).
- Massachusetts-based NGOs have developed websites that raise additional environmental impact concerns about glyphosate, such as the potential to contribute to development of glyphosate-resistant strains of weeds ("super weeds") that may then be difficult to control (NOFA/Mass, 2018). This NGO publication will be reviewed in Phase Two, along with others that are identified during the Glyphosate Commission's review of this Phase One report.

3.2.2 Peer-reviewed Publications

In recent decades, hundreds of peer-reviewed journal articles have reported on glyphosate contamination in the environment, exposures to this contamination, and specific biological effects. Conducting a systematic review of the entire history of glyphosate-related journal articles is outside the scope of this work. However, as part of its ongoing support for EPA's glyphosate review, ERG's subcontractor (Tetra Tech) has conducted extensive literature reviews of the evidence of glyphosate's environmental impacts.

Through that effort, ERG's subcontractor is familiar with the literature that addresses glyphosate's environmental impacts broadly (e.g., Ghandi et al., 2021; Gill et al., 2018; Maggi et al., 2020; Meftaul et al., 2020) as well as literature on glyphosate's impacts to specific receptors and species, including water fleas (Marek et al., 2013), rice fish (Smith et al., 2019), earthworms (Stellin et al., 2018), and phytoplankton (Wang et al., 2016). The citations presented in the previous sentence are only intended to show examples of relevant peer-reviewed literature and not to suggest that this is the universe of relevant publications. The Phase Two work will be based on our understanding of the overall body of literature, which was considered in the development of EPA's recent "Final National Level Listed Species Biological Evaluation for Glyphosate" (EPA, 2021). This review will consider the various types of environmental impacts listed at the beginning of this section, as well as strengths, limitations, and uncertainties associated with characterizing the impacts.

To ensure the Phase Two research is complete and current, Tetra Tech will assess the need for conducting a supplemental literature search. Whether this is necessary will depend on multiple factors, most notably on whether EFSA issues its final Renewal Assessment Report during Phase Two—and what date range of scientific publications were considered. The ERG Team will inform the Glyphosate Commission if a supplemental literature search will be conducted in Phase Two on glyphosate environmental impacts. If one is to be performed, the ERG Team will share with the Glyphosate Commission the search parameters (e.g., the search engine, the time frame of publications, and the search keywords).

3.2.3 Precedential Judicial Decisions

Certain aspects of the EPA pesticide registration process have faced legal challenges, with resolution to the most relevant challenge still pending. As noted previously, in 2020, NRDC and other parties filed suit against EPA to challenge multiple aspects of the proposed glyphosate registration, with part of the case centering on ensuring adequate protection of threatened and endangered species. While this litigation is still pending, the ERG Team is aware of recent efforts EPA has taken to ensure that its “pesticide program will meet its endangered species obligations” as documented in a publication that EPA issued just last month (EPA, 2022).

Additional precedential judicial decisions relevant to environmental impacts might be identified as ERG completes its review of case law at the beginning of Phase Two.

3.3 Assessments of Glyphosate Alternatives

For selected glyphosate alternatives, the Phase Two report will provide information on uses, effectiveness, and impacts on human health and the environment. The report will address the four categories of options listed in [Section 2.3](#), and provide more detailed information on selected EPA-registered chemical herbicide alternatives. The Phase Two report will consider assessments published for “minimum risk pesticides” that may serve as glyphosate alternatives; however, these alternatives might have limited published information on health and environmental impacts due to their “minimum risk” designation from EPA.

For the chemical herbicide alternatives reviewed in Phase Two, the ERG Team will consider the following two information sources for human health and environmental assessments:

- The ERG Team will conduct substance-specific searches on EPA’s Pesticide Chemical Search website (<https://ordspub.epa.gov/ords/pesticides/f?p=chemicalsearch:1>). For most substances listed in Table 1 of this report, this website provides links to documents with some combination of the following information: regulatory status, Reregistration Eligibility Decision (RED) documents, draft and final human health and ecological risk assessments, Endangered Species Act litigation, environmental fate and transport information, and regulatory dockets (which can include links to additional references).
- The ERG Team will also conduct substance-specific searches for human health and ecological risk assessments conducted by the USFS. These will be identified via searching the USFS Pesticide-Use Risk Assessments and Worksheets website (<https://www.fs.fed.us/foresthealth/protecting-forest/integrated-pest-management/pesticide-management/pesticide-risk-assessments.shtml>).

Project resources do not allow for more comprehensive searches of assessments for every alternative.

4.0 Key Stakeholders to Consult

This project’s scope of work calls for ERG to “consult with stakeholder groups on data and information collection.” In Phase One, ERG was only required to identify the stakeholder groups who will be contacted, but those groups will not be contacted until Phase Two. The ERG Team intends to contact stakeholders in Phase Two for the following reasons:

- To identify any relevant scientific assessments on glyphosate’s human health and environmental impacts, beyond those identified in Sections 3.1 and 3.2.
- To ask questions about relevant research in progress and pending assessments.
- To seek information on glyphosate uses in Massachusetts, the amounts of different glyphosate-containing formulations used, and experiences with using glyphosate alternatives.
- To understand glyphosate-related issues of greatest interest.

Based on these information needs, the ERG Team identified four categories of stakeholder groups to contact. Those categories are listed below, along with the stakeholders within each category whom ERG proposes contacting. ERG presented an initial list of proposed stakeholder contacts (and the rationale for selecting them) during the Glyphosate Commission meeting held on May 23, 2022. During ERG’s presentation, Commission

members and meeting participants recommended additional stakeholders to consider contacting. The ERG Team included those recommendations in the following list.

The ERG Team will contact the following stakeholders in Phase Two, to the extent that project resources will allow. The list includes initial points of contact for each stakeholder. The list is organized into four categories; within each category, the stakeholders are listed in alphabetical order, by the last names of the points of contact. The individuals listed below may refer ERG to other members or designees of their respective organizations. Individual stakeholder discussions will be limited to not longer than 1 hour.

Scientific Leads of Selected Glyphosate Assessments

- Dr. Aaron Blair, NCI, Chair for the 2017 IARC monograph
- Dr. Laura Beane Freeman, NCI, Principal Investigator for the Agricultural Health Study
- Dr. James Hetrick, EPA, Senior Advisor for the 2015 preliminary ecological risk assessment
- Dr. Hana Pohl, ATSDR, Lead for the 2020 Toxicological Profile for Glyphosate

Massachusetts Pesticide Board Subcommittee Members

- Michael Moore, chairperson, Massachusetts Department of Public Health
- Richard Berman, public member of the Pesticide Board Subcommittee
- Margret Cooke, Acting Commissioner, Massachusetts Department of Public Health
- John Lebeaux, Commissioner, MDAR
- Jim Montgomery, Commissioner, Massachusetts Department of Conservation and Recreation

Selected Non-Government Organizations (Alphabetical Order by Last Name of Contact)

- Diane Butt, Board of Directors, Massachusetts Christmas Tree Association
- Liam Condon, President, Bayer Crop Science Division
- Janet Domenitz, Executive Director, MASSPIRG
- Jocelyn Forbush, Acting President and Chief Executive Office, The Trustees of Reservations
- Robb Johnson, Executive Director, Massachusetts Land Trust Coalition
- Karen Kerr, President, Massachusetts Association of Landscape Professionals
- Jocelyn Langer, Executive Director, Northeast Organic Farming Association, Massachusetts Chapter
- Rie Macchiarolo, President, Ecological Landscape Alliance
- Doak Marasco, President, International Society of Arboriculture, New England Chapter
- Peter Mezitt, President, Massachusetts Nursery and Landscape Association
- Kristin O'Brien, Coordinator, Sudbury-Assabet-Concord Cooperative Invasive Species Management Area
- Margaret O'Gorman, President, Wildlife Habitat Council
- David O'Neill, President, Massachusetts Audubon Society
- Joe Szczechowicz, President, Massachusetts Association of Lawn Care Professionals
- Steve Seymour, Executive Director, GreenCAPE
- Warren Shaw, President, Massachusetts Farm Bureau Federation
- Mark Smith, President, Grow Native Massachusetts
- Ed Stockman, Co-Founder, Regeneration Massachusetts
- Steve Ward, President, Cape Cod Cranberry Growers' Association
- Kate Wilson, President, North American Invasive Species Management Association

Selected Contacts from State Government Agencies and Universities in Massachusetts

- George Batchelor, Supervisor of Landscape Design, Massachusetts Department of Transportation
- Brian Hawthorne, Habitat Program Manager, MassWildlife
- Dr. Randall Probst, Extension Weed Specialist, University of Massachusetts Extension
- Nancy Putnam, Director of Ecology, Massachusetts Department of Conservation and Recreation
- Eve Schlüter, Assistant Director, Massachusetts Natural Heritage and Endangered Species Program

The ERG Team plans to update the previous list based on comments received on this report. The ERG Team will also revisit project resources before contacting stakeholders, because the current budget might not allow for contacting every stakeholder on this list. During Phase Two, the ERG Team will contact as many randomly selected individuals from the previous list as project resources will allow. This project's Phase Two report will document that selection process, if it needs to be applied.

5.0 References

AGG (Assessment Group on Glyphosate). 2021. Procedure and outcome of the draft Renewal Assessment Report on glyphosate, June 2021. https://ec.europa.eu/food/system/files/2021-06/pesticides_aas_agg_report_202106.pdf

AGG. 2022. Presentation RAC-60 CLH Dossier: Glyphosate. March 16, 2022.

AHS. 2022. Agricultural Health Study. About the Study. <https://aghealth.nih.gov/about/>

Andreotti, G., Koutros, S., Hofmann, J.N., Sandler, D.P., Lubin, J.H., et al. 2018. Glyphosate Use and Cancer Incidence in the Agricultural Health Study. *JNCI*, 110(5):509-516. Epub 2017 Nov 9. <https://pubmed.ncbi.nlm.nih.gov/29136183/>

ATSDR. 2020. Toxicological profile for Glyphosate. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. <https://www.cdc.gov/tsp/ToxProfiles/ToxProfiles.aspx?id=1488&tid=293>

APVMA. 2016. Australian Pesticide and Veterinary Medicines Authority. Regulatory position: consideration of the evidence for a formal reconsideration of glyphosate. <https://apvma.gov.au/sites/default/files/publication/20701-glyphosate-regulatory-position-report-final.pdf>

Barker, A.V., and Probst. R.G. 2008. Herbicide Alternatives Research. Prepared by University of Massachusetts Transportation Center, Report # SPRII03.23. Prepared for the Massachusetts Executive Office of Transportation and Public Works. <https://www.mass.gov/doc/herbicide-alternatives-research/download>

Barker, A. and R. Probst. 2009. Alternative Management of Roadside Vegetation. *Hort. Technol.* April-June 19(2); 346-352. <https://journals.ashs.org/horttech/view/journals/horttech/19/2/article-p346.xml>

Benbrook, C.M. 2016. Trends in glyphosate herbicide use in the United States and globally. *Environ Sci Eur* 28, 3. <https://doi.org/10.1186/s12302-016-0070>

Benbrook, C.M. 2019. How did the US EPA and IARC reach diametrically opposed conclusions on the genotoxicity of glyphosate-based herbicides? *Environmental Sciences Europe* 31.1: 1-16. <https://enveurope.springeropen.com/articles/10.1186/s12302-018-0184-7>

Boffetta, P., Ciocan, C., Zunarelli, C., and Pira, E. Exposure to glyphosate and risk of non-Hodgkin lymphoma: an updated meta-analysis. *Med Lav* 112(3)194-199. <https://pubmed.ncbi.nlm.nih.gov/34142676/>

Busse, M.D., Ratcliff, A.W., Shestak, C.J., and Powers, R.F. 2001. Glyphosate toxicity and the effects of long-term vegetation control on soil microbial communities. *Soil biology and biochemistry* 33(12-13): 1777-1789. https://www.fs.fed.us/psw/publications/busse/2001_sdarticle.pdf

CalEPA. 2017. California Environmental Protection Agency (CalEPA). Initial Statement of Reasons: Glyphosate. Proposition 65 Safe Harbors. <https://oehha.ca.gov/media/downloads/proposition-65/chemicals/glyphosate032917isor.pdf>

CalEPA. 2022. California Environmental Protection Agency (CalEPA). Extension of Comment Period for Proposed Modification of Text and Addition of Documents to Rulemaking File for Glyphosate Warning Regulation. <https://oehha.ca.gov/proposition-65/crn/extension-comment-period-proposed-modification-text-and-addition-documents>

Chiotti, D., Ritter, L., Schlenk, D., Wilen, C., and Schiff, K. 2010. Alternatives to Glyphosate for Vegetation Management in Los Angeles County: Technical Committee Report. Southern California Coastal Water Research Project, Technical Report 1103. January 2010. https://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/1103_GlyphosateAlternativesPanel.pdf

Commonwealth of Massachusetts. 2021. Acts of 2021. Chapter 24: An Act Making Appropriations for the Fiscal Year 2022 for the Maintenance of the Departments, Boards, Commissions, Institutions and Certain Activities of the Commonwealth, for Interest, Sinking Fund and Serial Bond Requirements and for Certain Permanent Improvements. July 16, 2021. <https://malegislature.gov/Laws/SessionLaws/Acts/2021/Chapter24>

De Roos, A.J., Blair, A., Rusiecki, J.A., Hoppin, J.A., Svec, M., et al. (2005). Cancer Incidence among Glyphosate-Exposed Pesticide Applicators in the Agricultural Health Study. *Environmental Health Perspectives*, 113(1):49-54. <https://pubmed.ncbi.nlm.nih.gov/15626647/>

EFSA. 2015. Conclusion on the peer review of the pesticide risk assessment of the active substance glyphosate. *EFSA Journal* 2015;13(11):4302. <https://www.efsa.europa.eu/en/efsajournal/pub/4302>

EFSA. 2017. Conclusion on the peer review of the pesticide risk assessment of the potential endocrine disrupting properties of glyphosate. *EFSA Journal* 2017;15(9):4979. <https://doi.org/10.2903/j.efsa.2017.4979>

EFSA. 2018. Scientific Report on evaluation of the impact of glyphosate and its residues in feed on animal health. *EFSA Journal* 2018;16(5): 5283, 22 pp. <https://efsa.onlinelibrary.wiley.com/doi/full/10.2903/j.efsa.2018.5283>

EPA. 2013. Preliminary Ecological Risk Assessment in Support of the Registration Review of Glyphosate and Its Salts. Office of Chemical Safety and Pollution Prevention, U.S. Environmental Protection Agency, Washington, D.C. <https://www.regulations.gov/document/EPA-HQ-OPP-2009-0361-0077>

EPA. 2015a. Active Ingredients Eligible for Minimum Risk Pesticide Products. December 2015. U.S. Environmental Protection Agency, Washington, D.C. <https://www.epa.gov/sites/default/files/2018-01/documents/minrisk-active-ingredients-tolerances-jan-2018.pdf>

EPA. 2015b. Preliminary Ecological Risk Assessment in Support of the Registration Review of Glyphosate and Its Salts. September 2015. U.S. Environmental Protection Agency, Washington, D.C. <https://www.regulations.gov/document/EPA-HQ-OPP-2009-0361-0077>

EPA. 2016. Inert Ingredients Eligible for FIFRA 25(b) Pesticide Products. November 2016. U.S. Environmental Protection Agency, Washington, D.C. https://www.epa.gov/sites/default/files/2016-11/documents/minrisk_inert_ingredients_w_tolerances_2016-11-16.pdf

EPA. 2017a. Pelargonic Acid (217500) Fact Sheet. Office of Pesticide Programs. U.S. Environmental Protection Agency. <https://www.govinfo.gov/content/pkg/FR-2019-11-18/html/2019-24919.htm>

EPA. 2017b. Environmental Fate and Ecological Risk Assessment for the Registration Review of Glufosinate. U.S. Environmental Protection Agency Environmental Fate and Effects Division (EFED) Environmental Risk Branch IV. <https://www.regulations.gov/document/EPA-HQ-OPP-2008-0190-0023>

EPA. 2018a. Glyphosate Draft Human Health Risk Assessment for Registration Review. February 2018. Docket Number EPA-HQ-OPP-2009-0361. U.S. Environmental Protection Agency, Washington, D.C. <https://www.regulations.gov/document/EPA-HQ-OPP-2009-0361-0068>

EPA. 2018b. Revised Glyphosate Issue Paper: Evaluation of Carcinogenic Potential. February 2018. Docket Number EPA-HQ-OPP-2009-0361. U.S. Environmental Protection Agency, Washington, D.C. <https://www.regulations.gov/document/EPA-HQ-OPP-2009-0361-0073>

- EPA. 2018c. Summary Review of Recent Analysis of Glyphosate Use and Cancer Incidence in the Agricultural Health Study. Docket Number EPA-HQ-OPP-2009-0361. U.S. Environmental Protection Agency, Washington, D.C. <https://www.regulations.gov/document/EPA-HQ-OPP-2009-0361-0073>
- EPA. 2018d. Glyphosate - Systematic Review of Open Literature. Docket Number EPA-HQ-OPP-2009-0361. U.S. Environmental Protection Agency, Washington, D.C. <https://www.regulations.gov/document/EPA-HQ-OPP-2009-0361-0067>
- EPA. 2019. Glyphosate: Response to Comments on the Human Health Draft Risk Assessment. May 2019. Docket Number EPA-HQ-OPP-2009-0361. U.S. Environmental Protection Agency, Washington, D.C. <https://www.regulations.gov/document/EPA-HQ-OPP-2009-0361-2343>
- EPA. 2020a. Glyphosate Interim Registration Review Decision Case Number 0178. January 2020. Docket Number EPA-HQ-OPP-2009-0361. U.S. Environmental Protection Agency, Washington, D.C. <https://www.regulations.gov/document/EPA-HQ-OPP-2009-0361-14442>
- EPA. 2020b. Glyphosate: Epidemiological Review of Zhang et al. (2019) and Leon et al. (2019) publications for Response to Comments on the Proposed Interim Decision. February 2020. Docket Number EPA-HQ-OPP-2009-0361. U.S. Environmental Protection Agency, Washington, D.C. <https://www.regulations.gov/document/EPA-HQ-OPP-2009-0361-14445>
- EPA. 2020c. Glyphosate Response to Comments on the Proposed Interim Decision Regarding the Human Health Risk Assessment. February 2020. Docket Number EPA-HQ-OPP-2009-0361. U.S. Environmental Protection Agency, Washington, D.C. <https://www.regulations.gov/document/EPA-HQ-OPP-2009-0361-14444>
- EPA. 2021. Final National Level Listed Species Biological Evaluation for Glyphosate. November 2021. U.S. Environmental Protection Agency, Washington, D.C. <https://www.epa.gov/endangered-species/final-national-level-listed-species-biological-evaluation-glyphosate>
- EPA. 2022. Balancing Wildlife Protection and Responsible Pesticide Use: How EPA's Pesticide Program Will Meet Its Endangered Species Act Obligations. U.S. Environmental Protection Agency. https://www.epa.gov/system/files/documents/2022-04/balancing-wildlife-protection-and-responsible-pesticide-use_final.pdf
- FAO/WHO. 2016. Special Session of the Joint Food and Agriculture Organization (FAO) of the United Nations / World Health Organization (WHO) Meeting on Pesticide Residues. <https://www.fao.org/3/i5693e/i5693E.pdf>
- FSCJ. 2016. Food Safety Commission of Japan (FSCJ). Risk Assessment Report: Pesticides, Glyphosate. https://www.fsc.go.jp/english/evaluationreports/agrichemicals/e1.data/kya0100622449b_202.pdf
- FSC. 2020. Environmental and Social Risk Assessment: National Guidance for the United States. Appendix 1: National Guidance ESRA for Glyphosate. Forest Stewardship Council. Minneapolis, MN. <https://us.fsc.org/preview.appendix-1-glyphosate.a-817.pdf>
- GF and PAN. 2017. Analysis of European Glyphosate Risk Assessment and the Irrational Dismissal of Studies that Report Toxic Effects. générations futures and the Pesticide Action Network. https://www.pan-europe.info/sites/pan-europe.info/files/Glyphosate%20Dismissal_Technical%20Report.pdf
- Ghandi, K., Khan, S., Patrikar, M., Markad, A., Kumar, N., Choudhari, A., Sagar, P., and Indurkar, S. 2021. Exposure risk and environmental impacts of glyphosate: Highlights on the toxicity of herbicide co-formulants. Environmental Challenges 4:100149. <https://www.sciencedirect.com/science/article/pii/S2667010021001281?via%3Dihub>
- Gill, J., Sethi, N., Mohan, A., Datta, S., and Girdhar, M. 2018. Glyphosate toxicity for animals. Environmental Chemistry Letters 16(2):401-426. <https://www.proquest.com/openview/253b91d119f570bbbc8e63160b61f805>
- IARC. 2017. Working Group on the Evaluation of Carcinogenic Risks to Humans. Some organophosphate insecticides and herbicides. <https://publications.iarc.fr/549>
- Kelly Solutions. 2022. Massachusetts Pesticide Product Registration Information. System last access May 23, 2022. <https://www.kellysolutions.com/ma>

- Kniss, A. 2017. Long-term trends in the intensity and relative toxicity of herbicide use. *Nat Commun* 8, 14865. <https://doi.org/10.1038/ncomms14865>
- Leon et al. 2019. Pesticide use and risk of non-Hodgkin lymphoid malignancies in agricultural cohorts from France, Norway, and the USA: a pooled analysis from the AGRICOH consortium. *Int J. Epidemiol.* 48(5):1519-1535. <https://pubmed.ncbi.nlm.nih.gov/30880337/>
- Linz, G.M., Bleier, W.J., Overland, J.D., and Homan, H.J. 1999. Response of invertebrates to glyphosate-induced habitat alterations in wetlands. *Wetlands* 19(1):220-227. <https://link.springer.com/article/10.1007/BF03161751>
- Maggi, F., la Cecilia, D., Tang, F. H.M., and McBratney, A. 2020. The global environmental hazard of glyphosate use. *Science of The Total Environment* (717):137167. <https://www.sciencedirect.com/science/article/abs/pii/S004896972030677X>
- Marek, C., Traavik, T., and Bøhn, T. 2013. Clone-and age-dependent toxicity of a glyphosate commercial formulation and its active ingredient in *Daphnia magna*. *Ecotoxicology* 22(2):251-262. <https://link.springer.com/article/10.1007/s10646-012-1021-1>
- MassDOT. 2021. Vegetation Management Plan 2021 – 2025. MassDOT Highway Division. <https://www.mass.gov/doc/massdot-2021-2025-vmp/download>
- MDAR. 2022. Glyphosate. Massachusetts Department of Agricultural Resources. Updated May 13, 2022. <https://www.mass.gov/doc/glyphosate-factsheet-2022-updated-may13/download>
- Meftaul, I., Venkateswarlu, K., Dharmarajan, R., Annamalai, P., Asaduzzaman, M., Parven, A., and Megharaj, M. 2020. Controversies over human health and ecological impacts of glyphosate: Is it to be banned in modern agriculture? *Environmental Pollution* 263(A):114372. <https://www.sciencedirect.com/science/article/abs/pii/S0269749119368265>
- Mesnage, R., M. Ibragim, D. Mandrioli, L. Falcioni, E. Tibaldi, F. Belpoggi, I. Brandsma, E. Bourne, E. Savage, C. Mein, and M. Antoniou. 2021. Comparative Toxicogenomics of Glyphosate and Roundup Herbicides by Mammalian Stem Cell-Based Genotoxicity Assays and Molecular Profiling in Sprague-Dawley Rats. *Toxicological Sciences*, 186: 83–101. <https://academic.oup.com/toxsci/article/186/1/83/6446050>
- Mohammadi, K., M. Alizadeh Sani, P. Safaei, J. Rahmani, E. Molae-Aghae, and S. Mahdi Jafari. 2021. A systematic review and meta-analysis of the impacts of glyphosate on the reproductive hormones. *Environ Sci Pollut Res Int*, 2021 Aug 27. <https://pubmed.ncbi.nlm.nih.gov/34453247/>
- Neal, J., and Senesac, A. 2022. Are There Alternatives to Glyphosate for Weed Control in Landscapes? North Carolina State University Extension website. Last accessed May 1, 2022. <https://content.ces.ncsu.edu/are-there-alternatives-to-glyphosate-for-weed-control-in-landscapes>
- NOFA/Mass. 2018. NOFA/Mass Statement on Glyphosate (December 2018). Northeast Organic Farming Association, Massachusetts Chapter. <https://www.nofamass.org/glyphosate/>
- NRDC. 2019. Report: Monarchs, Other Species Endangered by Pesticides. Natural Resources Defense Council. <https://www.nrdc.org/experts/sylvia-fallon/report-monarchs-other-species-endangered-pesticides>
- NTP. 2022. National Toxicology Program, US Department of Health and Human Services. Highlighted Research Topics, Glyphosate and Glyphosate Formulations. Accessed on 5/10/22: <https://ntp.niehs.nih.gov/whatwestudy/topics/glyphosate/index.html#:~:text=A%3A%20In%201992%2C%20NTP%20reported,a%20cancer%20hazard%20for%20humans.>
- Pesticide Action Network (Europe) and Generations Future. 2017. Analysis of European Glyphosate Risk Assessment and The Irrational Dismissal Of Studies That Report Toxic Effects. https://www.pan-europe.info/sites/pan-europe.info/files/Glyphosate%20Dismissal_Technical%20Report.pdf
- Smith, C.M., Vera, M., and Bhandari, R.K. 2019. Developmental and epigenetic effects of Roundup and glyphosate exposure on Japanese medaka (*Oryzias latipes*). *Aquatic Toxicology* 210:215-226. <https://www.sciencedirect.com/science/article/abs/pii/S0166445X18310713>

Stellin, F., Gavinelli, F., Stevanato, P., Concheria, G., Squartini, A., and Paoletti, M. 2018. Effects of different concentrations of glyphosate (Roundup 360®) on earthworms (*Octodrilus complanatus*, *Lumbricus terrestris* and *Aporrectodea caliginosa*) in vineyards in the North-East of Italy. *Applied Soil Ecology* 123:802-808.

<https://www.sciencedirect.com/science/article/abs/pii/S0929139317300598>

UMass. 2008. Cranberry Production: A Guide for Massachusetts. Hilary A. Sandler and Carolyn J. DeMoranville (editors). University of Massachusetts Publication CP-08. UMass-Amherst, College of Natural Resources and the Environment. East Wareham, MA. <https://www.umass.edu/cranberry/downloads/CP-08.pdf>

UMass CAFE. 2020. Management Updates: Apr 6, 2020: Are There Glyphosate Alternatives? UMass Center for Agriculture, Food, and the Environment. <https://ag.umass.edu/turf>

USFS. 1997. US Forest Service. Glyphosate - Herbicide Information Profile. February 1997.

https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_025810.pdf

USFS. 2003. US Forest Service. Glyphosate - Human Health and Ecological Risk Assessment, Final Report.

https://www.fs.fed.us/r5/hfqlg/publications/herbicide_info/2003_glyphosate.pdf

USFS. 2011. US Forest Service. Glyphosate, Human Health and Ecological Risk Assessment, Final Report.

https://www.fs.fed.us/foresthealth/pesticide/pdfs/Glyphosate_SERA_TR-052-22-03b.pdf

Wang, C., Lin, X., Li, L., and Lin, S. 2016. Differential Growth Responses of Marine Phytoplankton to Herbicide Glyphosate. *PLOS One* 11(3). <https://doi.org/10.1371/journal.pone.0151633>

Wieben, C.M., 2021. Preliminary estimated annual agricultural pesticide use for counties of the conterminous United States, 2019: U.S. Geological Survey data release, <https://doi.org/10.5066/P9EDTHQL>

Zhang et al. 2019. Exposure to glyphosate-based herbicides and risk for non-Hodgkin lymphoma: a meta-analysis and supporting evidence. *Mutation Research/Reviews in Mutation Research* 781:186-206. doi:

10.1016/j.mrrev.2019.02.001. <https://pubmed.ncbi.nlm.nih.gov/31342895/>

6.0 Abbreviations Used in the Report

AGG	Assessment Group on Glyphosate
APVMA	Australian Pesticide and Veterinary Medicines Authority
ATSDR	Agency for Toxic Substances and Disease Registry
dRAR	draft Renewal Assessment Report
ECHA	European Chemicals Agency
EFSA	European Food Safety Authority
EPA	U.S. Environmental Protection Agency
ERG	Eastern Research Group, Inc.
FSC	Forest Stewardship Council
IARC	International Agency for Research on Cancer
MDAR	Massachusetts Department of Agricultural Resources
NGO	non-governmental organization
NRDC	Natural Resources Defense Council
NSRL	No Significant Risk Level
NTP	National Toxicology Program

OEHHA (California's) Office of Environmental Health Hazard Assessment

PMRA (Canada's) Pest Management Regulatory Agency

RED Reregistration Eligibility Decision

UMass University of Massachusetts

USDA U.S. Department of Agriculture

WHO World Health Organization

THE COMMONWEALTH OF MASSACHUSETTS

**EXECUTIVE OFFICE OF ENERGY AND
ENVIRONMENTAL AFFAIRS -**

**MASSACHUSETTS DEPARTMENT OF
AGRICULTURAL RESOURCES**

251 CAUSEWAY STREET, SUITE 500
BOSTON, MA 02114-2151



**Statewide Contract PRF61:
Management Consultants, Program Coordinators & Planners Services
Category: Environmental Consulting Services**

Request for Quote (RFQ)

**Document Title: Glyphosate Scientific Review
Document Number: AGR-GlyphosateStudy-FY22**

Responses will be received online, via COMMBUYS through December 29, 2021, at 11 AM.



Massachusetts Department of Agricultural Resources- MDAR
Request for Quote

Issue Date:	December 13, 2021
Purchasing Department	Department of Agricultural Resources
Address	251 Causeway Street, Suite 500
City, State Zip Code	Boston, MA 02114-2151
RFR Name/Title	Glyphosate Scientific Review
RFR Number	AGR-GlyphostateStudy-FY22

1. Description or Purpose of Procurement:

The Massachusetts Department of Agricultural Resources (“MDAR”), on behalf of the Glyphosate Commission (“Commission”) established by FY2022 budget line item 2511-0100 (“Budget Line Item”), seeks applicants to conduct a scientific review on the potential public health and ecological effects of glyphosate. **The Commission is working with a very tight timeline as required by the budget line item; an initial Report shall be submitted to the Commission three weeks after the start of the contract, and a final Report and presentation on the Report and findings must be submitted to the Commission no later than March 1, 2022.**

Massachusetts regulates pesticides through M.G.L. c. 132B, the Massachusetts Pesticide Control Act (“Act”). This law, enacted in 1978, places the power of pesticide regulation with MDAR. MDAR has authority to promulgate regulations under its authority set forth in the Act, which can be found at 333 CMR 2.00 through 14.00. . The Act also created a Pesticide Board Subcommittee, which is charged with registering pesticides in the Commonwealth in accordance with M.G.L. c. 132B, Section 7A. Pesticide registration requirements include ecological risk assessments to ensure that the intended use will not cause unreasonable adverse effects on the environment.

The Budget Line Item created the Commission and authorized it to conduct a scientific review of the potential impacts of glyphosate and its most common alternative herbicides on the environment and public health. The legislature also stipulated that “pesticide subcommittee established under section 3A of chapter 132B of the General Laws shall use said scientific review as part of an individual conducted under 333 C.M.R 8.03 to determine chapter 132B of the General Laws to determine whether current uses of glyphosate pose unreasonable adverse effects to the environment, and whether current registered uses of glyphosate should be altered or suspended.”

Scope

The Commission is seeking proposals from contractors to conduct a scientific review of the potential impacts of glyphosate and its most common alternative herbicides on the environment and public health. This review must be undertaken in collaboration with the Massachusetts Natural Heritage and Endangered Species Program to evaluate the potential impacts of glyphosate and most common alternative herbicides on:

- (i) all species of plants and animals that have been determined to be endangered, threatened, or of special concern pursuant to chapter 131A of the General Laws; and
- (ii) all significant habitats designated pursuant to said chapter 131A; provided further, that the commission may expend any portion of its funds it deems necessary to enable the collaboration of the natural heritage and endangered species program

Massachusetts Department of Agricultural Resources- MDAR
Request for Quote

Deliverables (Phase 1)

- Complete an initial report consisting of the following:
 1. a summary of available information on the use of glyphosate in the Commonwealth and key herbicide agent alternatives (e.g., pelargonic acid; glufosinate); this should identify and summarize use restrictions and requirements to minimize impacts.
 2. a list of key assessments (e.g., recent assessments by recognized authorities including, for example, USEPA; peer reviewed publications; precedential judicial decisions), of the potential public health and environmental impacts of glyphosate and its alternatives; and
 3. a list of key stakeholders to be consulted (for example, NAISMA).
- The initial report will be provided to the Commission **three weeks after the start of the contract** and will serve to inform elements to be included in the final report. The Commission will review and affirm the submission to be used to complete the tasks below and may suggest additions.

Deliverable (Phase 2)

- Detailed assessment of the use of glyphosate in the Commonwealth, including methodologies (how) and rationale for use (why), and its key herbicide agent alternatives informed by the Phase 1 deliverable described above. Alternatives should also include discussion of non-pesticide methods of vegetation control (e.g., mechanical methods). The summary of uses should include a review of the effectiveness, application methods and other approaches to avoid or minimize impacts.
- In consultation with the Massachusetts Natural Heritage and Endangered Species Program, summarize the potential impacts of glyphosate and alternative herbicide agents on species determined to be endangered, threatened or of special concern and significant habitats, or habitats of concern.
- Identify and collect regulatory assessments, peer-reviewed scientific publications and other sources of information and data on glyphosate and alternative agents.
- Review, analyze and summarize key assessments, such as recent assessments by recognized authorities (e.g., USEPA), publications in the peer reviewed literature; and precedential judicial decisions) informed by the Phase 1 deliverable.
- Summarize legislation, regulations, and other management requirements for these herbicides by federal agencies, New England states, and any state implementing new management techniques or programs. Summarize key findings of fact from precedential judicial decisions.
- Compare potential public health and environmental impacts of glyphosate and alternative herbicide Agents based on key assessments, informed by the Phase 1 deliverable, and addressed under (4) above.
- Consult with other State, local, and national agencies as well as stakeholder groups identified or informed by the Phase 1 deliverable, on data and information collection.
- Consult and collaborate with the Commission and its support staff on the development of review documents.

Deliverables (Final)

- Develop a report on the review of studies and information collected as noted above. A presentation of the Report will be made to the Commission **no later than March 1, 2022**.

Massachusetts Department of Agricultural Resources- MDAR
Request for Quote

2. Applicable Procurement Law

Check :	Type of Purchase	Executive Branch Goods & Services- Applicable Laws
<input checked="" type="checkbox"/>	Goods and Services	MGL c. 7, § 22; c. 30, § 51, § 52; 801 CMR 21.00

3. Acquisition Method:

Check All Applicable:	Category
<input checked="" type="checkbox"/>	Fee-For-Service

4. Bid Calendar Type:

Check	Type	Description
<input checked="" type="checkbox"/>	Standard	Procurement will not be reopened after the Bid Opening Date (Response deadline date)

5. Whether Single or Multiple Contractors are Required for Contract:

Check	Number of Contractors		
<input checked="" type="checkbox"/>	Single Contractor	Target Number of Contracts	One Contract will be Awarded

6. Entities Eligible to Use the Resulting Contract

Check	Limited User Contract- Eligible Entities/Agencies
<input checked="" type="checkbox"/>	Restricted to Use by Defined Entities Only: <ul style="list-style-type: none"> • MDAR- Department of Agricultural Services and MDEP-Department of Environmental Protection

7. Expected Duration of Contract (Initial Duration and any Options to Renew):

Contract Duration	Number of Options	Number of Years/Months
Contract Duration		<u>Contract Effective Date through June 30, 2022</u>
Final Deliverable Due		<u>Study must be submitted by March 1, 2022</u>

8. Anticipated Expenditures, Funding or Compensation:

Check:	Compensation Type
<input type="checkbox"/>	Maximum Obligation Contract
<input checked="" type="checkbox"/>	Rate Contract- Contract will NOT have a Maximum Obligation

The funding for any contract is at least \$50,000. Additional funds may be made available.

Massachusetts Department of Agricultural Resources- MDAR
Request for Quote

9. Contract Performance and Business Specifications:

Work Requirements

- Summarize the use of glyphosate and its key herbicide alternatives agents in MA.
- In consultation with the MA natural heritage and endangered species program, summarize the potential impacts of glyphosate and alternative herbicide agents on species determined to be endangered, threatened or of special concern and significant habitats.
- Consult with MDAR relative to the pesticide laws and regulations that pertain to pesticides and pesticide product registration.
- Consult with any other state agency which the contractor feels necessary.
- Collect, review, and analyze to the extent feasible key regulatory and peer-reviewed scientific information and data on these agents.
- Summarize legislation, regulations, and other management requirements for these herbicides by federal agencies and key states.
- Identify other publications and assessments.
- Prepare a qualitative comparison of potential public health and environmental impacts of these agents based on key assessments.
- Consult with other State, local, and national agencies as well as stakeholder groups on data and information collection.
- Consult and collaborate with the Commission and its support staff on the development of review documents.
- Develop reports and summaries on the review of studies and information collected.
- Attend the Commission meetings.
- Present the final review to the Commission.
- Present the final review to the Pesticide Board Subcommittee.
- Report must be submitted to the Department **no later March 1, 2022.**

Minimum Qualifications Required

- Ability to collect, review, evaluate and synthesize summaries of knowledge, information, data related to toxicity and risks of certain pesticides.
- Ability to compose relevant reports and related documents.
- Ability to effectively communicate in writing and orally.
- Ability to read, understand, and relay scientific information in the context of a pesticide regulatory program.
- Experience in scientific writing and communication

Preferred Qualifications

- Graduate degree in Ecology, Toxicology, Environmental Science, Entomology, or related fields.
- Experience or knowledge of ecological risk assessment
- Knowledge of federal and state pesticide regulation and supporting risk assessment procedures
- Research and Field experience in a biological or ecological setting.

Massachusetts Department of Agricultural Resources- MDAR
Request for Quote

10. Small Business Purchasing Program

Check	Size of Procurement Annually	SDP Commitment
<input checked="" type="checkbox"/>	Small Procurement (<= \$250,000)	SBPP section applies to this Procurement
<input type="checkbox"/>	Large Procurement (> \$250,000)	SBPP section does not apply to this Procurement

Program Background: The Massachusetts [Small Business Purchasing Program](#) (SBPP) was established pursuant to [Executive Order 523](#) to increase state contracting opportunities with small businesses having their principal place of business within the Commonwealth of Massachusetts. Pursuant to the SBPP, it is the intention of the issuing department to award this Small Procurement to one or more SBPP participating business(es) as described below.

SBPP Award Preference: While all businesses, no matter the size or principal place of business, may submit responses to this solicitation, should an SBPP participant respond and meet the best value criteria as described in this solicitation, the SBPP participant shall be awarded the contract. The Strategic Sourcing Services Team (SSST) will not evaluate submissions from non-SBPP participants unless no SBPP Bidder meets the SSST's best value evaluation criteria.

SBPP Participation Eligibility: To be eligible to participate in this procurement as an SBPP participant, an entity must meet the following criteria, and be marked as an SBPP-registered business in [COMMBUYS](#):

1. Have its principal place of business in the Commonwealth of Massachusetts;
2. Been in business for at least one year;
3. Employ a combined total of 50 or fewer full-time equivalent employees in all locations, or employees work less than a combined total of 26,000 hours per quarter; and
4. Have gross revenues, as reported on appropriate tax forms, of \$15 million or less, based on a three-year average.

Non-profit firms also must be registered as a non-profit or charitable organization with the MA Attorney General's Office and be up to date with all filings required by that office and be tax exempt under Section 501(c) of the Internal Revenue Code.

SBPP Compliance Requirements: It is the responsibility of the Bidder to ensure that their SBPP status is current at the time of submitting a response and throughout the life of any resulting contract. Misrepresentation of SBPP status will result in disqualification from consideration, and may result in debarment, contract termination, and other actions. To learn more about the SBPP, including how to apply, visit the [SBPP Webpage](#).

Program Resources and Assistance: Bidders and Contractors seeking assistance regarding SBPP may visit the SBPP webpage, <http://www.mass.gov/sbpp>, or contact the SBPP Help Desk at sbpp@mass.gov.

Massachusetts Department of Agricultural Resources- MDAR
Request for Quote

11. Supplier Diversity Plan

Check	Size of Procurement Annually	SDP Commitment
<input checked="" type="checkbox"/>	Small Procurement (<= \$250,000)	Submission is NOT required for this Procurement
<input type="checkbox"/>	Large Procurement (> \$250,000)	Submission is MANDATORY for Procurements with estimated annual values exceeding \$250,000

Supplier Diversity Plan is not required for this Procurement

12. Environmentally Preferable Products

Products and services purchased by state agencies must be in compliance with [Executive Order 515](#), issued October 27, 2009. Under this Executive Order, Executive Departments are required to reduce their impact on the environment and enhance public health by procuring environmentally preferable products and services (EPPs) whenever such products and services perform to satisfactory standards and represent best value, consistent with 801 CMR 21.00. In line with this directive, all Contracts, whether departmental or statewide, must comply with the specifications and guidelines established by OSD and the EPP Program. EPPs are products and services that help to conserve natural resources, reduce waste, protect public health and the environment, and promote the use of clean technologies, recycled materials, and less toxic products. Bid responses must identify how a contractor meets these goals.

13. Environmental Justice Policy

For the purposes of this RFQ, “Environmental Justice” is defined as the equal protection and meaningful involvement of all people and communities with respect to the development, implementation, and enforcement of energy, climate change, and environmental laws, regulations, and policies and the equitable distribution of energy and environmental benefits and burdens. Environmental Justice is based on the principle that all people have a right to be protected from environmental hazards and to live in and enjoy a clean and healthful environment regardless of race, color, national origin, income or English language proficiency.

“Environmental Justice Population” is defined by the Environmental Justice Policy, issued by the Massachusetts Executive Office of Energy and Environmental Affairs in 2017, as neighborhoods where one or more of the following criteria are met:

- Annual median household income equal to or less than 65 percent of the statewide median
- 25% of its population is minority; or
- 25% or more of the residents have English Isolation.

Massachusetts Department of Agricultural Resources- MDAR
Request for Quote

14. Evaluation Criteria

Contractors must submit responses that meet all the submission requirements of the RFQ. Only responsive proposals that meet the submission requirements will be evaluated, scored and ranked by the evaluation team according to the evaluation criteria. Additional information may be requested for evaluation purposes.

General Evaluation: The Department will consider no responses received after the deadline. The Department will award Contracts to the most responsive bidder(s) that offers the best value. The fulfillment of the qualifications listed in this RFQ, the completion of all required forms as listed in the RFQ, and a determination by the Department that contracting with the bidder will provide the “best value” to the Commonwealth will determine the basis for evaluation. In making this determination, the Department will consider and score a number of factors including price, experience, geographic location for ease of service, and quality. The Department may disqualify Responses that are incomplete or inaccurate at its own discretion.

15. Instructions for Submission of Responses:

Only electronic quotes submitted via COMMBUYS will be accepted in response to this RFQ. Responses must be sent via the “Create Quote” functionality in COMMBUYS. For instructions concerning how to submit a Quote, please see Appendix B.

Any submission which fails to meet the submission requirements of the RFQ will be found non-responsive without further evaluation unless the evaluation team, at its discretion, determines that the non-compliance is insubstantial and can be corrected. In these cases, the evaluation team may allow the vendor to make minor corrections to the submission.

COMMBUYS Submission Instructions:

Include at a minimum the following with your submission:

- Company/Vendor overview and credentials.
- Methodology/Approach of the project
- Quote for Project or rates- Include any additional rates if applicable.
- Sample report
- Confirmation you can meet the report deadline. (If not, provide closest completion date)

All terms, conditions, requirements, and procedures included in this RFQ must be met for a Response to be determined responsive. If a Respondent fails to meet any material term, condition, requirement or procedure, its Response may be deemed unresponsive and disqualified. The Department reserves the right to request additional information from a Respondent to clarify their response to this RFQ, provided that, in the Department's view, any such opportunity to provide further information does not prejudice the interests of the other Respondents.

Note: Prices submitted by the vendor will be set for the full duration of the Initial Contract. Any change in pricing will be submitted and approved in advance by the Department upon each renewal option.

Additional Invasives or services may be agreed upon and added at time of renewal, or mid agreement, via a contract amendment.

Massachusetts Department of Agricultural Resources- MDAR
Request for Quote

16. Estimated Procurement Calendar

Procurement Activity	Date
Original Release of this RFR/RFQ/Bid:	December 16, 2021
Amended RFR Document Released:	NA
Application Due Date: (COMMBUYS Bid Opening Date)	December 29, 2021, 11AM
Estimated Contract Start Date:	Estimated- January 3, 2022

**Bidders are required to monitor COMMBUYS for changes to the procurement calendar for this Bid.*

a. COMMBUYS Online Questions (Bid Q&A):

Written Questions must be entered using the “Bid Q&A” tab for the Bid in COMMBUYS no later than the “Online Questions Due” date and time indicated in the Estimated Procurement Calendar (above). The issuing department reserves the right to not respond to questions submitted after this date. It is the Bidder’s responsibility to verify receipt of questions.

It is the responsibility of the prospective Bidder and awarded Contractor to maintain an active registration in COMMBUYS and to keep current the email address of the Bidder’s contact person and prospective contract manager, if awarded a contract, and to monitor that email inbox for communications from the Purchasing Department, including requests for clarification. The Purchasing Department and the Commonwealth assume no responsibility if a prospective Bidder’s/awarded Contractor’s designated email address is not current, or if technical problems, including those with the prospective Bidder’s/awarded Contractor’s computer, network, or internet service provider (ISP) cause email communications sent to/from the prospective Bidder/Awarded contractor and the Purchasing Department to be lost or rejected by any means including email or spam filtering.

Written Responses to Questions will be released on or about the “Responses to Questions Posted Online” date indicated in the Estimated Procurement Calendar (above). Written questions and responses will be posted on the Bid Q&A Tab for this Bid in COMMBUYS.)

Required RFQ Attachments Included:

Appendix A: Required Specifications

Appendix B: COMMBUYS Electronic Quote Submission Instructions

Massachusetts Department of Agricultural Resources- MDAR
Request for Quote

RFQ Attachments

Appendix A: Required Specifications

RFQ - Required Specifications for Commodities and Services

Revision Date: October 5, 2021

In general, most of the required contractual stipulations are referenced in the *Standard Contract Form and Instructions* and the *Commonwealth Terms and Conditions*. However, the following RFQ provisions must appear in all Commonwealth competitive procurements conducted under 801 CMR 21.00.

The terms of *801 CMR 21.00: Procurement of Commodities and Services* are incorporated by reference into this RFQ. Words used in this RFQ shall have the meanings defined in 801 CMR 21.00. Additional definitions also may be identified in this RFQ. Other terms not defined elsewhere in this document may be defined in OSD's [Glossary of Terms](#). Unless otherwise specified in this RFQ, all communications, responses, and documentation must be in English, all measurements must be provided in feet, inches, and pounds and all cost proposals or figures in U.S. currency. All responses must be submitted in accordance with the specific terms of this RFQ.

1. COMMBUYS Market Center. COMMBUYS is the official source of information for this Bid and is publicly accessible at no charge at www.commbuys.com. Information contained in this document and in COMMBUYS, including file attachments, and information contained in the related Bid Questions and Answers (Q&A), are components of the Bid, as referenced in COMMBUYS, and are incorporated into the Bid and any resulting contract.

Bidders are solely responsible for obtaining all information distributed for this Bid via COMMBUYS. Bid Q&A supports Bidder submission of written questions associated with a Bid and publication of official answers.

It is each Bidder's responsibility to check COMMBUYS for:

- Any amendments, addenda, or modifications to this Bid, and
- Any Bid Q&A records related to this Bid.

The Commonwealth accepts no responsibility and will provide no accommodation to Bidders who submit a Quote based on an out-of-date Bid or on information received from a source other than COMMBUYS.

2. COMMBUYS Registration. Bidders may elect to register for a free COMMBUYS Seller account which provides value-added features, including automated email notification associated with postings and modifications to COMMBUYS records. However, to respond to a Bid, Bidders must register and maintain an active COMMBUYS Seller account.

All Bidders submitting a Quote (previously referred to as Response) in response to this Bid (previously referred to as Solicitation) agree that, if awarded a contract: 1) they will maintain an active seller account in COMMBUYS; 2) they will, when directed to do so by the procuring entity, activate and maintain a COMMBUYS-enabled catalog using Commonwealth Commodity Codes; 3) they will comply with all requests by the procuring entity to utilize COMMBUYS for the purposes of conducting all aspects of purchasing and invoicing with the Commonwealth, as added functionality for the COMMBUYS system is activated; and 4) in the event the Commonwealth adopts an alternate e-procurement platform, successful Bidders will be required to utilize such system, as directed by the procuring entity. Commonwealth Commodity Codes are based on the United Nations Standard Products and Services Code (UNSPSC).

Massachusetts Department of Agricultural Resources- MDAR
Request for Quote

COMMBUYS uses terminology with which bidders must be familiar to conduct business with the Commonwealth. To view this terminology and to learn more about COMMBUYS, please visit the [Learn about COMMBUYS Resources page on mass.gov](#).

3. Multiple Quotes. Bidders may not submit Multiple Quotes in response to a Bid unless the RFQ authorizes them to do so. If a Bidder submits multiple quotes in response to an RFQ that does not authorize multiple responses, only the latest dated quote submitted prior to the bid opening date will be evaluated.

4. Quote Content. Bid specifications for delivery, shipping, billing, and payment will prevail over any proposed Bidder terms entered as part of the Quote, unless otherwise specified in the Bid.

5. Supplier Diversity Office (SDO) Programs. Pursuant to Executive Orders [523](#) and [565](#), the Commonwealth supports the use of diverse and small businesses through the Small Business Purchasing Program (SBPP) and the Supplier Diversity Program (SDP). Based on the estimated value of the procurement, one of the above-mentioned programs shall be applicable to this RFQ. For more information on the program that applies to this solicitation, see the body of this RFQ.

6. Small Business Purchasing Program (SBPP)

Program Background. The Massachusetts [Small Business Purchasing Program](#) (SBPP) was established pursuant to [Executive Order 523](#) to increase state contracting opportunities with small businesses having their principal place of business within the Commonwealth of Massachusetts. Pursuant to the SBPP, it is the intention of the issuing department to award this Small Procurement to one or more SBPP participating business(es) as described below.

SBPP Award Preference. While all businesses, no matter the size or principal place of business, may submit responses to this solicitation, should an SBPP participant respond and meet the best value criteria described in this solicitation, the SBPP participant shall be awarded the contract. The Strategic Sourcing Services Team (SST) will not evaluate submissions from non-SBPP participants unless no SBPP Bidder meets the SSST's best value evaluation criteria.

SBPP Participation Eligibility. To be eligible to participate in this procurement as an SBPP participant, an entity must meet the following criteria, and be marked as an SBPP-registered business in [COMMBUYS](#):

5. Have its principal place of business in the Commonwealth of Massachusetts;
6. Been in business for at least one year;
7. Employ a combined total of 50 or fewer full-time equivalent employees in all locations, or employees work less than a combined total of 26,000 hours per quarter; and
8. Have gross revenues, as reported on appropriate tax forms, of \$15 million or less, based on a three-year average.

Non-profit firms also must be registered as a non-profit or charitable organization with the MA Attorney General's Office and be up to date with all filings required by that office and be tax exempt under Section 501(c) of the Internal Revenue Code.

SBPP Compliance Requirements. It is the responsibility of the Bidder to ensure that their SBPP status is current at the time of submitting a response and throughout the life of any resulting contract. Misrepresentation of SBPP status will result in disqualification from consideration, and may result in debarment, contract termination, and other actions. To learn more about the SBPP, including how to apply, visit the SBPP webpage, <http://www.mass.gov/sbpp>.

Program Resources and Assistance. Bidders and Contractors seeking assistance regarding SBPP may visit the [SBPP Webpage](#), or contact the SBPP Help Desk at sbpp@mass.gov.

7. Supplier Diversity Program (SDP)

Massachusetts Department of Agricultural Resources- MDAR
Request for Quote

Program Background. Pursuant to [Executive Order 565](#), the Commonwealth's [Supplier Diversity Program](#) (SDP) promotes business-to-business relationships between awarded Contractors and diverse businesses and non-profit organizations ("SDP Partners") certified or recognized (see below for more information) by the [Supplier Diversity Office \(SDO\)](#).

Financial Commitment Requirements. All Bidders responding to this solicitation are required to make a significant financial commitment ("SDP Commitment") to partnering with one or more SDO-certified or recognized diverse business enterprise(s) or non-profit organization(s). This SDP Commitment must be expressed as a percentage of contract sales resulting from this solicitation that would be spent with the SDP Partner(s).

After contract award (if any), the Total SDP Commitment shall become a contractual requirement to be met annually on a Massachusetts fiscal year basis (July 1 – June 30) for the duration of the contract. The minimum acceptable Total SDP Commitment in response to this solicitation shall be 1%. Bidders shall be awarded additional evaluation points for higher SDP Commitments.

No contract shall be awarded to a Bidder without an SDP Commitment that meets the requirements stated herein. This requirement extends to **all** Bidders regardless of their own supplier diversity certification.

Eligible SDP Partner Certification Categories

SDP Partners must be business enterprises and/or non-profit organizations certified or recognized by the SDO in one or more of the following certification categories:

- Minority-Owned Business Enterprise (MBE)
- Minority Non-Profit Organization (M/NPO)
- Women-Owned Business Enterprise (WBE)
- Women Non-Profit Organization (W/NPO)
- Veteran-Owned Business Enterprise (VBE)
- Service-Disabled Veteran-Owned Business Enterprise (SDVOBE)
- Disability-Owned Business Enterprise (DOBE)
- Lesbian, Gay, Bisexual, and Transgender Business Enterprise (LBGTBE)

Eligible Types of Business-to-Business Relationships. Bidders and Contractors may engage SDP Partners as follows:

- **Subcontracting**, defined as a partnership in which the SDP partner is involved in the provision of products and/or services to the Commonwealth.
- **Ancillary Products and Services**, defined as a business relationship in which the SDP partner provides products or services that are not directly related to the Contractor's contract with the Commonwealth but may be related to the Contractor's own operational needs.

Other types of business-to-business relationships are not acceptable under this contract. All provisions of this RFQ applicable to subcontracting shall apply equally to the engagement of SDP Partners as subcontractors.

Program Flexibility. The SDP encompasses the following provisions to support Bidders in establishing and maintaining sustainable business-to-business relationships meeting their needs:

- SDP Partners are **not** required to be subcontractors.
- SDP Partners are **not** required to be Massachusetts-based businesses.
- SDP Partners **may be changed or added** during the term of the contract, provided the Contractor continues to meet its SDP Commitment.

SDP Plan Form Requirements. All Bidders must complete the SDP Plan Form included in this solicitation and attach it to their bid response. In addition to proposing an SDP Commitment, each Bidder must propose one or more SDP Partner(s) to utilize to meet its SDP Commitment. Certified diverse Bidders may not list their own companies, their

Massachusetts Department of Agricultural Resources- MDAR
Request for Quote

subsidiaries, or affiliates as SDP Partners and may not meet their SDP Commitment by spending funds internally or with their own subsidiaries or affiliates.

Bidders may propose SDP Partners that are:

- **Certified or recognized by the SDO:** Such partners appear in the [SDO Directory of Certified Businesses](#) or in the [U.S. Dept of Veterans Affairs VetBiz Vendor Information Pages](#) directory. After contract award (if any), spending with such partners will contribute to meeting the Contractor's SDP Commitment.
- **Not yet certified or recognized by the SDO:** Such partners must be certified in eligible categories by a third-party certification body, such as another city or state supplier diversity certification office, the [National Minority Supplier Development Council](#), the [Women Business Enterprise National Council](#), [Disability: IN](#), or the [National LGBT Chamber of Commerce \(NGLCC\)](#), but are not listed in the above-mentioned directories. Self-certification is not acceptable. While Bidders may list such proposed SDP Partners on their SDP Plans, spending with such partners will not contribute to meeting the Contractor's SDP Commitment unless they apply for and are granted SDO supplier diversity certification or recognition. If proposed SDP Partners do not receive SDO supplier diversity certification or recognition, the Contractor must find alternative SDP Partners to meet the SDP Commitment.

It is the responsibility of the Contractor to ensure that their proposed SDP Partners obtain such certification or recognition by the SDO after contract award (if any). The issuing department and the SDO will not conduct outreach to proposed SDP Partners to ensure their certification. Furthermore, no guarantee may be made that a proposed SDP Partner will be certified, or regarding the time it may take to process a proposed SDP Partner certification. Contractors may direct partners to the SDO's homepage, www.mass.gov/sdo and the [Certification Self-Assessment Tool](#) for guidance on applying for certification.

It is **desirable** for Bidders to provide an SDP Focus Statement that describe the bidder's overall approach to increasing the participation of diverse businesses in the provision of products and services under this proposal/contract (subcontracting) and in the Bidder's general business operations (ancillary products and services). Such a description may include but not be limited to:

- A clearly stated purpose or goal.
- Specific types of diverse and small businesses targeted.
- Which departments/units within the business are responsible for implementing supplier diversity.
- Types of opportunities for which diverse and small businesses are considered.
- Specific measures/methods of engagement of diverse and small businesses.
- An existing internal supplier diversity policy.
- Public availability of the Bidder's supplier diversity policy.

It also is **desirable** for Bidders to use the SDP Plan Form to describe additional creative initiatives (if any) related to engaging, buying from, and/or collaborating with diverse businesses. Such initiatives may include but not be limited to:

- Serving as a mentor in a mentor-protégé relationship.
- Technical and financial assistance provided to diverse businesses.
- Participation in joint ventures between nondiverse and diverse businesses.
- Voluntary assistance programs by which nondiverse business employees are loaned to diverse businesses or by which diverse business employees are taken into viable business ventures to acquire training and experience in managing business affairs.

Evaluation of SDP Forms. To encourage Bidders to develop substantial supplier diversity initiatives and commitments as measures valuable to the Commonwealth, at least 25% of the total available evaluation points for this bid solicitation shall be allocated to the evaluation of the SDP Plan submissions. Because the purpose of the SDP is to promote business-to-business partnerships, the Bidders' workforce diversity initiatives will not be considered in the evaluation.

Massachusetts Department of Agricultural Resources- MDAR
Request for Quote

SDP Spending Reports and Compliance. After contract award, Contractors shall be required to provide reports demonstrating compliance with the agreed-upon SDP Commitment as directed by the department, which in no case shall be less than annually.

Only spending with SDP Partners that appear in the [SDO Directory of Certified Businesses](#) or in the [U.S. Dept of Veterans Affairs VetBiz Vendor Information Pages](#) directory shall be counted toward a Contractor's compliance with their SDP Commitment. Spending with SDP Partners that do not appear in the directories above shall not be counted toward meeting a Contractor's SDP Commitment.

It is the responsibility of the Contractor to ensure they meet their SDP Commitment, and the SDO and the issuing department assume no responsibility for any Contractor's failure to meet its SDP Commitment.

SDP Spending Verification. The SDO and the contracting department reserve the right to contact SDP Partners at any time to request that they attest to the amounts reported to have been paid to them by the Contractor.

Program Resources and Assistance. Contractors seeking assistance in the development of their SDP Plans or identification of potential SDP Partners may visit the SDP webpage, www.mass.gov/sdp, or contact the SDP Help Desk at sdp@mass.gov.

8. Agricultural Products Preference (only applicable if this is a procurement for Agricultural Products). Chapter 123 of the Acts of 2006 directs the State Purchasing Agent to grant a preference to products of agriculture grown or produced using locally grown products. Such locally grown or produced products shall be purchased unless the price of the goods exceeds the price of products of agriculture from outside the Commonwealth by more than 10%. For purposes of this preference, products of agriculture are defined to include any agricultural, aquacultural, floricultural, or horticultural commodities; the growing and harvesting of forest products; the raising of livestock, including horses; raising of domesticated animals, bees, and/or fur-bearing animals; and any forestry or lumbering operations.

9. Best Value Selection and Negotiation. The Strategic Sourcing Services Team or SSST may select the response(s) which demonstrates the best value overall, including proposed alternatives that will achieve the procurement goals of the department. The SSST and a selected bidder, or a contractor, may negotiate a change in any element of contract performance or cost identified in the original RFQ or the selected bidder's or contractor's response which results in lower costs or a more cost effective or better value than was presented in the selected bidder's or contractor's original response.

10. Bidder Communication. Bidders are prohibited from communicating directly with any employee of the procuring department or any member of the SSST regarding this RFQ except as specified in this RFQ, and no other individual Commonwealth employee or representative is authorized to provide any information or respond to any question or inquiry concerning this RFQ. Bidders may contact the contact person for this RFQ in the event this RFQ is incomplete or the bidder is having trouble obtaining any required attachments electronically through COMMBUYS.

11. Contract Expansion. If additional funds become available during the contract duration period, the department reserves the right to increase the maximum obligation to some or all contracts executed as a result of this RFQ or to execute contracts with contractors not funded in the initial selection process, subject to available funding, satisfactory contract performance and service or commodity need.

12. Costs. Costs which are not specifically identified in the bidder's response and accepted by a department as part of a contract will not be compensated under any contract awarded pursuant to this RFQ. The Commonwealth will not be responsible for any costs or expenses incurred by bidders responding to this RFQ.

Massachusetts Department of Agricultural Resources- MDAR
Request for Quote

13. Electronic Communication/Update of Bidder's/Contractor's Contact Information. It is the responsibility of the prospective bidder and awarded contractor to keep current on COMMBUYS the email address of the bidder's contact person and prospective contract manager, if awarded a contract, and to monitor that email inbox for communications from the SSST, including requests for clarification. The SSST and the Commonwealth assume no responsibility if a prospective bidder's/awarded contractor's designated email address is not current, or if technical problems, including those with the prospective bidder's/awarded contractor's computer, network, or internet service provider (ISP) cause email communications sent to/from the prospective bidder/awarded contractor and the SSST to be lost or rejected by any means including email or spam filtering.

14. Electronic Funds Transfer (EFT). All bidders responding to this RFQ must agree to participate in the Commonwealth Electronic Funds Transfer (EFT) program for receiving payments, unless the bidder is able to provide compelling proof that it would be unduly burdensome. EFT is a benefit to both contractors and the Commonwealth because it ensures fast, safe, and reliable payment directly to contractors and saves both parties the cost of processing checks. Contractors may track and verify payments made electronically through the Comptroller's [Vendor Web system](#). A link to the EFT application may be found on the [OSD Forms](#) page (www.mass.gov/lists/osd-forms). Additional information about EFT is available on the [VendorWeb](#) site (www.mass.gov/osc). Click on MASSfinance.

Successful bidders, upon notification of contract award, will be required to enroll in EFT as a contract requirement by completing and submitting the *Authorization for Electronic Funds Payment Form* to this department for review, approval, and forwarding to the Office of the Comptroller. If the bidder already is enrolled in the program, it may so indicate in its response. Because the *Authorization for Electronic Funds Payment Form* contains banking information, this form, and all information contained on this form, shall not be considered a public record and shall not be subject to public disclosure through a public records request.

The requirement to use EFT may be waived by the SSST on a case-by-case basis if participation in the program would be unduly burdensome on the bidder. If a bidder is claiming that this requirement is a hardship or unduly burdensome, the specific reason must be documented in its response. The SSST will consider such requests on a case-by-case basis and communicate the findings to the bidder.

15. Executive Order 509, Establishing Nutrition Standards for Food Purchased and Served by State Agencies. Food purchased and served by state agencies must be in compliance with Executive Order 509, issued in January 2009. Under this Executive Order, all contracts resulting from procurements posted after July 1, 2009, that involve the purchase and provision of food must comply with nutrition guidelines established by the Department of Public Health (DPH). The nutrition guidelines are available at the Department's website: [Tools and Resources for Implementation of Executive Order 509](#).

16. HIPAA: Business Associate Contractual Obligations. Bidders are notified that any department meeting the definition of a Covered Entity under the Health Insurance Portability and Accountability Act of 1996 (HIPAA) will include in the RFQ and resulting contract sufficient language establishing the successful bidder's contractual obligations, if any, that the department will require in order for the department to comply with HIPAA and the privacy and security regulations promulgated thereunder (45 CFR Parts 160, 162, and 164) (the Privacy and Security Rules). For example, if the department determines that the successful bidder is a business associate performing functions or activities involving protected health information, as such terms are used in the Privacy and Security Rules, then the department will include in the RFQ and resulting contract a sufficient description of business associate's contractual obligations regarding the privacy and security of the protected health information, as listed in 45 CFR 164.314 and 164.504 (e), including, but not limited to, the bidder's obligation to: implement administrative, physical, and technical safeguards that reasonably and appropriately protect the confidentiality, integrity, and availability of the protected health information (in whatever form it is maintained or used, including verbal communications); provide individuals access to their records; and strictly limit use and disclosure of the protected health information for only those purposes approved by the department. Further, the department reserves the right to add any requirement during the course of the contract that it determines it must include in the contract in order for the department to comply with the Privacy and Security Rules. Please see other sections of the RFQ for any further HIPAA details, if applicable.

Massachusetts Department of Agricultural Resources- MDAR
Request for Quote

17. Minimum Quote (Bid Response) Duration. Bidders Quotes made in response to this Bid must remain in effect for at least 90 days from the date of quote submission.

18. Prompt Payment Discounts (PPD). All bidders responding to this procurement must agree to offer discounts through participation in the Commonwealth's Prompt Payment Discount (PPD) initiative for receiving early and/or on-time payments, unless the bidder provides compelling proof that it would be unduly burdensome. PPD benefits both contractors and the Commonwealth. Contractors benefit by increased, usable cash flow as a result of fast and efficient payments for commodities or services rendered. Participation in the Electronic Funds Transfer (EFT) initiative further maximizes the benefits with payments directed to designated accounts, thus eliminating the impact of check clearance policies and traditional mail lead time or delays. The Commonwealth benefits because contractors reduce the cost of products and services through the applied discount. Payments that are processed electronically may be tracked and verified through the Comptroller's Vendor Web system. The PPD form may be found as an attachment for this Bid on [COMMBUYS](#).

Bidders must submit agreeable terms for Prompt Payment Discount using the PPD form within their proposal, unless otherwise specified by the SSST. The SSST will review, negotiate, or reject the offering as deemed in the best interest of the Commonwealth.

The requirement to use PPD offerings may be waived by the SSST on a case-by-case basis if participation in the program would be unduly burdensome on the bidder. If a bidder is claiming that this requirement is a hardship or unduly burdensome, the specific reason must be documented in or attached to the PPD form.

19. Public Records. All responses and information submitted in response to this RFQ are subject to the Massachusetts Public Records Law, M.G.L., c. 66, s. 10, and to c. 4, s. 7, ss. 26. Any statements in submitted responses that are inconsistent with these statutes, including marking by bidders of information as confidential during the quote submission process in COMMBUYS, shall be disregarded.

20. Reasonable Accommodation. Bidders with disabilities or hardships that seek reasonable accommodation, which may include the receipt of RFQ information in an alternative format, must communicate such requests in writing to the contact person. Requests for accommodation will be addressed on a case by case basis. A bidder requesting accommodation must submit a written statement which describes the bidder's disability and the requested accommodation to the contact person for the RFQ. The SSST reserves the right to reject unreasonable requests.

21. Restriction on the Use of the Commonwealth Seal. Bidders and contractors are not allowed to display the Commonwealth of Massachusetts Seal in their bid package or subsequent marketing materials if they are awarded a contract because use of the coat of arms and the Great Seal of the Commonwealth for advertising or commercial purposes is prohibited by law.

22. Subcontracting Policies. Prior approval of the department is required for any subcontracted service of the contract. Contractors are responsible for the satisfactory performance and adequate oversight of its subcontractors. Human and social service subcontractors are also required to meet the same state and federal financial and program reporting requirements and are held to the same reimbursable cost standards as contractors.

23. Acceptable Forms of Signature

Department will instruct contractor on what form of Signature will be required for this procurement. Effective June 15, 2021, for all 1) CTR forms, including the Standard Contract Form, W-9s, Electronic Funds Transfer (EFT) forms, ISAs, and other CTR-issued documents and forms, or 2) documents related to state finance and within the statutory area of authority or control of CTR (i.e. contracts, payrolls, and related supporting documentation), CTR will accept signatures executed by an authorized signatory in any of the following ways: 1. Traditional "wet signature" (ink on paper); 2. Electronic signature that is either: a. Hand drawn using a mouse or finger if working

Massachusetts Department of Agricultural Resources- MDAR
Request for Quote

from a touch screen device; or Page 2 b. An uploaded picture of the signatory's hand drawn signature 3. Electronic signatures affixed using a digital tool such as Adobe Sign or DocuSign. If using an electronic signature, the signature must be visible, include the signatory's name and title, and must be accompanied by a signature date. Please be advised that typed text of a name not generated by a digital tool such as Adobe Sign or DocuSign, even in computer-generated cursive script, or an electronic symbol, are not acceptable forms of electronic signature.

Massachusetts Department of Agricultural Resources- MDAR
Request for Quote

Appendix B: Instructions for Vendors Responding to Bids

Introduction

COMMBUYS refers to all solicitations, including but not limited to Requests for Proposals (RFP), Invitations for Bid (IFB), Requests for Response (RFQ), Requests for Quote (RFQ), as “Bids.” All responses to Bids are referred to as “Quotes.”

Steps for Bidders to Submit a Quote

1. Launch the COMMBUYS website by entering the URL (www.COMMBUYS.com) into the browser.
2. Enter Bidder login credentials and click the **Login** button on the COMMBUYS homepage. Bidders must be registered in COMMBUYS in order to submit a Quote. Each Vendor has a COMMBUYS Seller Administrator, who is responsible for maintaining authorized user access to COMMBUYS.
3. Upon successful login, the Vendor home page displays with the Navigation and Header Bar as well as the Control Center. The Control Center is where documents assigned to your role are easily accessed and viewed.
4. Click on the **Bids** tab
5. Clicking on the Bid tab opens four sections:
 - a. Request for Revision
 - b. Bids/Bid Amendments
 - c. Open Bids
 - d. Closed Bids
6. Click on the blue **Open Bid** hyperlinks to open and review an open bid
7. A new page opens with a message requesting you acknowledge receipt of the bid. Click **Yes** to acknowledge receipt of the bid. Bidders should acknowledge receipt to receive any amendments/updates concerning this bid.
8. After acknowledgement, the bid will open.

The top left half of the page contains the following information:

- a. Purchaser
- b. Department
- c. Contact for this bid
- d. Type of purchase
 - i. Open Market
 - ii. Blanket
- e. Pre-Bid Conference details (if applicable)
- f. Ship-to and Bill-to addresses
- g. Any attachments to the bid, which may include essential bid terms, response forms, etc.

The top right half of the bid includes the following information:

- h. Bid Date
- i. Required Date
- j. Bid Opening Date – date the bid closes and no further quotes will be accepted

Massachusetts Department of Agricultural Resources- MDAR
Request for Quote

- k. Informal Bid Flag
 - l. Date goods/services are required
9. The lower half of the page provides information about the specific goods/services the bid is requesting.
10. Click **Create Quote** to begin.
11. The General tab for a new quote opens. This page is populated with some information from the bid. Fields available to update include:
- a. Delivery days
 - b. Shipping terms
 - c. Ship via terms
 - d. Is “no” bid – select if you will not be submitting a quote for this bid
 - e. Promised Date
 - f. Info Contact
 - g. Comments
 - h. Discount Percent
 - i. Freight Terms
 - j. Payment Terms

It is important to note that the bid documents (RFQ and attachments) may specify some or all of these terms and may prohibit you from altering these terms in your response. Read the bid documents carefully and fill in only those items that are applicable to the bid to which you are responding.

Update these fields as applicable to the bid and click **Save & Continue** to save any changes and create a Quote Number.

The page refreshes and messages display. Any message in Red is an error and must be resolved before the quote can be submitted. Any message in Yellow is only a warning and will allow processing to continue.

The following messages are received:

Terms & Conditions is not acknowledged – to resolve this, click on the Terms & Conditions tab and accept the terms. Your quote has not been submitted – information message; no action required

12. Click on the Terms & Conditions Tab. This tab refers to the terms and conditions that apply to this bid. The terms and conditions must be accepted before your quote can be submitted. If your acceptance is subject to any exceptions, those exceptions must be identified here. Exceptions cannot contradict the requirements of the RFQ, or required Commonwealth standard forms and attachments for the bid. For instance, an RFQ may specify that exceptions may or will result in disqualification of your bid.
13. Click the **Items** tab. The Items tab displays information about the items requested in the bid. To view additional details about an item, click the item number (blue hyperlink) to open.

Massachusetts Department of Agricultural Resources- MDAR
Request for Quote

14. The item opens. Input all of your quote information and click **Save & Exit**.
 15. **CONFIDENTIAL INFORMATION:** If documents uploaded in your quote response contain confidential information (security sensitive, EFT, W9, Commonwealth Terms and Conditions), **you must mark each item as confidential**. The confidential column on the Attachments view allows the user to select whether the attached form is confidential or not. Place a check box under the confidential column for each confidential attached form.
 16. Click on the **Attachments** Tab. Follow the prompts to upload and name all required attachments and forms and bid response documents in accordance with the instructions contained in the solicitation or bid documents. After uploading each individual file or form, click **Save & Continue**. After you have uploaded all required documents click **Save & Exit**. Be sure to review your attachments to make sure each required document has been submitted.
 17. Click the Summary tab. Review the information and update/correct, as needed. If the information is correct, click the **Submit Quote** button at the bottom of the page.
 18. A popup window displays asking for verification that you wish to submit your quote. Click **OK** to submit the quote.
 19. The Summary tab redisplay with an updated Status for the quote of **Submitted**.
 20. Your quote submission is confirmed only when you receive a confirmation email from COMMBUYS. If you have submitted a quote and have not received an email confirmation, please contact the COMMBUYS Help Desk at COMMBUYS@state.ma.us.
- If you wish to revise or delete a quote after submission, you may do so in COMMBUYS: (1) for a formal bid, prior to the bid opening date, or (2) for an informal bid (which may be viewed upon receipt), prior to the opening of your quote by the issuing entity or the bid opening date, whichever is earlier.

Bidders may not submit Multiple Quotes in response to a Bid unless the Bid authorizes Multiple Quote submissions. If you submit multiple quotes in response to a bid that does not allow multiple quotes, only the latest submission prior to the bid opening date will be evaluated.

**Proposed Administrative Consent Agreement
Background Summary**

Subject: Avesta Housing
307 Cumberland Ave.
Portland, Maine 04101

Date of Incident(s): November 1, 2021

Background Narrative: A resident of the Solterra Housing Complex located at 58 Boyd St. in Portland contacted the BPC regarding an unauthorized pesticide application made in their apartment on November 1, 2021. The housing complex is managed by Avesta Housing. The resident was notified on October 27, 2021, that their apartment, the adjacent trash room and other common areas in the building were to be treated for cockroaches and fruit flies by Ehrlich Pest Control. On October 29, 2021 the resident requested that the treatment to their apartment be postponed because they could not have the unit prepared for an application. Representatives at Avesta Housing acknowledged the resident's request and informed them that the treatment would be postponed. Avesta Housing failed to contact Ehrlich Pest Control in a timely manner to postpone the scheduled application. On November 1, 2021, an Ehrlich applicator applied Shockwave 1 Insecticide inside the resident's apartment while they were not home.

Summary of Violations: CMR 01-026 Chapter 26 Section 6: Tenant's Consent: Except in cases where a public health or code enforcement official with jurisdiction has determined a need for immediate pest management, application to a tenant's residential unit is prohibited if the tenant is opposed to such treatment. A pesticide application may not be made until such time as alternative control measures have been tried and documented as to their failure to control a pest problem, which poses health risks, threatens significant property damage or threatens to infest other parts of the building.

Rationale for Settlement: Avesta Housing was negligent in honoring the tenant's opposition to the scheduled pesticide application in their apartment by failing to appropriately postpone the application as requested by the tenant.

Attachments: Proposed Consent Agreement

DEC 27 2022

CK Amt \$750 -
Date: 12-15-22
CK# 7770

STATE OF MAINE
DEPARTMENT OF AGRICULTURE, CONSERVATION, AND FORESTRY
BOARD OF PESTICIDES CONTROL

In the Matter of:)
Avesta Housing) ADMINISTRATIVE CONSENT AGREEMENT
307 Cumberland Ave.) AND
Portland, Maine 04101) FINDINGS OF FACT

This Agreement, by and between Avesta Housing (hereinafter called the Company) and the State of Maine Board of Pesticides Control (hereinafter called the "Board"), is entered into pursuant to 22 M.R.S.A. §1471-M (2)(D) and in accordance with the Enforcement Protocol amended by the Board on December 13, 2013.

The parties to this Agreement agree as follows:

1. That the Company develops and manages rental housing in Maine and New Hampshire, including Portland, Maine.
2. That among the properties managed by the Company is the Solterra Housing Complex, (herein after referred to as "the Complex"), 58 Boyd St., Portland, Maine.
3. That on October 27, 2021, the tenant at Unit #110 of the Complex, received notice from Avesta Housing in a letter dated October 25, 2021, that their unit would be treated for fruit flies by Ehrlich Pest Control on November 1, 2021. This notification letter included preparation requirements for the unit to be completed prior to the application.
4. That, in addition, sometime prior to November 1, 2021, the tenant notified the Company that Unit #110 had cockroaches and requested extermination services for cockroaches as well.
5. That on October 29, 2021, the tenant emailed Avesta Housing requesting postponement of the application due to extensive preparation requirements, and the tenant's inability to complete all of the preparations prior to the scheduled service date.
6. That, due to administrative errors, the request for postponement was not transmitted to Ehrlich Pest Control until the afternoon of the planned application on November 1, 2021.
7. That by the time Ehrlich Pest Control received the request for postponement, the November 1 application to Unit #110 had already been made.
8. That on November 22, 2021, the Board received a phone call from a tenant at the complex. The tenant reported that an incorrect pesticide application was made at their apartment, Unit # 110, possibly exposing them and their four children to pesticides on November 1, 2021.
9. That on November 23, 2021, a Board inspector met with the tenant and representatives of Ehrlich Pest Control. The Inspector determined and documented that on November 1, an Ehrlich employee applied Shockwave 1, EPA Registration Number 1021-2804, to Unit #110 for control of German roaches and Phantom Aerosol, EPA Registration Number 7969-285 to the trash room to control fruit flies and German roaches.

10. That CMR 01-026 Chapter 26, Section 6 prohibits the application of pesticides to a tenant's residential unit if the tenant is opposed to such treatment.
11. That Avesta Housing's tardiness in directing Ehrlich to postpone the pesticide application at the Complex resulted in an unauthorized pesticide application to residential Unit # 110.
12. That the circumstances described in paragraphs one through eleven constitute a violation of CMR 01-026 Chapter 26, Section 6.
13. That the Board has regulatory authority over the activities described herein.
14. That the Company expressly waives:
 - a. Notice of or opportunity for hearing;
 - b. Any and all further procedural steps before the Board; and
 - c. The making of any further findings of fact before the Board.
15. That this Agreement shall not become effective unless and until the Board accepts it.
16. That, in consideration for the release by the Board of the causes of action which the Board has against the Company resulting from the violation referred to in paragraph thirteen, the Company agrees to pay to the State of Maine a penalty in the amount of \$750. All payments must be by check, made payable to the Treasurer, State of Maine.

IN WITNESS WHEREOF, the parties have executed this Agreement of three pages.

AVESTA HOUSING,

By:  Date: 12/21/22

Type or Print Name: Amanda Gilliam, Director of Property Management

BOARD OF PESTICIDES CONTROL

By: _____ Date: _____

Megan Patterson, Director

APPROVED

By: _____ Date: _____

Mark Randlett, Assistant Attorney General

**Proposed Administrative Consent Agreement
Background Summary**

Subject: Green Thumb Lawn Services
64 Stevens Road
Brewer, ME 04412

Date of Incident(s): June 19, 2020

Background Narrative: The owner of Green Thumb Lawn Services self-reported a misapplication of pesticides to the incorrect property by one of their licensed applicators. On June 19, 2020, licensed applicator, Justin Thomas, made an application of Bisect L Insecticide to a portion of the property at 3 Waldron Way in Bar Harbor. The owners of 3 Waldron Way were not customers of Green Thumb Lawn Services. The intended property was 2 Glen Mary Road, Bar Harbor. The company did have a positive property identification system in place including GPS coordinates and detailed property description. The applicator failed to use the property identification system prior to commencing the application.

Summary of Violations: CMR 01-026 Chapter 20 Section 6(D)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.

Rationale for Settlement: Green Thumb lawn Services did not have the property owners' authorization to apply a pesticide to their property. The applicator failed to positively identify the application location.

Attachments: Proposed Consent Agreement

DEC 10 2022

Ck# 14957
Date - 12/12/22
Amt - \$1000.00

STATE OF MAINE
DEPARTMENT OF AGRICULTURE, CONSERVATION AND FORESTRY
BOARD OF PESTICIDES CONTROL

In the Matter of: ADMINISTRATIVE CONSENT
Green Thumb Lawn Services) AGREEMENT
64 Stevens Road) AND
Brewer, Maine 04412) FINDINGS OF FACT

This Agreement by and between Green Thumb Lawn Services (hereinafter called the "Company") and the State of Maine Board of Pesticides Control (hereinafter called the "Board") is entered into pursuant to 22 M.R.S. §1471-M (2)(D) and in accordance with the Enforcement Protocol amended by the Board on December 13, 2013.

The parties to this Agreement agree as follows:

- 1) That the Company provides commercial pest control services and has the firm license number SCF 956 issued by the Board pursuant to 22 M.R.S. § 1471-D (1)(B).
- 2) That the Company operations manager/owner Jeremy LeGasse, called the Board's office to report one of the Company's licensed applicators made a pesticide application to the wrong property in Bar Harbor on June 19, 2020.
- 3) That in response to the call described in paragraph two, a Board inspector met with Company licensed applicator, Daniel Love, and the Company owner on June 26, 2020, to conduct a follow up inspection. During the course of the inspection, the following facts and documents were ascertained:
 - a) Written statements about the misapplication were obtained from Love and LeGasse.
 - b) A written statement from applicator Justin Thomas was obtained.
 - c) A copy of the Company work order Thomas was given to make the pesticide application was obtained. The work order included the GPS decimal coordinates for the house and the correct customer's name, street name, and house number. The color of the house was listed as beige.
 - d) It was the first time that Company was to spray Daugherty's property.
 - e) Thomas began spraying what he assumed was Daugherty's property until he came to the front door and noticed that the front door faces Waldron Way. This observation provided evidence that the location might have been incorrect.
 - f) Thomas stopped spraying, knocked on the door and got the owner's information from a painter working inside the home.
 - g) The intended property was Denise Daugherty's residence at 2 Glen Mary Road, across the street. Thomas had mistakenly begun spraying at Kristin Murphy's residence on 3 Waldron Road.
 - h) Both properties were on corner lots of a four-way intersection facing each other and there was a 3 on the front of the house where Thomas was spraying.
 - i) The inspector documented the details associated with Thomas' application. Bisect L insecticide was mistakenly applied to a portion of Kristin Murphy's residence on June 19, 2020.

- 4) That CMR 01-026 Chapter 20 Section 6(D)2 requires prior consent from the property owner before another person can apply pesticides to the property.
- 5) That the Company did not have the homeowner's authorization to make a pesticide application at 3 Waldron Road in Bar Harbor.
- 6) That from the inspection described in paragraph three, it was determined that Thomas' June 19, 2020 application was on the wrong street, the house number was incorrect, and the house color was white instead of beige listed on the work order.
- 7) That the circumstances described in paragraphs one through seven constitute a violation of CMR 01-026 Chapter 20 Section 6(D)2
- 8) That the Company expressly waives:
 - A. Notice of or opportunity for hearing;
 - B. Any and all further procedural steps before the Board; and
 - C. The making of any further findings of fact before the Board.
- 9) That this Agreement shall not become effective unless and until the Board accepts it.

That in consideration for the release by the Board of the cause of action which the Board has against the Company resulting from the violation referred to in paragraph eight, the Company agrees to pay a penalty to the State of Maine in the sum of \$1,000.00. (Please make checks payable to Treasurer, State of Maine).

IN WITNESS WHEREOF, the parties have executed this Agreement of two pages.

GREEN THUMB LAWN SERVICES

By:  Date: 12/17/2022

Type or Print Name: Jeremy Legasse

BOARD OF PESTICIDES CONTROL

By: _____ Date: _____

Megan Patterson, Director

APPROVED:

By: _____ Date: _____

Mark Randlett, Assistant Attorney General

From: [jody_spear](#)
To: Patterson, Megan L (AGR); adi shamir
Subject: signs disclosing pesticides
Date: Wednesday, December 28, 2022 3:15:12 PM

EXTERNAL: This email originated from outside of the State of Maine Mail System. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Here's my message to the board (albeit lacking a reply to my last message to you):

You'll be well familiar with the alarming statistics about insect extinctions in the story below. The collapse is driven, it reports, by chemicals used in agriculture, but the many thousands of biocides sprayed on lawns and parklands are obviously responsible too.

In the past I've seen warning signs posted outside by exterminators specifying what has been applied. You tell me that identification of chemicals is [now] required inside, not outside, school buildings.

And why is that? To make everyone aware of hazards to susceptible young people and keep them out of harm's way.

In light of the catastrophic decline of beneficial insects, as well as potential damage to humans of all ages, in all settings -- not only K-12 schools -- the use of lawn-care pesticides, especially for cosmetic purposes, should actually be *illegal*. Short of that, I request that identification of them be mandated on signs.

Jody Spear, Harborside

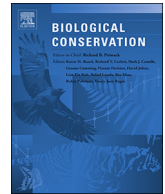
<https://www.theguardian.com/environment/2019/feb/10/plummeting-insect-numbers-threaten-collapse-of-nature>



ELSEVIER

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Review

Worldwide decline of the entomofauna: A review of its drivers

Francisco Sánchez-Bayo^{a,*}, Kris A.G. Wyckhuys^{b,c,d}^a School of Life & Environmental Sciences, Sydney Institute of Agriculture, The University of Sydney, Eveleigh, NSW 2015, Australia^b School of Biological Sciences, University of Queensland, Brisbane, Australia^c Chrysalis, Hanoi, Viet Nam^d Institute of Plant Protection, China Academy of Agricultural Sciences, Beijing, China

ARTICLE INFO

Keywords:

Extinction
Pollinators
Aquatic insects
Agriculture
Pesticides
Ecosystem services
Global change ecology

ABSTRACT

Biodiversity of insects is threatened worldwide. Here, we present a comprehensive review of 73 historical reports of insect declines from across the globe, and systematically assess the underlying drivers. Our work reveals dramatic rates of decline that may lead to the extinction of 40% of the world's insect species over the next few decades. In terrestrial ecosystems, Lepidoptera, Hymenoptera and dung beetles (Coleoptera) appear to be the taxa most affected, whereas four major aquatic taxa (Odonata, Plecoptera, Trichoptera and Ephemeroptera) have already lost a considerable proportion of species. Affected insect groups not only include specialists that occupy particular ecological niches, but also many common and generalist species. Concurrently, the abundance of a small number of species is increasing; these are all adaptable, generalist species that are occupying the vacant niches left by the ones declining. Among aquatic insects, habitat and dietary generalists, and pollutant-tolerant species are replacing the large biodiversity losses experienced in waters within agricultural and urban settings. The main drivers of species declines appear to be in order of importance: i) habitat loss and conversion to intensive agriculture and urbanisation; ii) pollution, mainly that by synthetic pesticides and fertilisers; iii) biological factors, including pathogens and introduced species; and iv) climate change. The latter factor is particularly important in tropical regions, but only affects a minority of species in colder climates and mountain settings of temperate zones. A rethinking of current agricultural practices, in particular a serious reduction in pesticide usage and its substitution with more sustainable, ecologically-based practices, is urgently needed to slow or reverse current trends, allow the recovery of declining insect populations and safeguard the vital ecosystem services they provide. In addition, effective remediation technologies should be applied to clean polluted waters in both agricultural and urban environments.

1. Introduction

For years, biologists and ecologists have been concerned about the worldwide reduction in biodiversity undergone by many terrestrial and aquatic vertebrates (Ceballos and Ehrlich, 2002; Pimm and Raven, 2000; Wilson, 2002), yet scientists have only recently voiced similar concerns about invertebrate taxa, particularly insects. Population declines imply not only less abundance but also a more restricted geographical distribution of species, and represent the first step towards extinction (Diamond, 1989). Much of the blame for biodiversity loss falls on human activities such as hunting and habitat loss through deforestation, agricultural expansion and intensification, industrialisation and urbanisation (Ceballos et al., 2017; Maxwell et al., 2016), which jointly claimed a 30–50% encroachment on natural ecosystems at the end of the 20th century (Vitousek et al., 1997).

There is compelling evidence that agricultural intensification is the main driver of population declines in unrelated taxa such as birds, insectivorous mammals and insects. In rural landscapes across the globe, the steady removal of natural habitat elements (e.g. hedgerows), elimination of natural drainage systems and other landscape features together with the recurrent use of chemical fertilisers and pesticides negatively affect overall biodiversity (Fuller et al., 1995; Newton, 2004; Tilman et al., 2001). Recent analyses point to the extensive usage of pesticides as primary factor responsible for the decline of birds in grasslands (Mineau and Whiteside, 2013) and aquatic organisms in streams (Beketov et al., 2013), with other factors contributing to or amplifying their effects to varying extent. Yet, we don't know whether the same factors explain the parallel entomological demise that we are witnessing.

In 2017, a 27-year long population monitoring study revealed a

* Corresponding author.

E-mail addresses: francisco.sanchez-bayo@sydney.edu.au, sanchezbayo@mac.com (F. Sánchez-Bayo).

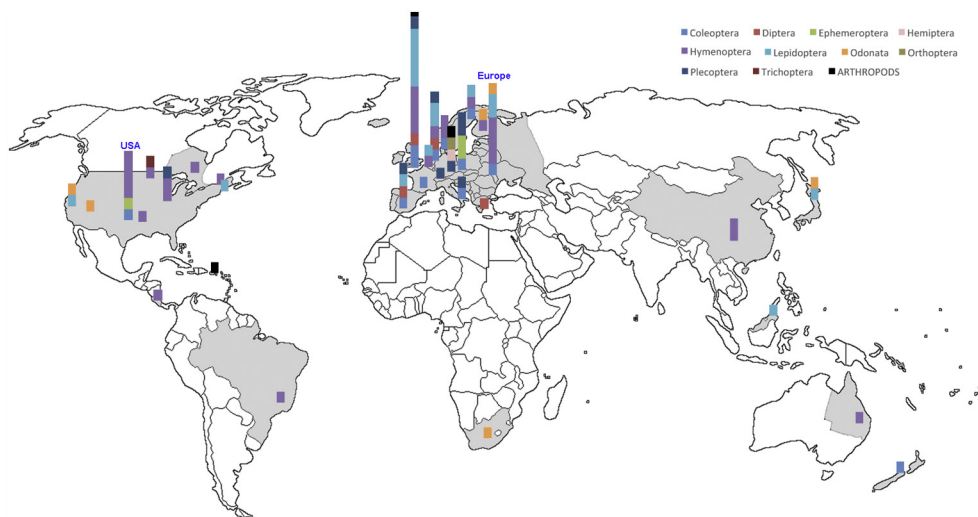


Fig. 1. Geographic location of the 73 reports studied on the world map. Columns show the relative proportion of surveys for each taxa as indicated by different colours in the legend. Data for China and Queensland (Australia) refer to managed honey bees only. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

shocking 76% decline in flying insect biomass at several of Germany's protected areas (Hallmann et al., 2017). This represents an average 2.8% loss in insect biomass per year in habitats subject to rather low levels of human disturbance, which could either be undetectable or regarded statistically non-significant if measurements were carried out over shorter time frames. Worryingly, the study shows a steady declining trend over nearly three decades. A more recent study in rainforests of Puerto Rico has reported biomass losses between 98% and 78% for ground-foraging and canopy-dwelling arthropods over a 36-year period, with respective annual losses between 2.7% and 2.2% (Lister and Garcia, 2018). The latter authors showed parallel declines in birds, frogs and lizards at the same areas as a result of invertebrate food shortages. Both studies agree with the declining trend in flying insects (mainly Diptera) observed a decade earlier in parts of Southern Britain (Shortall et al., 2009). As insects comprise about two thirds of all terrestrial species on Earth, the above trends confirm that the sixth major extinction event is profoundly impacting life forms on our planet (Thomas et al., 2004).

While the arthropod declines in tropical rainforests correlate well with climatic changes, the 12 different factors (e.g. increases in arable land, deforestation, global warming) that were thought to be responsible for year-to-year drops in insect biomass in Germany barely accounted for ~20% of observed declines. Rather surprisingly, 80% of observed inter-annual variability in insect numbers was left unexplained (Hallmann et al., 2017). Although the authors did not assess the effect of synthetic pesticides, they did point to them as a likely driver of the pervasive losses in insect biomass.

The above studies, however, are in line with previous reports on population declines among numerous insect taxa (i.e. butterflies, ground beetles, ladybirds, dragonflies, stoneflies and wild bees) in Europe and North America over the past decades. It appears that insect declines are substantially greater than those observed in birds or plants over the same time periods (Thomas et al., 2004), and this could trigger wide-ranging cascading effects within several of the world's ecosystems.

This review summarises our current state of knowledge about insect declines, i.e., the changes in species richness (biodiversity) and population abundance through time, and points to the likely drivers of the losses so that conservation strategies to mitigate or even reverse them may be implemented. Previous reviews are partial in scope, restricted to individual groups of insects (e.g. butterflies, carabids) in specific regions, but no study has put together a comprehensive review of all insect taxa nor compared the local findings among different parts of the world.

2. Methodology

We aimed at compiling all long-term insect surveys conducted over the past 40 years that are available through global peer-reviewed literature databases. To that effect we performed a search on the online Web of Science database using the keywords [insect*] AND [declin*] AND [survey], which resulted in a total of 653 publications. The majority of these referred to Hymenoptera (55), Diptera (45), Coleoptera (44) and Lepidoptera (37) taxa, among which only a few dealt with long-term surveys. Reports that focused on individual species, pest outbreaks or invasive species were excluded. We selected surveys that considered all species in a taxon (e.g. family or order) within large areas (i.e. a region, a country) or smaller areas surveyed intensively over periods longer than 10 years. Additional papers were obtained from the literature references. Finally, only surveys that reported changes in quantitative data over time, either species richness or abundance, were considered. Thus, this review covers 73 reports on entomofauna declines in various parts of the world (Fig. 1) and examines their likely causes (Table S1). Because the overwhelming majority of long-term surveys have been conducted in developed countries, particularly in the northern hemisphere, this review is geographically biased and does not adequately cover trends in tropical regions, where information on insect biodiversity is either incomplete or lacking (Collen et al., 2008).

The above literature records use accurate scientific data on species distribution from museum specimens (56%), which are compared with long-term survey data obtained decades later (72%), and sometimes rely upon citizen science data (8%). Because the latter data tend to overestimate the diversity of insects due to over-reporting of rare species (Gardiner et al., 2012), the overall assessment of biodiversity can be considered conservative.

Conservation status of individual species follows the IUCN classification criteria (IUCN 2009): threatened species include vulnerable (> 30% decline), endangered (> 50%) and critically endangered (> 75% decline) species. Data on population abundance are more difficult to obtain than geographical distribution records, but a few reports quantified the extent of such declines for Lepidoptera, Hymenoptera and dung beetles (Coleoptera). An annual rate of decline (percentage of species declining per year) was estimated for each taxon and region.

A meta-analysis of the declines among the various taxa and regions was performed, with groups compared using analysis of variance (ANOVA). Enumerated drivers of the declines -as indicated by the reports' authors- are tabulated and analysed, and further discussed with reference to experimental and other empirical data available in the literature.

3. Taxa declines

3.1. Lepidoptera

Butterflies and moths are valuable indicators of environmental quality, considering their high degree of host-plant specialisation and vulnerability to habitat deterioration (Erhardt and Thomas, 1991). Given their presence in a broad range of habitats, the loss of Lepidoptera may directly impact the delivery of key ecosystem services such as pollination and natural pest control (Fox, 2013). Moths, which are about 10 times more diverse than butterflies, constitute important prey items of bats and help sustain population levels of myriad other insectivorous animals (Hahn et al., 2015; Vaughan, 2008; Wilson et al., 1999).

Maes and van Dyck (2001) were the first to report drastic changes in butterfly biodiversity in Flanders (Belgium) during the 20th century, including the extinction of 19 (out of 64) native species since 1834. Habitat loss resulted in a steady decline of 69% of the 45 extant species, while the extinction rate increased from 0.2 to 1.7 species/5-year since 1950 as urbanisation and agricultural intensification expanded eight-fold (Maes and Van Dyck, 2001). A follow-up study in the Netherlands found that 11 of the 20 most common and widespread butterfly species declined both in distribution and abundance between 1992 and 2007, whereas populations of species associated with natural habitats in nature reserves remained stable. Local populations of *Lasiommata megera* and *Gonepteryx rhamni* are now endangered and two other species (*Aglais io* and *Thymelicus lineola*) are vulnerable (van Dyck et al., 2009). In parallel, the range of distribution of 733 species of day-flying moths was recorded between 1980 and 2000: overall declines were observed in 85% of species, 38% of them experiencing > 75% reduction in their area (i.e. critically endangered), 34% being considered threatened and 15% vulnerable (Groenendijk and van der Meulen, 2004). In particular, 47 of the 55 species monitored in peat-bog marshes declined, six remained stable and only two (*Plusia putnami* and *Deltote bankiana*) increased in range (Groenendijk and Ellis, 2011). The most affected species are those with lower dispersal abilities and preference for oligotrophic habitats.

Among the 269 species of macro-lepidopterans monitored for 50 years at the Kullaberg Nature Reserve (Sweden), 45% were declining, 22 were coloniser species and 159 were no longer found in 2004 (Franzén and Johannesson, 2007). Monophagous and oligophagous species using grass or herbs in wetlands were declining more than those feeding on deciduous trees or shrubs, confirming that dietary specialists bear the brunt of the declines. Species with a short flight-period or those restricted to non-forest habitats were all associated with a high extinction risk. A comparison of historical records of 74 butterflies in Finland showed how 60% of grassland species declined over the past 50 years, whereas 86% of generalist species and 56% of those living at forest edge ecotones increased in abundance (Kuussaari et al., 2007). Common traits of the 23 declining species are a reduced mobility, oligotrophic habitat preference and seasonal migration behaviour. Another study on the populations of 306 species of noctuid moths in Finland over 1988–1997 reported the greatest declines for species with comparatively small geographic range, whereas polyphagous moths with longer flight periods and those that overwintered as adults had the widest distributions (Mattila et al., 2006). By contrast, species that overwintered as either larval or pupal stages suffered the largest declines over that period.

Similar findings were reported for north-eastern Spain, where yearly monitoring of 183 butterfly species over 1994–2014 permitted an in-depth analysis of population trends and associated factors for 66 species. While 15 species had increased in abundance, five remain stable and 46 are declining (Melero et al., 2016). Although the extent of species decline did not differ among seven habitat types selected, forest butterflies appeared to be declining faster than those from other habitats due mainly to specialisation of the larval trophic stage and multi-

voltinism.

A comprehensive report on the status of 576 species of butterflies in Europe found that 71 were threatened and declined over a 25-year period (van Swaay et al., 2006). The largest declines occurred among specialist butterflies of grassland biotopes (19% species), wetlands and bogs (15%) and woodlands/forests (14%), due to habitat conversion into crops and the adoption of intensive agricultural practices, e.g. fertilisers and pesticides negatively affected 80% species. Some species (*Lopinga achine* and *Parnassius apollo*) had declined due to afforestation, i.e. conversion of open woodland habitats to dense forests. Climate change only affected a few endemic species adapted to mountainous biotopes. A more recent assessment of 435 butterflies native to Europe (van Swaay et al., 2010) found that populations of 19% of species are declining, particularly in Mediterranean and eastern countries, 8.5% species are threatened, and three are critically-endangered, i.e. *Pieris brassicae wollastoni*, *Triphysa phryne* and *Pseudochazara cingovskii*. Belgium and the Netherlands are the European countries with the highest losses of butterfly biodiversity (19 and 17 country-level extinctions, respectively), whereas Denmark and the U.K. have the least (4 species extinct each) (Maes and Van Dyck, 2001). One species (*Aricia hycinthus*) is considered extinct over the European continent.

Butterflies appear to be declining faster in the United Kingdom, as 74% of 46 non-migratory butterflies restricted their distribution over 1970–1999 (Warren et al., 2001). Using a comprehensive database compiled by amateur collectors and scientists over a 29-year period in the entire British Isles, the authors showed that habitat specialists experienced the largest reductions in distributional area. Specialist and sedentary species not showing changes in abundance over 25 years had reduced their distribution on average by 15%. Other studies indicate that 41 out of 54 common butterflies had been declining since the 1970s, with 26% of species showing decreases over 40% of their range (Fox et al., 2006), while 13% of 10-km squares in the monitoring grid reported disappearance of butterfly species (Thomas et al., 2004). Although authors did not attempt to correlate the declines with specific drivers, the following combination of factors was suggested: habitat fragmentation and/or destruction, intensification of agriculture, including the increased usage of chemical fertiliser and pesticides, and perhaps over-collecting – although such practice has been greatly reduced by more environmental awareness. To minimise biodiversity losses among butterflies and moths, the UK Butterfly Monitoring Scheme (UKBMS) was created, which compiles data on the abundance and distribution of all species across the country since 1976. An initial analysis of 50 species showed a large fluctuation in butterflies among years, with specialist species having declined by 34% nationally since the scheme was established; generalist species had declined in England (12%) but little (6%) or not at all in Scotland. Major declines occurred in forests and farmland regardless of the efforts to restore biodiversity from 2000 onwards (Brereton et al., 2011). A further analysis of 17 widespread and resident species of butterflies between 1984 and 2012 showed that abundance of all species decreased by 58% since the year 2000, while 15 species exhibited population declines at average annual rates between –0.8% and –6.7% (Gilburn et al., 2015). Thus, 41% of the species studied are threatened. Increasing summer temperatures had a marked positive effect on butterfly abundance, whereas none of the other climatic factors could explain the decrease in their populations. By contrast, the steepest declines occurred in areas with high proportions of farmland treated with neonicotinoid insecticides; indices for the 15 declining species showed negative associations with neonicotinoid usage.

Similar rates of decline were reported among 337 moth species throughout England between 1968 and 2003: 222 showed declining populations over the 35-year study period, with a median 10-yr population decrease of 12%, although decreases were larger in the south of the country (17%) compared to the north (5%) (Conrad et al., 2006). The larger declining trends in the south were associated with the degree of agricultural intensification, as also recorded at Rothamstead between

the 1940s and 1960s (Woiwod & Gould, 2008 cited in Fox, 2013). At that time, 71 species of moths were considered threatened, 58 were vulnerable and 13 endangered. Subsequent surveys of about 900 species of moths by experts and amateurs over 25 years corroborated the previous findings, with decreases in range size for moths mirroring those of butterflies (Fox et al., 2011). Notable declines were recorded for *Macaria wauaria* (77% decrease) *Graphiphora augur* and *Dasypolia templi* (> 45% each), which are now included in the country's Red List, while decreases of *M. wauaria* and *Eulithis mellinata* were likely due to insecticide use on their host plants (i.e., currants). A northward shift of 12 common moth species showed that these insects were moving at 7.8 km/year since 1985. Species such as *Katha depressa*, *Idaea rusticata* and *Collita griseola* have each doubled their distribution and spread northwards by approximately 100 km. Some moths extended their range as a result of the widespread cultivation of their host plants in gardens or commercial conifer plantations.

For the United States, long-term monitoring data of butterflies are limited. Surveys in prairie habitats and bogs of Wisconsin and Iowa over 2002–2013 indicate fluctuating populations of certain species, but lack of consistency prevents drawing temporal trends. Main drivers appear to be habitat modification and moisture levels dependent on climate change (Swengel et al., 2011; Swengel and Swengel, 2015). In Massachusetts, the distributional ranges of 116 species shifted northwards between 1992 and 2010. Two southern species adapted to warmer conditions expanded in range (*Papilio cresphontes* and *Poanes zabulon*), while populations of 80% of butterflies declined in southern parts of that State; the only trait that correlated significantly with the declines was the overwintering stage of each species (Breed et al., 2012). In California, surveys on presence/absence of 67 butterfly species at four sites between 1972 and 2012 revealed that the average number of species at any site (30) remained stable until 1997, but dropped steeply to 23 in the last year of the study. The overall trend implies that 23% of species are disappearing. Data on species richness were correlated to annual variables such as summer temperatures, percentage of land converted to agriculture and usage rates of different insecticide classes. Only the latter two variables showed a significant correlation with the observed declines, and within the pesticides only neonicotinoid usage showed a positive correlation; incidentally, the start of the declining trend in 1997 followed the introduction of these systemic insecticides in that State in 1995 (Forister et al., 2016).

Although survey records are limited, Lepidoptera declines appear to be less dramatic in certain parts of the Asian region. In Japan, 15% of the 240 species of butterflies are threatened, but among those 80% of the grassland species are endangered, with two species close to extinction in the national territory: *Melitaea scotosia* (98% decline) and *Argynnis nerippe* (95% decline) (Nakamura, 2011). At the individual island level, seven species are now extinct. Species of the woodlands (40) are the most stable, while the steady intensification of Japan's traditional "satoyama" landscape (i.e., a mosaic of rice paddy fields, grassland and coppice forests) has negatively affected most species. Collecting of specimens was also as a minor driver after 1990. In Malaysia, some 19% of moths at Mount Kinabalu (Borneo) had their abundance reduced between 1965 and 2007 (Chen et al., 2011). Species typical of high altitudes (28) have shrunk their range as they shifted some 300 m uphill, whereas a third of the moths expanded their upper boundary upward by 152 m and retreated their lower boundary by 77 m as a result of global warming during the 40-year period.

3.2. Hymenoptera

Bees are essential pollinators of flowering plants, accounting for a third of all pollinators (Ollerton et al., 2011) and honey bees have been managed for millennia as a source of honey and beeswax. Knowledge about their population status, therefore, is important for the ecosystem services they provide as well as their economic value (Gallai et al., 2009). However, the status of most other hymenopterans – i.e., ants,

wasps and parasitoids; several of which provide equally important ecosystem services – remains practically unknown to this date.

3.2.1. Bumblebees (*Bombus* spp., *Apidae*)

The first report on the status of 18 bumblebees in Britain, using a numerical approach on a national map grid, showed declining trends for seven species since the 1960s, with large reductions in the range of four species (i.e., *Bombus humilis*, *B. ruderatus*, *B. subterraneus* and *B. sylvarum*) in the southern and central parts of England (Williams, 1982). An analysis of the causal factors responsible for such declines, using foraging data on eight native bumblebees and information on their distribution, found that the species subject to the greatest reduction in distribution were host-plant specialists. Thus, bumblebees that forage on grasslands and farmland flowers underwent the largest reductions. Particularly, three species of long-tongued bumblebees (*B. humilis*, *B. ruderatus* and *B. subterraneus*) that forage on clover and other legumes, traditionally used in rotations as a source of nitrogen, had their populations curtailed after the foraging plants were steadily replaced by chemical fertilisers in southern England (Goulson et al., 2005). By contrast, short-tongued bumblebees remain common in gardens and urban areas where they have access to a large array of native and introduced flowers.

In Denmark, long-tongued bumblebee species have declined in richness and abundance since the 1930s, particularly during the red-clover flowering season, while short-tongued species were unaffected. Five out of the original 12 species present eight decades earlier were absent, all long-tongued species, and the once common *B. distinguendus* is now endangered. Only *B. pascuorum* seemed to be increasing in abundance, possibly by occupying some of the niches left vacant by declining species (Dupont et al., 2011). A larger study of 60 species and subspecies of bumblebees in central Europe found that 48 have declined in abundance over the past 136 years, with 30% of them being considered threatened and four having become extinct (Kosior et al., 2007). Most of the country extinctions occurred in the second half of the 20th century, coinciding with the expansion of agricultural intensification brought about by the Green Revolution. The abundance of pollinators in Swedish red clover fields also declined dramatically since 1940, with only two rare species remaining stable while two short-tongued generalist species now dominate the landscape: *B. terrestris* and *B. lapidarius* (Bommarco et al., 2012). Such a dramatic change in relative abundance has negatively affected the yields of that crop, which depends entirely on pollination services of long-tongued species. As in Denmark, *B. distinguendus* has completely disappeared from the southern part of Sweden. Large-scale conversion of landscapes to intensive agriculture together with unrelenting pesticide use are blamed for the changes in bumblebee biodiversity observed over the past 75 years (Bommarco et al., 2013). Major declining trends were identified among 46% of all *Bombus* species in Europe, of which 24% are threatened and one (*B. callumanns*) shows > 80% decline due mainly to habitat fragmentation and the replacement of clover with chemical fertilisers in agricultural areas (Rasmont 2005 cited by Nieto et al., 2014).

Several large studies have been conducted in North America to assess the status of bumblebee populations and their temporal and spatial changes in that continent since the middle of the 19th century. Half of the 14 species of bumblebees surveyed in southern Ontario (Canada) between 1971 and 2006 were declining, three were increasing (*B. bimaculatus*, *B. impatiens* and *B. rufocinctus*) while another three could not be found in that period: *B. affinis*, *B. pensylvanicus* and *B. terricola* (Colla and Packer, 2008). Higher tolerance to pesticides could explain the expansion of the three most abundant species at the expense of the more sensitive species, which had practically disappeared from the region. The Xerces Society reported losses of bumblebees in northern California and southern Oregon in 2005 and blamed the pathogen microsporidian *Nosema bombi* for most of the declines (Thorp and Shepherd, 2005). Using museum records from the Illinois Natural History Survey for the period 1900 to 2007, the distributional range of 16

species of bumblebees were analysed. Half of them have declined in numbers, whereas four species have become extinct in midwestern regions: *B. borealis*, *B. ternarius*, *B. terricola* and *B. variabilis*. The main reductions occurred during 1940–1960, coinciding with the expansion of intensive agriculture and increases in pesticide use (Grixti et al., 2009). At a national scale, changes in the distribution of eight bumblebee species could be determined by comparing historical records with intensive surveys across 382 locations in the USA. Half of the species declined in abundance by as much as 96% of their initial populations only in the last 30 years, and their geographical range was reduced between 23 and 87%. Declines were blamed on reduced floral and nesting resources, but declining populations also had greater infection rates by *N. bombi* and lower genetic diversity than the non-declining bee populations; some of the sharpest declines were recorded in regions dominated by intensive agriculture (Cameron et al., 2011). In Oklahoma, only five of the 10 species of bumblebees that were present in 1949 were found in 2013 after extensive surveys in 21 counties. Contrasting with other States, *B. pensylvanicus* was the most common species, whereas *B. variabilis* is presumed extinct (Figuerola and Bergey, 2015). In the latest study to date, historical records of 16 species of bumblebees in the eastern USA (New Hampshire) over 1866–2015 were analysed. Nine species have been declining, including five that are presently threatened: *B. ashtoni*, *B. fernaldae*, *B. rufocinctus*, *B. pensylvanicus* and *B. sandersoni*. One species, *B. terricola*, was found only at high elevations, suggesting that the current warming trend is restricting its original distribution (Jacobson et al., 2018). Given their preference for cold habitats, the range and population densities of many bumblebees in Europe and North America appear to be restricted by global warming.

3.2.2. Other wild bees

Wild bees are estimated to provide at least 20% of pollination services in agricultural production (Losey and Vaughan, 2006). Their populations are largely dependent on food specialisation within a limited foraging range and habitat resources for nesting (Roulston and Goodell, 2011). Thus, 34% of the 105 bee species near Krakow (Poland) are rare and prefer wet meadows to other grasslands (Moron et al., 2008).

Using historical records on a grid of 10 km squares, declines in 52% of wild bee species in Britain and 67% in the Netherlands were observed after 1980, whereas increases in species richness were only observed in 10% of British cells and 4% of the Netherlands cells. Declining species were habitat and dietary specialists, univoltine and sedentary species in all cases, among which solitary bees were the most affected; moreover, plant species reliant on bee pollination alone were declining in both countries (Biesmeijer et al., 2006).

In Europe, an assessment of 1965 species of wild and naturalised bees found that 77 species are threatened and seven are critically endangered, including three endemic species: *Ammobates dusmeti*, *Andrena labiatala* and *Nomada sicilensis*. However, since population trends for 57% of species are unknown, 9.2% species of European bees were estimated to be declining (Nieto et al., 2014). An exhaustive analysis of almost half a million historical records of flower-visiting Hymenoptera in Britain since the mid-1800s, led to distinguish 4 main phases of extinction in that country: i) the second half of the 19th century, with the introduction of guano fertilisers and conversion of arable crops to permanent grasslands, which reduced floral resources; ii) after the First World War, when florally-diverse crop rotations were replaced with chemical fertilisers; iii) between 1930 and 1960, when most species went extinct probably due to changes in agricultural policy (i.e. Green Revolution) that fostered agricultural intensification; and iv) from 1987 to 1994, when rates of decline slowed down perhaps because the most sensitive species were already lost or reduced substantially (Ollerton et al., 2014). As agriculture occupies 70% of land-use in Britain, a causal relationship between species decline and farm management may involve multiple factors, including habitat changes and the use of chemical fertilisers and pesticides. The net result is the country-wide

extinction of 23 species of flower-visiting Hymenoptera, including once common species.

The first long-term study on the distribution of wild bees in North America was done at Carlinville, Illinois (USA). A 1970–1972 survey found 140 bee species, implying a 32% reduction in biodiversity compared to historical records from the same location 75 years earlier: only 59 of the 73 prairie-inhabiting bees and 15 of the 27 forest-dwelling ones were recovered (Marlin and LaBerge, 2001). In addition to obvious changes in land use over the period, the authors blamed herbicide sprays that killed trees and vegetation that support specialist bees. Another comprehensive long-term study focused on stingless bees (Megachilidae) at Itasca State Park (Minnesota), where 293 species were found in eight habitats over 2010–2012. A comparison of the abundance of a subset of 30 species with historical records from 1937 showed that 11 species had declined in numbers, another 11 were missing while 4 new species had been found (Gardner and Spivak, 2014). In particular, *Megachile latimanus* had disappeared and no causal factors could be identified for its demise or for the sharp reductions in abundance of other species. A model that includes nesting resources and foraging landscapes as predictors of local bee densities suggests that wild bee abundance is high in resource-rich areas of the USA such as chaparral and desert shrublands, whereas intermediate densities are typical in temperate forests and grasslands, and low densities in agricultural crops (Koh et al., 2016). Wild bees were declining in 23% of the country between 2008 and 2013, mainly in the Midwest, Great Plains and the Mississippi valley, where grain production – particularly corn for biofuel production (Bennett and Isaacs, 2014) – had almost doubled during that period. Increased abundances were reported on a mere 10% of the land, specifically where crop fields had been abandoned or converted to shrublands. A detailed analysis of the interactions between 109 pollinating bees and their host plants was studied in 26 forests of Illinois (USA), and compared to historical records for the same site from the late 1800s and early 1970s. This floral network revealed many changes over the years, with only 24% of the original pollinator-plant interactions remaining. Shifts in network structure were due to losses of individual bee species in 45% of cases (Burkle et al., 2013). Overall, the network became less nested, more vulnerable, had lower redundancy and, while species richness per plant did not change much, experienced marked drops in abundance of pollinators over the past 40 years. Losses were more prevalent among specialist species, parasitic and cavity-nesters (e.g. Megachilidae), as predicted by other authors (Williams et al., 2010).

Losses of biodiversity among wild bees are also documented for tropical regions. A 12-year comparison of 24 orchid bees (Apidae: Euglossina) in two Atlantic forest reserves of Brazil showed declines in abundance of 63% species, mostly forest-dependent bees, while those of open and disturbed habitats increased in numbers (Nemesio, 2013). Similarly, regular surveys of wild bees visiting dry forest trees along a highway in Costa Rica over 1972–2004 showed a 60% decline in species up to 1996, coinciding with the urban sprawl in the region during that period (Frankie et al., 2009). Concurrently, populations of three species increased, probably due to more diversity of garden flowers in new dwellings. Bees belonging to the Halictidae and Megachilidae families suffered the greatest losses.

3.2.3. Honey bees (*Apis mellifera* L.)

In the USA, a peak of six million honey bee colonies was recorded in 1947 but this number has been declining ever since, with losses of 3.5 million over the past six decades at 0.9% annual rate of decline (Ellis, 2012). The demise started immediately after the introduction of the organochloride insecticide DDT in agriculture and has since continued unabated (Ellis et al., 2010). The main factors responsible for this steady decline include: widespread parasite and pathogen infections that are becoming more virulent in recent years (Anderson et al., 2011; Yang and Cox-Foster, 2007); lack of genetic variability; stress due to seasonal movement of hives for pollinating fruit and vegetable crops

(Smart et al., 2016); toxic pesticide residues found in the pollen and nectar or applied to hives for controlling *Varroa* mites (Johnson et al., 2013); poor nutritional value of agro-landscapes dominated by monocultures (e.g. corn, oilseed rape, cotton (Huang, 2012)); and finally the harsher climatic conditions of recent decades. The most likely explanation for the declines, however, is a combined effect derived from synergistic interactions between parasites, pathogens, toxins and other stressors (Alburaki et al., 2018; Goulson et al., 2015; Sánchez-Bayo et al., 2016b), which has resulted in the colony collapse disorder (CCD) (Underwood and vanEngelsdorp, 2007). Two thirds of American beekeepers presently lose about 40% of their colonies every year (Kulhanek et al., 2017), whereas 30% annual losses are reported for Europe, 29% in South Africa (Pirk et al., 2014) and 3–13% in China for both *A. mellifera* and *A. cerana* (Chen et al., 2017).

Managed colonies of honey bees worldwide are suffering from the same maladies and declining at similar rates (about 1% per year) in North America, Europe (Potts et al., 2010) and Australia (Gibbs, 2013). While parasites and diseases appear to be the proximate driver of the losses, synthetic pesticides have been involved in the losses from the very beginning (Ellis, 2012). The new generation of systemic insecticides, particularly neonicotinoids and fipronil, impair the immune system of bees (Di Prisco et al., 2013; Vidau et al., 2011) so that colonies become more susceptible to *Varroa* infections (Alburaki et al., 2015) and more prone to die when infected with viral or other pathogens (Brandt et al., 2017). Apart from bringing about multiple sub-lethal effects that reduce the foraging ability of worker bees (Desneux et al., 2007; Tison et al., 2016), neonicotinoid and fipronil insecticides equally impair the reproductive performance of queens and drones (Kairo et al., 2017; Williams et al., 2015), thus compromising the long-term viability of entire colonies (Pettis et al., 2016; Wu-Smart and Spivak, 2016).

3.2.4. Cuckoo wasps (*Chrysididae*)

This rare group of parasitic wasps has recently been studied in Finland, and surveys reveal that 23% of the 48 local species are declining, together with one of the host species (Paukkunen et al., 2018). Unlike with other taxa, none of the cuckoo wasps seem to be increasing in numbers or distribution. Declining species are typically small, rare and tend to nest above ground, whereas populations of the larger and/or ground-nesting species appear to be stable. Authors attribute the declines to habitat loss (i.e. deforestation) for agricultural purposes, which restrict the availability of logs for nesting.

3.2.5. Formicidae

Studies on ant (Formicidae) populations and trends are lacking except for a few invasive species (Cooling and Hoffmann, 2015; Vogel et al., 2010). Tropical deforestation has been invoked as a major cause for biodiversity losses of ants and other insects at the global scale – specifically for forest-inhabiting species (Wilson, 2002). Equally, logging of Nordic forests using established management practices was harmful to populations of the polydomous wood ant *Formica aquilonia*, because ants had their feeding and nesting resources restricted while abiotic conditions necessary for the development of the colonies had changed (Sorvari and Hakkarainen, 2007). Nothing is known about the fate of the multiple ant species that inhabit other types of habitats in both temperate and tropical settings.

3.3. Diptera

Hoverflies (Syrphidae) are important pollinators and key natural enemies of agricultural pests such as aphids, with a preference for damp habitats. Several surveys in Mediterranean countries have shown large local variations in biodiversity within this taxon, with 249 species alone in Greece (Petanidou et al., 2011) and 429 in Spain (Stefanescu et al., 2018). However, the only long-term study to date found parallel reductions in species richness among hoverflies in the Netherlands and

the U.K. (Biesmeijer et al., 2006). That migratory hoverflies fared better than their sedentary counterparts in the latter two countries suggests that mobility is an important trait for survival. While plant species reliant on bee pollination alone were declining in both countries, plants pollinated by both bees and hoverflies were increasing only in the Netherlands.

3.4. Coleoptera

The largest order of insects includes important groups of predatory and saprophytic species that provide essential ecosystem services in pest control and recycling of organic matter among others.

3.4.1. Carabidae

Ground beetles are a ubiquitous taxa and tiger beetles (Cicindelidae) are regularly used as indicators of biodiversity; this group occurs within habitats that harbour a diverse array of native butterflies and birds (Pearson and Cassola, 1992). Most of the changes among European carabids can be explained by habitat destruction, increased eutrophication due to agricultural intensification and expanding urbanisation. A study on 419 species within 10-km grid cells throughout the Netherlands, Belgium, Luxemburg and Denmark found that 34% of carabids declined between 1950 and 1980, with over 50% of xerophilic species of the genera *Amara*, *Harpalus* and *Cymindis* as well as *Carabus* decreasing in numbers (Desender and Turin, 1989). In the Netherlands, carabids with limited degrees of dispersal were the most affected, whereas those with large mobility or associated with man-made habitats had stable populations (Turin and den Boer, 1988).

In the U.K., dramatic declines of 49 out of the 68 carabids studied at 11 sites over 15 years, led to consider 26 species as vulnerable and eight endangered, whereas 19 species appear to be either stable or even increasing. Overall, a 16% loss of carabid beetle biomass was recorded during the 15-year period (Brooks et al., 2012). Changes in biodiversity were not linear and correlated with habitat and geographical variation, being most pronounced in mountainous regions of the west and north (64% of declining species), followed by moorlands (31%) and pastures (28%), whereas increases occurred in the southern downlands. Carabids in upland pastures, woodlands and hedgerows remained stable during the study period. Small species or those with spring breeding, dispersive or diurnal habits tend to be negatively affected. Microclimatic changes that alter soil moisture also affected some upland species (Brooks et al., 2012).

In New Zealand, 12 species of large carabid beetles are endangered and another 36 declining, together comprising about 8% of all known species in that country. Affected species belong mostly to two genera of giant carabids, *Mecodema* and *Megadromus* (McGuinness, 2007). The proportion of endangered carabids (about 4%) is twice as much as that of other local beetles, perhaps because they are large terrestrial species vulnerable to predation by introduced rats, hedgehogs, ferrets, weasels and possums. Habitat change due to forest clearance and conversion to pastures for sheep grazing have exacerbated the plight of these giant beetles, 92% of which are endemic and evolved in isolation during the past 80 million years.

3.4.2. Coccinellidae

Harmon et al. (2007) reviewed 62 historical datasets of aphidophagous coccinellids in the USA and Canada, spanning 1914–2004. Although biased towards predatory species within agricultural landscapes, the surveys showed that ladybird species richness and population sizes did not change much until 1986, when a major decline in native species began to be noticed and affected 68% of species over the following 20 years (Harmon et al., 2007). At least two previously common species (i.e. *Adalia bipunctata* and *Coccinella novemnotata*) have since become very rare or entirely disappeared from the north-eastern USA (Wheeler, 1995). At the same time, 22 introduced species have been recorded, though only six of those have established in North

America. Two likely causes of the declines include: i) habitat change, either towards intensive agriculture in the Midwest States or through afforestation (i.e., New York State); and ii) competitive displacement by foreign generalist species such as *C. septempunctata* and *Harmonia axyridis* (Brown and Miller, 1998), possibly fuelled by a steep population build-up of invasive aphid pests in agricultural crops. *H. axyridis* is out-competing native ladybirds in Great Britain (Roy and Brown, 2015), other European countries (Camacho-Cervantes et al., 2017) and Japan (Sato and Dixon, 2004), and gaining a competitive edge through its predation of aphids in agricultural crops (Rutledge et al., 2004).

Systematic records of abundance and distribution of ladybirds since 1976 in cereal crops, herbaceous plants and trees are available for the Czech Republic. Of the 13 species studied, six had declined in abundance while seven had increased, including *H. axyridis* (Honek et al., 2014). Agricultural intensification is the main driver of population changes in cereal crops and herbaceous stands, whereas coccinellid diversity and abundance in tree habitats remained stable over the 35-year period. Specifically, the extensive use of insecticides impacts both aphid pests and associated ladybird predators, and the recent conversion of crops to oilseed rape monocultures had an overall negative effect on *C. septempunctata* populations. Warming climate, by contrast, favoured the expansion of *Hippodamia variegata* (Brown and Roy, 2015).

In Britain, records of nine ladybird species collected by citizen scientists, along with systematic surveying between 1990 and 2013 were analysed by Brown and Roy, 2015). Five species were declining, two remained stable and two were expanding – *H. variegata* and *H. axyridis*. Changes in certain agricultural practices that led to lower aphid numbers in crops (i.e., reduced fertiliser use) may have resulted in the decline of three common native species (*A. bipunctata*, *C. undecimpunctata* and *Propylea quatuordecimpunctata*) and the concurrent increase of *H. variegata* and *H. axyridis*, indicating parallel coccinellid population trends for both the U.K. and continental Europe (Honek et al., 2014).

3.4.3. Dung beetles

Dung beetles comprise three main groups: rollers (Scarabaeinae), tunnellers (Geotrupidae and most Scarabaeidae) and dwellers (Aphodiidae). Their unique ecological function is of vital importance to the livestock sector and for the soil fertility of grasslands. Studies on the decline of these specialized beetles are available only for the Mediterranean region, which has the largest diversity of dung beetles in Europe.

Roller dung beetles comprise a fifth of the 55 local species in Spain. An analysis of their abundance and distribution during the 20th century showed that while most species increased in numbers up to 1950, the relative abundance of nine of them dropped since then from 28% to 7%, while their distributional range contracted from 48% to 29% of the 10-km grid cells (Lobo, 2001). The most threatened species were *Scarabaeus pius* and *Gymnopleurus mopsus*, whereas populations of *S. cica-tricosus* increased in its restricted southern area of distribution and those of *S. typhon* remained unchanged. Multivariate analyses reveal that large-scale urbanisation of the coasts for tourism and post-1950s agricultural intensification are primary causal factors.

In Italy, analysis of the abundance and distribution of 6870 records of 11 species of roller dung beetles for the entire 20th century showed a 31% reduction in both abundance and distribution affecting nine species (Carpaneto et al., 2007). Major declines started in the 1960s (2 species), increased in the 1970s (3 species) and became widespread in the 1980s (6 species). Their distribution, however, increased during the first half of the century and then decreased by 23% on a national level. The declines correlate with the local reduction of rangelands: 43% conversion of pastures to either forests or intensive agriculture since 1960. In addition, a shift from free-ranging livestock to stalled animals meant that dung was no longer available to foraging beetles. Two *Scarabaeus* and four *Gymnopleurus* species are considered threatened, and *G. mopsus* is probably extinct. The largest beetles are most at risk, suggesting that lower fecundity and enhanced predation by crows may

be factors at play. The use of helminthicides (i.e. avermectins) and other anti-parasitic insecticides was considered of minor importance, though other authors have documented their negative impacts on dung beetles (Lumaret et al., 1993; Strong, 1992).

In France, a 1996 survey in the coastal region of the Camargue collected 337 individuals of 11 species only (nine Scarabaeidae and two Aphodiidae; none Geotrupidae), though the entire dung beetle fauna of the region is known to comprise 72 species (Lumaret, 1990). Such a significant drop in biodiversity affects more generalist species with greater dispersal abilities than the dwellers and rollers. Among the latter group, abundance of *Scarabaeus semipunctatus* has lowered 45-fold over 24 years, while populations of *S. sacer* are restricted to two sites between France and Spain (Lobo et al., 2001). The use of insecticides for mosquito control and livestock treatment as well as urbanisation are the main factors explaining the declines, since no agricultural changes have taken place in the area for decades.

3.4.4. Saproxyllic beetles

Saprophytic beetles play a major role in decomposition of wood in ecosystems, thus recycling nutrients that would otherwise be locked in decay logs and branches. Some species are also involved in pollination (Stefanescu et al., 2018).

In Europe, logging, wood harvesting and agricultural expansion have caused losses of old native forests, thus threatening the survival of 56 species of saproxyllic beetles (a third of them endemic). While populations of at least 61 species are declining or have experienced a more confined distribution, nine others are increasing in numbers. Most threatened species are in Central and Eastern Mediterranean regions, and two endemic species, *Glaphyra bassetti* (Cerambycinae) and *Propomacrus cypricus* (Euchiridae), are now regarded as critically endangered. However, since population trends for 57% of the 436 known species are unknown, the number of declining species could be even higher (Nieto and Alexander, 2010). The only long-term study available is for long-horn beetles (Cerambycidae) in Sweden, where 118 species are known from historical records. About half of the beetles had maintained the same distribution and relative abundance since the early 1900s (Lindhe et al., 2011). The status of the remaining 50% is affected by a local shift from agriculture to industrial, large-scale forestry: 26 species experienced significant declines, 32 increased in abundance, and 5–10 species are presumed extinct.

3.5. Hemiptera

One study of planthoppers and leafhoppers (Auchenorrhyncha) in protected grasslands of Germany was found (Schuch et al., 2012). These are typical phytophagous insects of open areas, accounting for a large proportion of the biomass of flying insects in natural and anthropogenic grasslands of Europe (Biedermann et al., 2005). Historical sweep-net samples (1963–1967) were compared to recent samples (2008–2010) at the same sites with respect to species diversity, species composition, and abundance. Regardless of the strong inter-annual variability in abundance and weather conditions, overall species richness did not change. However, species composition changed considerably, with 14 species declining (mostly specialists) and nine others increasing (mostly generalists), while one species (*Zyginidia scutellaris*) characteristic of acidic grasslands became very dominant. Moreover, median abundance decreased by 66% (from 679 to 231 individuals per site) over the 47-year period (Schuch et al., 2012). Airborne and soil acidification, partly due to agricultural intensification, is the main factor affecting local grassland composition and the associated herbivore fauna.

3.6. Orthoptera

A single long-term study on grasshoppers and crickets is available, conducted at the same German sites as above (Schuch et al., 2011). Their biodiversity in protected grasslands did not change over four

decades (median 9 species per site), and changes in species assemblages were small. The only significant change included a sharp decline in a grasshopper of bare soils (*Myrmeleotettix maculatus*) and increases in two generalist species of bush-crickets typical of open woodland and scrub (*Tettigonia viridissima*, *Phaneroptera falcata*). Contrasting with other taxa, few Orthoptera species showed detectable temporal trends, perhaps because most species are highly-adaptable polyphagous grazers. Nevertheless, about half of the species are considered threatened in Germany.

3.7. Odonata

Dragonflies (Anisoptera) and damselflies (Zygoptera) comprise a relatively small order of insects that depend on water bodies for their larval development. Both nymphs and imagoes are predators of aquatic organisms and flying insects respectively, and they play an important role in controlling nuisance mosquitoes and agricultural pests, e.g. of rice (Painter et al., 1996; Relyea and Hoverman, 2008). Of the 118 aquatic species of endangered insects listed by the IUCN, 106 are Odonata (Kalkman et al., 2010), although it is clear that other aquatic taxa are underrepresented due to insufficient knowledge (DeWalt et al., 2005). A recent IUCN assessment indicates that 10% of the world's Odonata are threatened with extinction, although that study only covered a quarter of all species known and acknowledged data gaps for 35% of species, particularly those from tropical and Australasian regions (Clausnitzer et al., 2009). Given the above, 15% of all species may be threatened.

In the USA, recent surveys at 45 sites across California and Nevada were compared to historical records from 1914 to 1915. Occurrence rates of 52 species of dragonflies and damselflies (65% of all recorded) have declined over the 98-year period while those of 29 species have increased. Two generalist and pollution-tolerant species that were not recorded in 1914–1915 greatly expanded their range into California and became common, particularly in urban areas. At least nine species declined significantly, including four species (*Sympetrum danae*, *S. costiferum*, *Ophiogomphus occidentis* and *Libellula nodisticta*) that were also rare in early surveys. Declines occurred mostly among habitat specialists, whereas increases were recorded for generalist and migratory species that replaced the losses at the same sites. Specialist species included those with overwintering diapause, which appear to have declined due to an increase of minimum temperature over the period (Ball-Damerow et al., 2014). While species richness has not declined, Odonata assemblages have become more homogeneous in species composition, which is typically an effect of urbanisation (McKinney, 2006).

In Europe, 15% of the 138 Odonata species are currently threatened, with two damselflies (*Ceragrion georgifreyi* and *Pyrrhosoma elisabethae*) and one dragonfly (*Cordulegaster helladica* sp. *kastalia*) critically endangered in the Balkan Peninsula. A quarter of all species (33) are declining in population numbers and distribution, whereas 10% of them are increasing and about half remain stable. Major declines took place during post-1960 agricultural intensification, with canalisation of rivers for irrigation and water pollution by urban runoff, pesticides and fertilisers (i.e. eutrophication) being the main drivers of population extinctions over large areas (Kalkman et al., 2010). Ubiquitous species such as *Coenagrion puella* and *Sympetrum striolatum*, however, increased and shifted their range some 300 km northwards in Britain between 1960 and 1970 and 1985–1995 (Hickling et al., 2005). In central Finland, populations of 20 common species of Zygoptera and Anisoptera were surveyed at 34 small creeks over 1995–1996, and their distribution patterns were compared with historic records from 1930 to 1975. Two specialist and lentic dragonflies, *Coenagrion johanssoni* and *Aeshna caerulea* have disappeared from streams, and 45% of the 219 surveyed populations vanished. Local extinctions occurred in peat bogs and dynamic waters upstream, which are habitats for lentic-specialist species, whereas downstream water bodies had lower losses. Generalist species

(i.e., those that breed in both lentic and lotic waters) were less likely to become locally extinct. The construction of agricultural ditches and habitat fragmentation from forestry further impacted on populations of rare species (Korkeamäki and Suhonen, 2002).

In Japan, 57 out of 200 Odonata species are declining, with 23 being vulnerable and 19 endangered (Kadoya et al., 2009). The largest drops in abundance and distribution are among lentic species once common in rice paddy fields (e.g., *Lestes japonicus*, *Libellula angelina*, *Sympetrum maculatum* and *S. uniforme*). Island endemics are next in the extinction list, whereas those of lotic habitats of mountain streams are the least affected. The sharp decline in populations of red dragonflies (*Sympetrum* spp.) since the mid-1990s (Fukui, 2012; Futahashi, 2012) has been linked to the use of fipronil and neonicotinoid insecticides (Nakanishi et al., 2018), which affect the aquatic nymphal stages by curtailing the emergence of adults (Jinguji et al., 2013).

Of the 155 Odonata species recorded in South Africa, 13 are declining and four are extinct (Samways, 1999). The protection of rare species in nature reserves of that country does not necessarily guarantee their survival, as current livestock management and other human activities negatively impact on these aquatic insects.

3.8. Other freshwater taxa

Freshwater insect taxa tend to have rather inflexible life cycles, with many species being univoltine, thus making them particularly sensitive to habitat change. Flow alterations, habitat fragmentation, pollution and invasive species are the main threats to all aquatic organisms, including insects (Allan and Flecker, 1993; Zwick, 1992). Data pertaining to three main orders of freshwater insects, Plecoptera, Ephemeroptera and Trichoptera, are reported here but no surveys were found for Coleoptera (e.g. Dytiscidae, Hydrophilidae), Hemiptera (e.g. Notonectidae, Gerridae) or Diptera (e.g. Chironomidae, Tipulidae).

3.8.1. Plecoptera

Stoneflies (Plecoptera) are numerically and ecologically a significant component of the entomofauna of running waters, typified by high degrees of endemism and narrow ecological requirements (Zwick, 2000). More than half of the species are univoltine and their nymphs require mainly cold and well-oxygenated waters of temperate and cold regions. In Europe, once common species of lowland rivers such as *Taeniopteryx araneoides* and *Oemopteryx loewi* are now extinct over the entire continent, while *Isogenus nubecula* has locally disappeared (Fochetti and de Figueroa, 2006). The percentage of species threatened with extinction ranges from 50% in Switzerland (Aubert, 1984) to 13–16% in Mediterranean countries like Spain and Italy, where many species are endemic. Up to 63% of the 516 European species of stoneflies are susceptible to climate change, particularly species endemic to the high mountains of the Alps, Pyrenees and Mediterranean peninsulas, which experience altitudinal shifts in habitat (Tierno de Figueroa et al., 2010). Although stoneflies are relatively tolerant of acidification as compared to other macro-invertebrates, they are highly sensitive to changes in water flows and eutrophication by organic pollution (Tixier and Guérol, 2005).

In the Czech Republic, species diversity and abundance of 78 stoneflies in rivers, streams and lakes were compared at 170 sites between 1955 and 1960 and 2006–2010 (Bojková et al., 2012). Three quarters of the changes in species diversity occurred at low- and mid-altitude streams, with pollution, impoundment and channelization affecting those sites. Lowland river habitats had five threatened species of the original 14 species recorded at the turn of the 19th century, while four are now extinct. Over a 50-year time frame, 12% of the species were no longer found, whereas two new species have appeared (*Brachyptera monilicornis* and *Leuctra geniculata*). Moreover, 22% species had declined by > 50%, including once common species such as *Perla abdominalis*, *Amphinemura standfussi* and *Nemurella pictetii*, and a further 10% have become vulnerable. Contrary to terrestrial taxa, most

declines were observed among habitat generalists and less specialized species (60–70%), which are tolerant to organic pollution. These species survived a first wave of extinctions during the 1920s–1930s and the industrialisation of the 1960s–1980s. Sites affected by organic pollution showed, however, the greatest change in community assemblage, particularly in agricultural and urbanised settings, whereas communities in montane and sub-montane areas have remained almost intact: only 17–33% of sensitive and eurytopic species declined since the mid-1990s (Bojková et al., 2014); some degree of species recovery has been observed following pollution mitigation in acidified habitats (Nedbalová et al., 2006). In Switzerland, half of the species of stoneflies and mayflies in water courses of industrial and agricultural areas were lost between 1940s and 1980s (Küry, 1997), and the same occurred in other European countries and the USA, where the entire Plecoptera fauna of lowland rivers can now be considered threatened.

In Illinois (USA), 29% of the 77 local stonefly species were lost and 62% of the remainder became threatened over the past century (DeWalt et al., 2005). Main losses occurred in the large rivers and agricultural areas of the Grand Prairie during the 1940s and 1950s, when both agricultural and urban expansion took place. Structural modification of river flows due to dams, channels and tile drainage networks have all impacted negatively on these insects, as they increased siltation and organic waste. The large, long-lived species of Perlidae (summer stones) and Perlodidae (spring stones) were impacted the most, and 36% of summer stones have gone extinct since 1860. For sensitive genera such as *Acronuria*, 88% of the entire contingent was lost over the past century, whereas genera tolerant to organic pollution such as *Perlesta* have increased 4-fold. Species losses were largest within semi-voltine and univoltine stoneflies adapted to permanent waters.

3.8.2. Ephemeroptera

The most comprehensive checklist of mayflies (Ephemeroptera) of the Czech Republic recognised 107 species of which four had become extinct, seven are critically endangered, seven endangered, 16 vulnerable and 14 near threatened – a 43% overall decline of local species of mayflies (Zahrádková et al., 2009). A comparison of local mayfly communities in 60 streams between 1955 and 2011 showed clear changes in species composition but no losses in biodiversity except for the large lowland rivers, which lost five specialist species but gained several silt-tolerant species (Zedková et al., 2015). Biodiversity, however, increased slightly in mid- and upper streams and rivers, indicating perhaps some recovery given the substantial reduction in water pollution post-1989 (Bojková et al., 2014). Two species became extinct (*Isonychia ignota* and *Ephemerella mesoleuca*), three became very rare, 11 were declining and nine were expanding their range, including the dominant *Centropilum luteolum* and *Baetis niger*. Main changes were due to losses or turnover of previously common and widespread species such as *B. alpinus* and *Epeorus assimilis*, so the overall dissimilarity among sites (15–30%) was mainly driven by species replacement. The current communities have shifted towards more simplified and less specialized assemblages in large rivers, whereas mayflies in small creeks have been replaced with species tolerant to pollution and siltation.

In North America, a total of 672 species of mayflies are listed though no details are available regarding distribution or status (McCafferty et al., 2010; McCafferty, 1996). A similar compilation for North and South Carolina (USA) reported 204 species (Pescador et al., 1999), but again no status was indicated. A later study in relation to 10 rare species revealed, however, that four of the species collected in the early 20th century should be considered extinct (McCafferty, 2001).

3.8.3. Trichoptera

Another taxon of inconspicuous insects, the caddisflies (Trichoptera) has been poorly studied. Of the 278 species recorded in relatively undisturbed regions of Minnesota (USA) since the 1890s, 6–37% of species losses have occurred in different areas, especially

within the Limnephilidae (44% of species), Phryganeidae (21%) and Leptoceridae (12%) families (Houghton and Holzenthal, 2010). *Agrypnia glacialis* and *Anobolia sordida* are currently extinct, and 17 rare species have not been found since the 1950s, while only one record is known of *Limnephilus secludens* since 1985 (Houghton and Holzenthal, 2010). All species in the affected families are either univoltine or semivoltine and, because of their long lifespan and feeding habits, are particularly vulnerable to anthropogenic disturbances in water courses. The majority of losses are found among shredder (72%) and predatory species (11%), in agreement with losses of aquatic taxa in other countries (Jenderedjian et al., 2012; Karatayev et al., 2009). The regional caddisfly community is now dominated by filtering collectors (65% of species), with tolerant species such as *Potamyia flava* (Hydropsychidae) having increased in abundance several-fold since the 1950s, particularly in large rivers and agricultural regions that now account for over 95% of the original prairie habitats.

4. Discussion

Biodiversity loss has become a major global issue, and the current rates of species decline – which could progress into extinction – are unprecedented (Barnosky et al., 2011; Pimm and Raven, 2000). Yet, until recently, most scientific and public attention has focused on charismatic vertebrates, particularly on mammals and birds (Ceballos and Ehrlich, 2002; Manne et al., 1999), whereas insects were routinely underrepresented in biodiversity and conservation studies in spite of their paramount importance to the overall functioning and stability of ecosystems worldwide (Fox, 2013; McKinney, 1999; Thomas et al., 2004).

This review brings to the fore the demise of major insect taxa (albeit no studies are available for most Diptera, Orthoptera and Hemiptera), which started at the dawn of the 20th century, accelerated during the 1950s–1960s, and attained alarming proportions globally over the last two decades. Our aim is to draw attention to the extent of the problem and point out its drivers, so that adequate conservation measures may be implemented and prioritised.

From our compilation of published scientific reports, we estimate the current proportion of insect species in decline (41%) to be twice as high as that of vertebrates, and the pace of local species extinction (10%) eight times higher, confirming previous findings (Dirzo et al., 2014). At present, about a third of all insect species are threatened with extinction in the countries studied (Table 1). Moreover, every year about 1% of all insect species are added to the list, with such biodiversity declines resulting in an annual 2.5% loss of biomass worldwide (Fig. 2).

Among terrestrial taxa, the largest losses of biodiversity are among dung beetles in Mediterranean countries, with > 60% of species in decline and a large proportion considered threatened (Fig. 3a). About half of Coleoptera and Lepidoptera species (both moths and butterflies) are declining at a faster rate than the annual average (2.1% and 1.8% respectively, Fig. 2). A similar trend is observed among bees, where one in six species have gone regionally extinct. The fate of other pollinators such as hoverflies is, however, largely unknown. In agreement with biodiversity losses reported in other animal taxa (Ricciardi and Rasmussen, 1999), declines are even higher among aquatic insects, despite the scarce knowledge available for most countries: 33% of aquatic insects are threatened compared to 28% among terrestrial taxa (Fig. 3b).

Insect declines appear to be similar in tropical and temperate regions of the world (mean 45.3% vs 45.4% of species, $p = 0.93$), though the low number of studies in the tropics ($n = 3$) does permit statistical comparison. Within temperate regions, the U.K. seems to have the largest documented declines across taxa (60% of species), followed by North America (51%) and Europe (44%), but with no significant differences among them ($p = 0.21$, $F = 3.15$, $df = 59$, ANOVA); within Europe, insect declines are also similar between Mediterranean and

Table 1

Proportion of declining and threatened species per taxa according to IUCN criteria (> 30% decline), the annual rate of decline in species (i.e. additional declines per year) and the local or regional extinction rate (i.e. percent of species not observed in > 50 years).

Taxon	Declining (%)	Threatened (%)	Annual species declines (%)	Extinction rate (%)	No. Reports
A) Insects	41	31	1.0	10	73 ^a
Coleoptera	49	34	2.1	6.6	12
Diptera (Syrphidae)	25	0.7 ^g	n.a.	n.a.	4
Ephemeroptera	37	27	0.6	2.7	3
Hemiptera (Auchenorrhyncha)	8 ^g	n.a.	0.2 ^g	n.a.	1
Hymenoptera	46	44	1.0	15	21
Lepidoptera	53	34	1.8	11	17
Odonata	37	13	1.0	6	6
Orthoptera	49	n.a.	1.0	n.a.	1
Plecoptera	35	29	0.6	19	7
Trichoptera	68	63	0.6	6.8	1
Terrestrial	38	28	1.2	11	56
Aquatic	44	33	0.7	9	17
B) Vertebrates	22	18	2.5	1.3	11
Amphibians	23	23	n.a.	n.a.	1 ^b
Birds	26	13	2.3	0.8	3 ^c
Mammals (land)	15	15	0.1	1.8	3 ^d
Mammals (Chiroptera)	27	n.a.	5.2	1.2	3 ^e
Reptiles	19	19	n.a.	n.a.	1 ^f

^a This paper; see Table S1.

^b Temple and Cox, 2009.

^c Thomas et al., 2004; Birdlife_International, 2015.

^d Ceballos and Ehrlich, 2002; Temple and Cuttelod, 2008; Temple and Terry, 2009.

^e Mickleburgh et al., 2002; Mitchell-Jones, 1990; Van der Meij et al., 2015.

^f Cox and Temple, 2009.

^g Insufficient data.

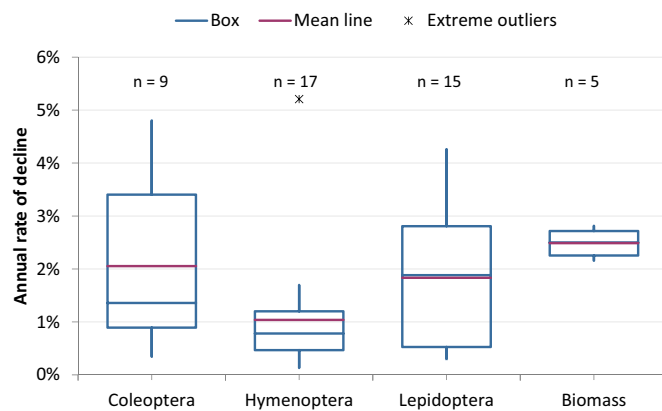


Fig. 2. Annual rate of decline of the three major taxa studied (percentage of species declining per year) and of insect biomass.

central or northern countries ($p = 0.27$, $F = 4.15$, $df = 33$, ANOVA). Studies from all other regions have a significantly lower proportion of insect declines (23%, $p = 0.01$, $F = 2.51$, $df = 68$, ANOVA), except for a single study that showed a 62.5% decline of orchid bees (*Euglossina*) in Brazil, which can be regarded as an outlier (Fig. 4).

The pace of modern insect extinctions surpasses that of vertebrates by a large margin, although the extent of losses cannot be accurately quantified. This is largely due to a dearth of historical knowledge in many regions (e.g. China, sub-tropical and tropical countries and Australia), an absence of comparative surveys for multiple insect orders and an underestimation of the host-associated species (e.g., specialist herbivores, pollinators, obligate parasitoids and parasites) that are lost through co-extinction of their host plant or animal (Dunn, 2005; Koh et al., 2004). Since the declines affect the majority of species in all taxa, it is evident that we are witnessing the largest extinction event on Earth since the late Permian and Cretaceous periods (Ceballos et al., 2017; Raup and Sepkoski Jr, 1986). Because insects constitute the world's most abundant and speciose animal group and provide critical services

within ecosystems, such event cannot be ignored and should prompt decisive action to avert a catastrophic collapse of nature's ecosystems (May, 2010).

Most worrying is the fact that the declining terrestrial insect fauna comprise not only specialists with narrow ecological requirements, such as dependence on particular host plants (e.g., *Coenonympha oedippus* in bogs), ecological niches (e.g., roller dung-beetles) or restricted habitats (e.g., *Bombus terricola* in the USA), but also generalist species that were once common in many countries (e.g., *Aglais io* in the Netherlands or *Macaria wauaria* in the U.K.). This suggests that the causes of insect declines are not tied to particular habitats, but instead affect common traits shared among all insects (Gaston and Fuller, 2007). The disappearance of habitat generalists is particularly notorious among aquatic insects, for which major losses have been recorded among stoneflies, mayflies, caddisflies and dragonflies that once inhabited the large rivers of Europe and North America (Bojková et al., 2014). Thus, the biodiversity of the Rhine river plummeted during the industrial expansion of the 1930s, and subsequent efforts aimed at its recovery have failed to bring back many of the native species (Marten, 2001). Interestingly, aquatic insect communities remain stable or show lesser declines in pristine mountain streams and lakes. In aquatic environments, the evidence points to pollution as the main driver of the declines and extinctions recorded so far.

Anthropogenic pressure is shifting multiple insect communities towards species-poor assemblages dominated by generalists (White and Kerr, 2007), with current biodiversity losses and shifts in community composition being the forerunners of extinction (Chapin-III et al., 2000). In aquatic settings, the disappearance of susceptible species and their steady replacement with (often non-native) tolerant ones poses a major threat to freshwater biodiversity (Karatayev et al., 2009). Species losses are expected to lead to a steady decay of insect-mediated ecosystem services, which are likely to be provided by fewer and less specialized species (Bartomeus et al., 2014; Pimentel, 1961). As insect biodiversity is essential for the proper functioning of all ecosystems, the current trends are disrupting – to varying degree – the invaluable pollination, natural pest control, food resources, nutrient recycling and decomposition services that many insects provide (Aizen et al., 2009;

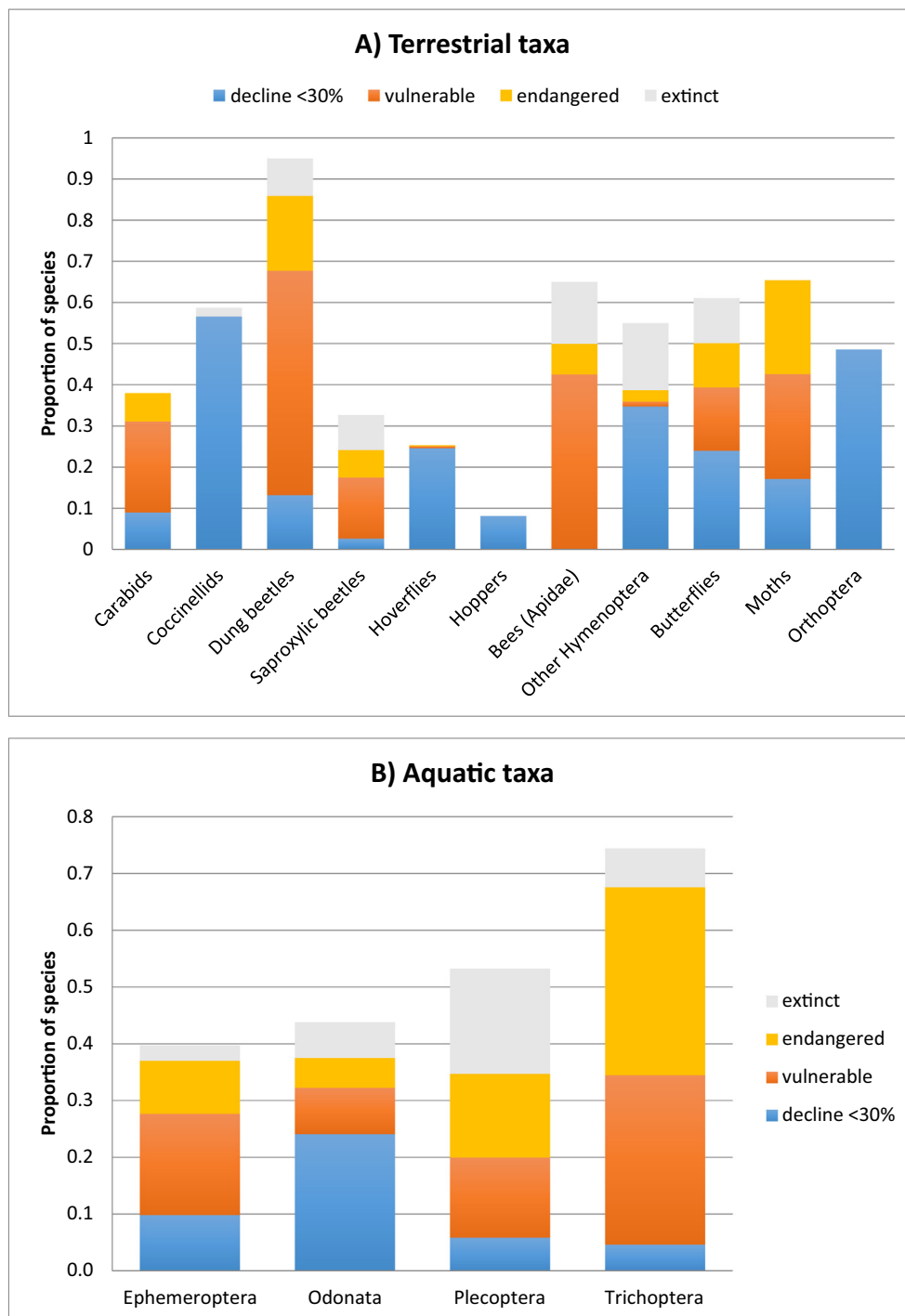


Fig. 3. Proportion of insect species in decline or locally extinct according to the IUCN criteria: vulnerable species (> 30% decline), endangered species (> 50% decline) and extinct (not recorded for > 50 years). A) terrestrial taxa; B) aquatic taxa.

Davis et al., 2004; Kreutzweiser et al., 2007).

While countless insect species are disappearing, few others are occupying vacant niches and expanding their distribution. In terrestrial ecosystems, most of the occupying species are generalists with diverse ecological preferences (e.g., *Bombus impatiens*, *Plusia putnami*, *Laemostenus terricola* and *Hippodamia variegata*). In aquatic environments, species replacement is also mediated by ecological traits such as degree of tolerance to pollutants (e.g. *Sympetrum striolatum*, *Brachyptera risi* and *Potamyia flava*), with communities thus becoming more uniform and less diverse in composition (Houghton and Holzenthal, 2010). Species replacement may help retain the delivery of certain ecosystem

services, but it's unclear to what extent natural ecosystems can sustain their overall ecological resilience (Mémott et al., 2004).

Species extinctions equally impact the overall biomass of entire ecosystems, as insects form the base that supports intricate food webs. Indeed, the essential role that insects play as food items of many vertebrates is often forgotten. Shrews, moles, hedgehogs, anteaters, lizards, amphibians, most bats, many birds and fish feed on insects or depend on them for rearing their offspring. Even if some declining insects might be replaced with others, it is difficult to envision how a net drop in overall insect biomass could be countered. The large declines in insect biomass observed in Europe (Hallmann et al., 2017) and Puerto Rico

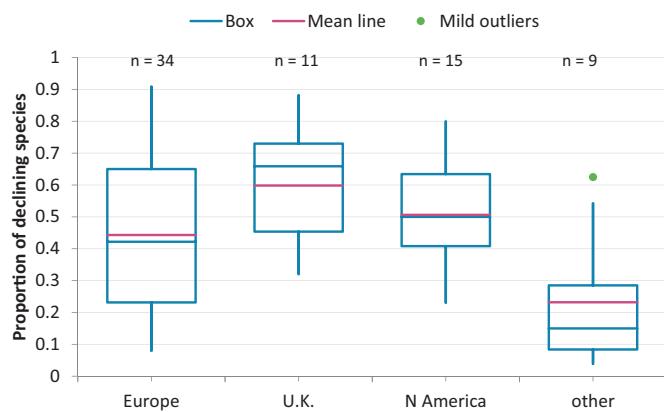


Fig. 4. Proportion of declining insect species in different regions of the world.

(Lister and Garcia, 2018) inevitably lead to a starvation of dependent vertebrates (Hallmann et al., 2014; Lister and Garcia, 2018; Poulin et al., 2010; Wickramasinghe et al., 2003). This kind of cascading effect was first observed with grey partridge (*Perdix perdix*) populations in England since 1952, and was ascribed to reproductive failure. The ultimate cause of the partridge collapse was a combined use of insecticides and herbicides in agricultural land, leading to insufficient insect numbers to feed the chicks (Potts, 1986). Equally, in the U.K. the diversity and abundance of bats in intensive agricultural landscapes is considerably lower than on organic farms because of a reduction in insect biomass caused by pesticide use in the former settings (Wickramasinghe et al., 2004), and direct insecticide exposure through the bats' prey items (Mispaigel et al., 2004; Stahlschmidt and Bruhl, 2012).

4.1. Drivers of the declines

A large proportion of studies (49.7%) point to habitat change as the main driver of insect declines, a factor equally implicated in global bird and mammal declines (Chamberlain and Fuller, 2000; Diamond, 1989). Next on the list is pollution (25.8%) followed by a variety of biological factors (17.6%), whereas few studies (6.9%) indicate climate change as triggering the losses (Fig. 5; Table S2).

4.1.1. Habitat change

Habitat change is an immediate consequence of human activities. Its global pace and scope has been expanding over the past centuries, with increasing amounts of land being transformed to provide dwellings, facilitate transportation and enable tourism (urbanisation), grow food

(agriculture) and manufacture goods (industrialisation) at the expense of various natural habitats. Among Coleoptera, Lepidoptera and Hymenoptera, land-use change and landscape fragmentation is surely the main cause of species declines (Fig. 5), with agricultural conversion and intensification for food production listed in 24% of the reports (Fig. 6). Urbanisation, by contrast, is reported in 11% of cases, while deforestation appears in 9% of reports.

As agricultural crops comprise about 12% of the total land surface on the planet (FAO, 2015), farming directly affects a considerable proportion of insect species (Dudley and Alexander, 2017). In Europe and North America, the expansion of the agricultural frontier took place mostly in the first half of the 20th century, whereas in South America, Africa and Asia occurred mainly in the second half of the century (Foley et al., 2005; Gibbs et al., 2010). In its wake, rare species associated with pristine ecosystems and natural habitats either retreated or were entirely lost (Grixti et al., 2009; Ollerton et al., 2014). Major insect declines occurred, however, when agricultural practices shifted from traditional, low-input farming style to the intensive, industrial scale production brought about by the Green Revolution (Bambaradeniya and Amerasinghe, 2003; Ollerton et al., 2014). The latter practices did not necessarily involve deforestation or habitat modification (e.g., grassland conversion, drainage of wetlands) but rather entailed the planting of genetically-uniform monocultures, the recurrent use of synthetic fertilisers and pesticides, the removal of hedgerows and trees in order to facilitate mechanization, and the modification of surface waterways to improve irrigation and drainage. Monocultures led to a great simplification of insect biodiversity among pollinators, insect natural enemies and nutrient recyclers, and created the suitable conditions for agricultural pests to flourish. A quarter of the reports indicate these agriculture-related practices as the main driver of insect declines in both terrestrial and aquatic ecosystems (Wilcove et al., 1998).

The susceptibility of specialist pollinators to land-use changes (involving loss of floral resources, nesting and hibernation sites), appears to be a determining factor in the decline of many bumblebees and wild bees (Williams and Osborne, 2009). For specialist ground beetles, the loss of hedgerows and trees likely triggered their decline (Brooks et al., 2012). Declines in moths are tied to the fate of their overwintering larval host plants: forbs for species overwintering as larvae, and trees for those overwintering as egg, pupa, or adult. The combined removal of weeds and trees in intensive agricultural settings may thus explain the decline of moth species overwintering as larvae (Fox, 2013; Mattila et al., 2006; Merckx et al., 2009; Pocock and Jennings, 2008). Conversely, the change from intensive farming to organic farming has led to increases in abundance and diversity of moths (Taylor and Morecroft, 2009), while the abandonment of grazing land has allowed the recovery of some common butterflies (Kuussaari et al., 2007).

Agricultural intensification also entails stream channelization, draining of wetlands, modification of floodplains, and removal of riparian canopy cover with subsequent loss of soil and nutrients – all resulting in homogenization of stream microhabitats and alteration of aquatic insect communities (Houghton and Holzenthal, 2010). These activities increase eutrophication, siltation and sedimentation in water bodies, thus reducing the richness of shredders and predators while favouring filterer species (Burdon et al., 2013; Niyogi et al., 2007; Olson et al., 2016). Diverse communities of aquatic plants are an important habitat component in lentic systems such as paddy fields, allowing herbivory, oviposition and emergence of many insects and providing refugia for Odonata nymphs (Nakanishi et al., 2014). In general, loss of permanent flows in streams and rivers leads to a decrease of biodiversity (King et al., 2016), whereas irrigation and man-made water bodies in urbanised areas may have favoured certain species (Kalkman et al., 2010).

In recent decades, urbanisation has taken over agricultural land across the globe, causing the disappearance of many habitat specialists and their replacement with a few generalists adapted to the artificial

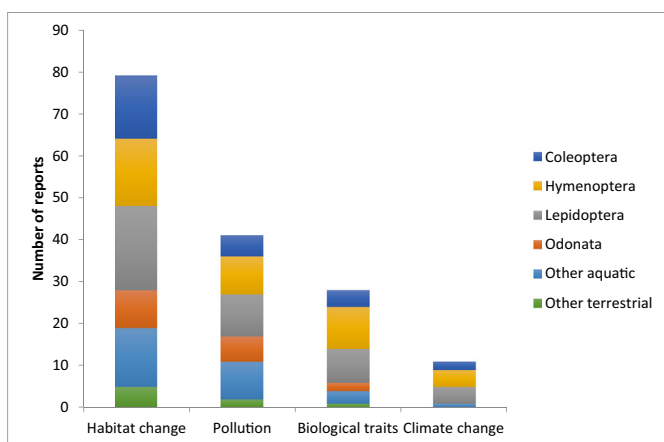


Fig. 5. The four major drivers of decline for each of the studied taxa according to reports in the literature.

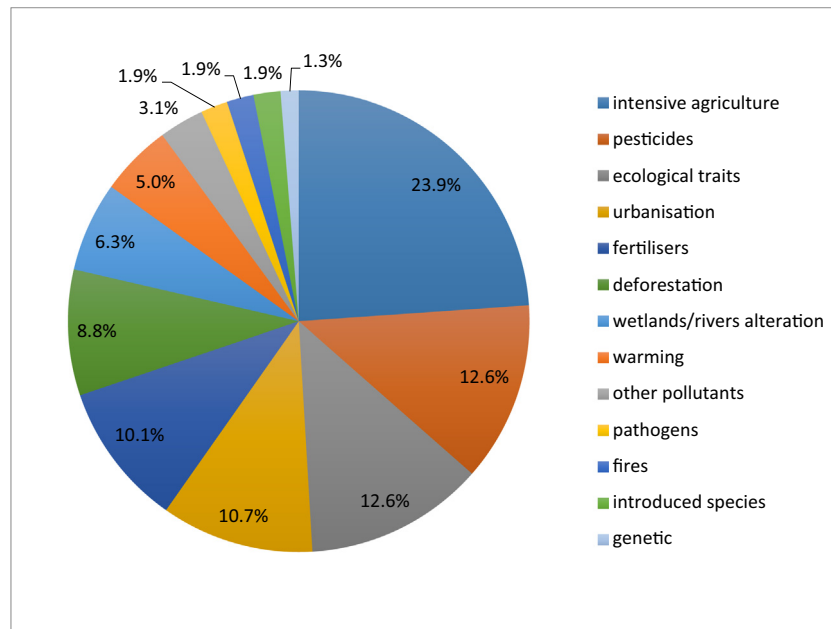


Fig. 6. Main factors associated with insect declines – see also Fig. 5.

human environment. However, such losses can be partially counterbalanced by the creation of urban parklands and gardens, which offer refuge to native and newly-colonising species, including pollinators like *Bombus* spp. (Botías et al., 2017) and butterflies like *Lycaena phlaeas* and *Aphantopus hyperantus* (van Dyck et al., 2009).

In tropical countries of South America, Africa and Asia, deforestation has been and still is a main driver of biodiversity loss and insect declines (Carrasco et al., 2017; Wilson, 2002), including dragonflies (Samways, 1999). Recent research on herbariums of Pacific islands suggests that deforestation and other human impacts on those ecosystems are not confined to the extinction of birds, mammals and snails (Kingsford et al., 2009) but also of insects such as leafminers (Lepidoptera: Gracillariidae) (Hembry, 2013). In Europe, deforestation is the main driver of saproxylic beetles' decline (Nieto and Alexander, 2010). Conversely, afforestation may increase the number of generalist butterflies by increasing habitat diversity at the forest edge (Kuussaari et al., 2007), but woodland diversity, structural and micro-climatic heterogeneity are far more important than forested area per se for maintaining the diversity of moths, butterflies as well as birds (Fuller et al., 2005; van Swaay et al., 2006). Very few generalist species benefit and expand under afforestation, and some European butterfly species even exhibited notable declines (van Swaay et al., 2006). In Britain, a 20-fold increase in conifer plantations since the 19th century did not increase biodiversity nor abundance of Lepidoptera species (Brereton et al., 2011; Fox, 2013).

4.1.2. Pollution

Pollution is the second major driver of insect declines (Fig. 5). Sources of environmental pollution include fertilisers and synthetic pesticides used in agricultural production, sewage and landfill leachates from urbanised areas and industrial chemicals from factories and mining sites. Among these, pesticide pollution is reported in 13% of cases (Fig. 6), followed by fertiliser inputs (10%) and to a lesser extent urban and industrial pollutants (3%).

Intensive agriculture implies the systematic and widespread use of pesticides for controlling crop pests (insecticides), competing weeds (herbicides) and fungal infections (fungicides) among others (Dudley and Alexander, 2017). In terms of toxicity, insecticides are by far the most toxic to all insects and other arthropods, followed by fungicides but not herbicides (Mulé et al., 2017; Sánchez-Bayo and Goka, 2014).

Herbicides, however, reduce the biodiversity of vegetation within the crops and in surrounding areas through drift (Egan et al., 2014) and runoff, thus impacting indirectly on the arthropod species that depend upon wild plants, which either disappear completely or decline significantly in numbers (Goulet and Masner, 2017; Marshall et al., 2003). Thus, the application of herbicides to cropland has had more negative impacts on both terrestrial and aquatic plants and insect biodiversity than any other agronomic practice (Hyvonen and Salonen, 2002; Lundgren et al., 2013). Pesticides have caused the decline of moths in rural areas of the U.K. (Hahn et al., 2015; Wickramasinghe et al., 2004) and pollinators in Italy (Brittain et al., 2010); broad-spectrum insecticides reduce the abundance and diversity of beneficial ground-dwelling and foliage-foraging insects (Lundgren et al., 2013); systemic insecticides reduce populations of ladybirds and butterflies in gardens and nurseries (Krischik et al., 2015), and inflict multiple lethal and sublethal effects on bees (see 3.2.3) and other arthropods. Fungicides are not less damaging to insects, and synergism of a particular group of compounds (i.e., azoles) with insecticide toxicity (Biddinger et al., 2013; Pilling and Jepson, 1993) is certainly involved in honey bee collapses (Simon-Delso et al., 2014).

Pyrethroid, neonicotinoid and fipronil insecticides have a devastating impact on aquatic insects and crustaceans due to their high acute and chronic toxicity (Beketov and Liess, 2008; Kasai et al., 2016; Mian and Mulla, 1992; Roessink et al., 2013), thus reducing significantly their abundance in water bodies (van Dijk et al., 2013). Persistent residues of fipronil in sediments inhibit the emergence of dragonflies (Jinguji et al., 2013; Ueda and Jinguji, 2013) and the development of chironomids and other insect larvae, with negative cascading effects on fish survival (Weston et al., 2015). Systemic insecticides impair the long-term viability of shredder larvae that decompose leaf litter and other organic material (Kreutzweiser et al., 2008), undermine the basis of the insect food web (Sánchez-Bayo et al., 2016a) and thus derail natural biological control mechanisms e.g., in rice paddy ecosystems (Settle et al., 1996). Also, these products readily translocate to pollen, nectar, guttation drops, and all tissues of the treated crops and adjacent plants, impacting on nectar-feeding biota such as bees, butterflies, hoverflies and parasitic wasps (van der Sluijs et al., 2015). Unlike the short-term effects of other pesticides on aquatic organisms (Schäfer et al., 2011; van den Brink et al., 1996), neonicotinoids do not allow the recovery of univoltine and semivoltine aquatic insects (Beketov et al.,

2008), and appear to be the main driver of dragonfly declines in Japan (Nakanishi et al., 2018).

Also, the treatment of livestock with persistent avermectins and insect growth regulators has inadvertently contributed to a reduction of dung beetles in many countries, as residues of these pesticides in dung pats eliminate the developing larvae (Lumaret et al., 1993; Strong, 1992; Wardhaugh and Mahon, 1991). Unfortunately, more tolerant species of Ceratopogonidae and Psychodidae flies that breed in the same pats had their numbers boosted in Japan (Iwasa et al., 2005).

Overall, the systematic, widespread and often superfluous use of pesticides in agricultural and pasture land over the past 60 years has negatively impacted most organisms, from insects to birds and bats (Mineau and Callaghan, 2018; Sánchez-Bayo, 2011). Several multivariate and correlative statistical analyses confirm that the impact of pesticides on biodiversity is larger than that of other intensive agriculture practices (Fuentes-Montemayor et al., 2011; Gibbs et al., 2009; Mineau and Whiteside, 2013), though some authors continue to emphasize habitat and climate changes (Fox, 2013). Hallmann et al. (2017) demonstrated that 80% of the flying insect biomass losses in Germany was not caused by increases in agricultural land, deforestation, urbanisation or climate change but instead by an unknown factor, which the authors believe is pesticide use. This is even more evident for aquatic environments, where pesticide residues from agricultural and urban runoff are the major cause of biodiversity declines at all taxa levels (Beketov et al., 2013; Weston et al., 2014).

Apart from pesticides, the introduction of synthetic fertilisers early in the 20th century is recognised as a key driver of pollinator losses in the U.K. and Europe (Ollerton et al., 2014), particularly among specialist bumblebees. In terrestrial ecosystems, the diversity of plants and associated insect populations correlates negatively with nitrogen input (Öckinger et al., 2006; Pollard et al., 1998; van Swaay et al., 2006). Aquatic species such as dragonflies have also been affected by the eutrophication of surface waters, caused by excessive fertiliser use in rural areas (Kalkman et al., 2010). Equally, anoxia due to eutrophication by fertiliser and sewage has been linked to the depletion of Chironomidae, Trichoptera and Ephemeroptera in lakes (Jenderedjian et al., 2012).

The acidification of waters in Sudbury (Ontario, Canada), as a consequence of reckless mining and smelting activities since the 1850s, has inflicted direct and indirect impacts on aquatic insect communities: mayflies were eliminated in streams with pH below 5.5, but some Odonata and Diptera species increased in numbers due to lack of fish predation (Carbone et al., 1998). Acidic waters, nevertheless, reduce the abundance of Diptera (Ceratopogonidae, Chironomidae), although aquatic insect communities can recover slowly after neutralization and recolonization.

The impact of industrial chemicals (e.g., heavy metals, persistent halogenated hydrocarbons) on insect populations has not been adequately studied. Sub-lethal effects of metal pollution on moth larvae have been reported in Europe (van Ooik et al., 2007), but its link to population-level impacts is not well established. There is consensus, however, that global declines of stoneflies, mayflies and caddisflies can be ascribed to man-made pollutants discharged into streams and rivers (Aubert, 1984; Bojková et al., 2012). Occasionally, industrial spills have wiped out entire communities of aquatic organisms, not just insects, and their recovery has taken years of cleaning efforts (Capel et al., 1988; Giger, 2009). Nevertheless, since aquatic organisms are exposed simultaneously to mixtures of several pollutants, it is difficult to assign causality to individual toxic compounds. A weight-of-evidence approach concluded that insecticides were the most toxic to chironomids, snails and fish, whereas metals and other organic pollutants had a minor effect on those organisms (Kellar et al., 2014). Similar findings have been reported by other authors working with combinations of chromium and pesticides on honeybees: neonicotinoid insecticides were the most toxic to bees, whereas the metal had an antagonistic effect upon fungicide toxicity (Sgolastra et al., 2018).

4.1.3. Biological factors

Parasites and pathogens are definitively involved in the collapse of honeybee colonies in various countries (Goulson et al., 2015) and also appear associated with the declining wild bees in North America (Thorp and Shepherd, 2005). The global spread of *Varroa destructor* mite and the small hive beetle (*Aethina tumida*) pose a real concern for the apicultural industry because they transmit viral infections (vanEngelsdorp et al., 2012). However, pathogens have historically co-existed with managed bee colonies: their recent virulence is more likely to have been fostered by the exposure of bees to pesticide-contaminated pollen and nectar (Long and Krupke, 2016) that weakens their immune system (Sánchez-Bayo et al., 2016b; Tesovnik et al., 2017).

Insect biological control has helped mitigate hundreds of harmful invasive pests worldwide, though unintended ecological impacts have been recorded for at least 10 ill-fated historical efforts (Heimpel and Cock, 2018; Hajek et al., 2016; Hoddle, 2004). The human-assisted introduction of exotic species for biological control can contribute to a decline of endemic insects through processes such as competitive displacement (Roy and Brown, 2015), or direct predation and parasitism (Boettner et al., 2008; Henneman and Memmott, 2001). Yet, few documented species extinctions can be directly ascribed to insect biological control, with such cases largely confined to vulnerable island ecosystems in the Pacific (Hoddle, 2004; King et al., 2010). In the meantime, the practice of biological control has matured over the past decades, and the necessary safeguards have now been put in place to avert the introduction of species that pose tangible ecological risk – e.g., generalist feeders or vertebrate predators (Heimpel and Cock, 2018). Although carefully selected host-specific agents might still cause minor, transient impacts, they regularly reach background population levels as their (invasive) pest targets are being suppressed. Moreover, scientifically-guided biological control can help to permanently resolve invasive species problems and protect biodiversity over extensive geographical areas (Wyckhuys et al., 2019). Hence, this practice need not be viewed as a prime threat to insect biodiversity, but should instead be embraced as a tailor-made alternative to pesticide measures for invasive species control, crop protection or habitat restoration. Biological control, as a core component of ecological intensification (Bommarco et al., 2013; Wyckhuys et al., 2013), can help cut insecticide pollution in agricultural environments, revert insect biodiversity declines and help conserve insect-feeding vertebrates.

Invasive species, on the other hand, can have major impacts on the make-up and functioning of ecosystems in both mainland and island settings (Kenis et al., 2009; Reaser et al., 2007). Ecological impacts are relatively well documented for invasive ants, forest herbivores and bumblebees, with effects on locally-occurring insect communities through trophic interactions such as predation or parasitism (Kenta et al., 2007). For some invasive species, impacts can be temporary as introduced species succumb due to poor adaptation to the novel environment (Cooling and Hoffmann, 2015), while others inflict long-lasting effects, i.e. mammals that prey on giant carabids of New Zealand (McGuinness, 2007). For multiple invasive plant and animal species, ecosystem-wide cascading effects have been reported with pervasive impacts on native insect communities (Bezemer et al., 2014). For example, a global meta-analysis revealed how in 56% cases, invasive plants had negative effects leading to a reduction in the overall abundance, diversity and fitness of different organisms, including insects (Schirmel et al., 2015). The introduction of fish predators such as the rainbow trout (*Oncorhynchus mykiss*) for economic and recreational activities in South Africa has reduced the distribution of the rare dragonfly *Ecchlorolestes peringueyi*, which is currently a threatened species (Samways, 1999). Cattle grazing and the planting of exotic trees along the rivers' edge of that country have also impacted negatively on the diversity of lotic dragonflies, which are at greater risk of extinction than their lentic relatives (Clausnitzer et al., 2009).

Many reports (13%) associate the insect declines with several ecological or life-history traits (Fig. 6). The responsible traits vary among

taxa, but some general trends appear consistently. For example, specialist species are declining at higher rates than non-specialists, because they are either most susceptible to habitat changes and losses of host plants or have lower fecundity rates – usually both traits are combined in *K*-selected species. Generalist species are by nature more adaptable to environmental change due to their broader range of host plants, food and shelter requirements, behavioural plasticity and climatic adaptability, surviving under wide-ranging conditions and often colonising vacant niches and new urbanised environments (van Strien et al., 2016).

Finally, increased predation has been suggested as a contributing factor in the decline of large dung beetles in Italy (Carpaneto et al., 2007). Over-collection of specimens has also been suggested in Japan (Nakamura, 2011), but the relative impact of these factors is comparatively minor and geographically confined.

4.1.4. Climate change

The current warming trend, thought by some as the main driver of butterfly and wild bees declines (Bartomeus et al., 2011; Breed et al., 2012; Parmesan et al., 1999), might positively impact on their abundance in temperate regions as they exhibit superior thermal tolerance which - in turn - may benefit their development (Deutsch et al., 2008). In contrast, insects of tropical regions have more narrow thermal thresholds and are particularly susceptible to temperature increases. Hence, global warming has increased the populations of certain butterflies in northern Europe (Kuussaari et al., 2007), expanded their geographical distribution (Isaac et al., 2011; Stefanescu et al., 2011) and caused altitudinal shifts of certain species (Chen et al., 2011; Colwell et al., 2008), yet populations of half of the world's insects are declining counter to that trend (Gilburn et al., 2015).

Global warming has certainly reduced the range of some dragonflies, stoneflies and bumblebees adapted to cold climates and higher latitudes (Ball-Damerow et al., 2014; Jacobson et al., 2018; Tierno de Figueroa et al., 2010), negatively impacted some pollinators in Mediterranean regions such as the beetle *Mylabris nevadensis* (Stefanescu et al., 2018), and might increase the extinction risk of mountainous insect species (Menéndez et al., 2006). There is also clear evidence that climate change is reducing arthropod biomass in the rainforests of Caribbean islands (Lister and Garcia, 2018).

5. Conclusions

This review highlights the dreadful state of insect biodiversity in the world, as almost half of the species are rapidly declining and a third are being threatened with extinction. The information presented here refers mostly to developed countries of Europe and North America (Fig. 1) since those regions have the most comprehensive historical records that allow comparisons of biodiversity on a temporal scale.

Habitat change and pollution are the main drivers of such declines. In particular, the intensification of agriculture over the past six decades stands as the root cause of the problem, and within it the widespread, relentless use of synthetic pesticides is a major driver of insect losses in recent times (Dudley and Alexander, 2017). Given that these factors apply to all countries in the world, insects are not expected to fare differently in tropical and developing countries. The conclusion is clear: unless we change our ways of producing food, insects as a whole will go down the path of extinction in a few decades (Dudley et al., 2017; Fischer et al., 2008; Gomiero et al., 2011). The repercussions this will have for the planet's ecosystems are catastrophic to say the least, as insects are at the structural and functional base of many of the world's ecosystems since their rise at the end of the Devonian period, almost 400 million years ago.

Habitat restoration, coupled with a drastic reduction in agro-chemical inputs and agricultural 'redesign', is probably the most effective way to stop further declines, particularly in areas under intensive agriculture. For example, flower and grassland strips established at the

field edge enhance the abundance of wild pollinators (Blaauw and Isaacs, 2014; Hopwood, 2008), and rotation of crops with clover boosts the abundance and diversity of bumblebees (Ekroos et al., 2014; Haaland and Bersier, 2011), which in turn boost crop yield and farm profitability. These 'ecological engineering' tactics not only favour pollinators but also conserve insect natural enemies that are essential for keeping at bay the herbivorous pest species of many crops (Dover et al., 2011; Gurr et al., 2012; Lu et al., 2015). However, for these measures to be effective, it is imperative that current pesticide usage patterns, mainly insecticides and fungicides, are reduced to a minimum as to permit a recovery of insect numbers and their associated 'biological control' services (Heong et al., 2015; Way and Heong, 1994). There is no danger in reducing synthetic insecticides drastically, as they do not contribute significantly to crop yields, but trigger pest resistance, negatively affect food safety and sometimes lower farm revenue (Bredeson and Lundgren, 2018; Lechenet et al., 2017). The judicious implementation of integrated pest management (IPM) in Europe as well as in developing countries of Africa and Asia over the years achieved similar or even greater crop yields (Furlan et al., 2017; Pretty and Bharucha, 2015; Pretty et al., 2011; Thancharoen et al., 2018). Furthermore, in many of the world's farming systems, biological control constitutes an under-used yet cost-effective means to resolve agricultural pest problems while conserving biodiversity both on-farm and beyond the field border (Wyckhuys et al., 2019).

For aquatic insects, rehabilitation of marshlands and improved water quality are a must for the recovery of biodiversity (van Strien et al., 2016). This may require the implementation of effective remediation technologies to clean the existing polluted waters (Arzate et al., 2017; Pascal-Lorber and Laurent, 2011). However, priority should be given to reducing the contamination by runoff and leaching of toxic chemicals, particularly pesticides. Only such conditions can allow the re-colonization of a myriad of discrete species that support essential ecosystem services such as litter-decomposition and nutrient recycling, provide food to fish and other aquatic animals, and are efficient predators of crop pests, aquatic weeds and nuisance mosquitoes.

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.biocon.2019.01.020>.

References

- Aizen, M.A., Garibaldi, L.A., Cunningham, S.A., Klein, A.M., 2009. How much does agriculture depend on pollinators? Lessons from long-term trends in crop production. *Ann. Bot.* 103, 1579–1588.
- Alburaki, M., Boutin, S., Mercier, P.-L., Loubliey, Y., Chagnon, M., Derome, N., 2015. Neonicotinoid-coated *Zea mays* seeds indirectly affect honeybee performance and pathogen susceptibility in field trials. *PLoS One* 10, e0125790.
- Alburaki, M., Chen, D., Skinner, J.A., Meikle, W.G., Tapy, D.R., Adamczyk, J., Stewart, S.D., 2018. Honey bee survival and pathogen prevalence: from the perspective of landscape and exposure to pesticides. *Insects* 9, 65.
- Allan, J.D., Flecker, A.S., 1993. Biodiversity conservation in running waters. *Bioscience* 43, 32–43.
- Anderson, K.E., Sheehan, T.H., Eckholm, B.J., Mott, B.M., DeGrandi-Hoffman, G., 2011. An emerging paradigm of colony health: microbial balance of the honey bee and hive (*Apis mellifera*). *Insect. Soc.* 58, 431–444.
- Arzate, S., García Sánchez, J.L., Soriano-Molina, P., Casas López, J.L., Campos-Mañas, M.C., Agüera, A., Sánchez Pérez, J.A., 2017. Effect of residence time on micro-pollutant removal in WWTP secondary effluents by continuous solar photo-Fenton process in raceway pond reactors. *Chem. Eng. J.* 316, 1114–1121.
- Aubert, J., 1984. L'atlas des pléocoptères de Suisse - influence de la pollution. *Ann. Limnol.* 20, 17–19.
- Ball-Damerow, J.E., M'Gonigle, L.K., Resh, V.H., 2014. Changes in occurrence, richness, and biological traits of dragonflies and damselflies (Odonata) in California and Nevada over the past century. *Biodivers. Conserv.* 23, 2107–2126.
- Bambaradeniya, C.N.B., Amerasinghe, F.P., 2003. Biodiversity Associated with the Rice Field Agroecosystem in Asian Countries: A Brief Review. Sri Lanka, International Water Management Institute, Colombo, pp. 24.
- Barnosky, A.D., Matzke, N., Tomiya, S., Wogan, G.O.U., Swartz, B., Quental, T.B., Marshall, C., McGuire, J.L., Lindsey, E.L., Maguire, K.C., Mersey, B., Ferrer, E.A., 2011. Has the Earth's sixth mass extinction already arrived? *Nature* 471, 51–57.
- Bartomeus, I., Ascher, J.S., Wagner, D., Danforth, B.N., Colla, S., Kornbluth, S., Winfree, R., 2011. Climate-associated phenological advances in bee pollinators and bee-pollinated plants. *Proc. Natl. Acad. Sci.* 108, 20645–20649.
- Bartomeus, I., Potts, S.G., Steffan-Dewenter, I., Vaissière, B.E., Woyciechowski, M.,

- Krewenka, K.M., Tschulin, T., Roberts, S.P.M., Szentgyörgyi, H., Westphal, C., Bommarco, R., 2014. Contribution of insect pollinators to crop yield and quality varies with agricultural intensification. *PeerJ* 2, e328.
- Beketov, M.A., Liess, M., 2008. Acute and delayed effects of the neonicotinoid insecticide thiacloprid on seven freshwater arthropods. *Environ. Toxicol. Chem.* 27, 461–470.
- Beketov, M., Schäfer, R.B., Marwitz, A., Paschke, A., Liess, M., 2008. Long-term stream invertebrate community alterations induced by the insecticide thiacloprid: effect concentrations and recovery dynamics. *Sci. Total Environ.* 405, 96–108.
- Beketov, M.A., Kefford, B.J., Schäfer, R.B., Liess, M., 2013. Pesticides reduce regional biodiversity of stream invertebrates. *Proc. Natl. Acad. Sci.* 110, 11039–11043.
- Bennett, A.B., Isaacs, R., 2014. Landscape composition influences pollinators and pollination services in perennial biofuel plantings. *Agric. Ecosyst. Environ.* 193, 1–8.
- Bezemer, T.M., Harvey, J.A., Cronin, J.T., 2014. Response of native insect communities to invasive plants. *Annu. Rev. Entomol.* 59, 119–141.
- Biddinger, D.J., Robertson, J.L., Mullin, C., Frazier, J., Ashcraft, S.A., Rajotte, E.G., Joshi, N.K., Vaughn, M., 2013. Comparative toxicities and synergism of apple orchard pesticides to *Apis mellifera* (L.) and *Osmia cornifrons* (Radoszkowski). *PLoS One* 8, e72587.
- Biedermann, R., Achtziger, R., Nickel, H., Stewart, A.J.A., 2005. Conservation of grassland leafhoppers: a brief review. *J. Insect Conserv.* 9, 229–243.
- Biesmeijer, J.C., Roberts, S.P.M., Reemer, M., Ohlemüller, R., Edwards, M., Peeters, T., Schaffers, A.P., Potts, S.G., Kleukers, R., Thomas, C.D., Settele, J., Kunin, W.E., 2006. Parallel declines in pollinators and insect-pollinated plants in Britain and the Netherlands. *Science* 313, 351–354.
- Birdlife International, 2015. European Red List of Birds. Publications Office of the European Union, Luxembourg.
- Blaauw, B.R., Isaacs, R., 2014. Flower plantings increase wild bee abundance and the pollination services provided to a pollination-dependent crop. *J. Appl. Ecol.* 51, 890–898.
- Boettner, G.H., Elkinton, J.S., Boettner, C.J., 2008. Effects of a biological control introduction on three nontarget native species of Saturniid moths. *Conserv. Biol.* 14, 1798–1806.
- Bojková, J., Komprdová, K., Soldán, T., Zahrádková, S., 2012. Species loss of stoneflies (Plecoptera) in the Czech Republic during the 20th century. *Freshw. Biol.* 57, 2550–2567.
- Bojková, J., Rádková, V., Soldán, T., Zahrádková, S., 2014. Trends in species diversity of lotic stoneflies (Plecoptera) in the Czech Republic over five decades. *Insect Conserv. Divers.* 7, 252–262.
- Bommarco, R., Lundin, O., Smith, H.G., Rundlöf, M., 2012. Drastic historic shifts in bumble-bee community composition in Sweden. *Proc. R. Soc. B Biol. Sci.* 279, 309–315.
- Bommarco, R., Kleijn, D., Potts, S.G., 2013. Ecological intensification: harnessing ecosystem services for food security. *Trends Ecol. Evol.* 28, 230–238.
- Bottas, C., David, A., Hill, E.M., Goulson, D., 2017. Quantifying exposure of wild bumblebees to mixtures of agrochemicals in agricultural and urban landscapes. *Environ. Pollut.* 222, 73–82.
- Brandt, A., Grikscheit, K., Siede, R., Grosse, R., Meixner, M.D., Büchler, R., 2017. Immunosuppression in honeybee queens by the neonicotinoids thiacloprid and clothianidin. *Sci. Rep.* 7, 4673.
- Bredeson, M.M., Lundgren, J.G., 2018. Thiamethoxam seed treatments have no impact on pest numbers or yield in cultivated sunflowers. *J. Econ. Entomol.* 108, 2665–2671.
- Breed, G.A., Stichter, S., Crone, E.E., 2012. Climate-driven changes in northeastern US butterfly communities. *Nat. Clim. Chang.* 3, 142.
- Brereton, T., Roy, D.B., Middlebrook, I., Botham, M., Warren, M., 2011. The development of butterfly indicators in the United Kingdom and assessments in 2010. *J. Insect Conserv.* 15, 139–151.
- Brittain, C.A., Vighi, M., Bommarco, R., Settele, J., Potts, S.G., 2010. Impacts of a pesticide on pollinator species richness at different spatial scales. *Basic Appl. Ecol.* 11, 106–115.
- Brooks, D.R., Bater, J.E., Clark, S.J., Monteith, D.T., Andrews, C., Corbett, S.J., Beaumont, D.A., Chapman, J.W., 2012. Large carabid beetle declines in a United Kingdom monitoring network increases evidence for a widespread loss in insect biodiversity. *J. Appl. Ecol.* 49, 1009–1019.
- Brown, M., Miller, S., 1998. Coccinellidae (Coleoptera) in apple orchards of eastern West Virginia and the impact of invasion by *Harmonia axyridis*. *Entomol. News* 109, 143–151.
- Brown, P.M.J., Roy, H.E., 2015. Reflections on the long-term assessment of ladybird (Coleoptera: Coccinellidae) populations in the Czech Republic and the United Kingdom. *Acta Soc. Zool. Bohemicae* 79, 19–27.
- Burdon, F.J., McIntosh, A.R., Harding, J.S., 2013. Habitat loss drives threshold response of benthic invertebrate communities to deposited sediment in agricultural streams. *Ecol. Appl.* 23, 1036–1047.
- Burkle, L.A., Marlin, J.C., Knight, T.M., 2013. Plant-pollinator interactions over 120 years: loss of species, co-occurrence, and function. *Science* 339, 1611–1615.
- Camacho-Cervantes, M., Ortega-Iturriga, A., del Val, E., 2017. From effective biocontrol agent to successful invader: the harlequin ladybird (*Harmonia axyridis*) as an example of good ideas that could go wrong. *PeerJ* 5, e3296.
- Cameron, S.A., Lozier, J.D., Strange, J.P., Koch, J.B., Cordes, N., Solter, L.F., Griswold, T.L., 2011. Patterns of widespread decline in North American bumble bees. *Proc. Natl. Acad. Sci. U. S. A.* 108, 662–667.
- Capel, P.D., Giger, W., Reichert, P., Wanner, O., 1988. Accidental input of pesticides into the Rhine River. *Environ. Sci. Technol.* 22, 992–997.
- Carbone, J., Keller, W., Griffiths, R.W., 1998. Effects of changes in acidity on aquatic insects in rocky littoral habitats of lakes near Sudbury, Ontario. *Restor. Ecol.* 6, 376–389.
- Carpaneto, G.M., Mazziotto, A., Valerio, L., 2007. Inferring species decline from collection records: roller dung beetles in Italy (Coleoptera, Scarabaeidae). *Divers. Distrib.* 13, 903–919.
- Carrasco, L.R., Webb, E.L., Symes, W.S., Koh, L.P., Sodhi, N.S., 2017. Global economic trade-offs between wild nature and tropical agriculture. *PLoS Biol.* 15, e2001657.
- Ceballos, G., Ehrlich, P.R., 2002. Mammal population losses and the extinction crisis. *Science* 296, 904–907.
- Ceballos, G., Ehrlich, P.R., Dirzo, R., 2017. Biological annihilation via the ongoing sixth mass extinction signaled by vertebrate population losses and declines. *Proc. Natl. Acad. Sci.* 114, E6089–E6096.
- Chamberlain, D.E., Fuller, R.J., 2000. Local extinctions and changes in species richness of lowland farmland birds in England and Wales in relation to recent changes in agricultural land-use. *Agric. Ecosyst. Environ.* 78, 1–17.
- Chapin-III, F.S., Zavaleta, E.S., Eviner, V.T., Naylor, R.L., Vitousek, P.M., Reynolds, H.L., Hooper, D.U., Lavorel, S., Sala, O.E., Hobbie, S.E., Mack, M.C., Diaz, S., 2000. Consequences of changing biodiversity. *Nature* 405, 234–242.
- Chen, I.C., Hill, J.K., Shiu, H.J., Holloway, J.D., Benedict, S., Chey, V.K., Barlow, H.S., Thomas, C.D., 2011. Asymmetric boundary shifts of tropical montane Lepidoptera over four decades of climate warming. *Glob. Ecol. Biogeogr.* 20, 34–45.
- Chen, C., Liu, Z., Luo, Y., Xu, Z., Wang, S., Zhang, X., Dai, R., Gao, J., Chen, X., Guo, H., Wang, H., Tang, J., Shi, W., 2017. Managed honeybee colony losses of the Eastern honeybee (*Apis cerana*) in China (2011–2014). *Apidologie* 48, 692–702.
- Clausnitzer, V., Kalkman, V.J., Ram, M., Collen, B., Baillie, J.E.M., Bedjanic, M., Darwall, W.R.T., Dijkstra, K.-D.B., Dow, R., Hawking, J., Karube, H., Malikova, E., Paulson, D., Schütte, K., Suhling, F., Villanueva, R.J., von Ellenrieder, N., Wilson, K., 2009. Odonata enter the biodiversity crisis debate: the first global assessment of an insect group. *Biol. Conserv.* 142, 1864–1869.
- Colla, S., Packer, L., 2008. Evidence for decline in eastern North American bumblebees (Hymenoptera: Apidae), with special focus on *Bombus affinis* Cresson. *Biodivers. Conserv.* 17, 1379–1391.
- Collen, B., Ram, M., Zamin, T., McRae, L., 2008. The tropical biodiversity data gap: addressing disparity in global monitoring. *Trop. Conserv. Sci.* 1, 75–88.
- Colwell, R.K., Brehm, G., Cardelús, C.L., Gilman, A.C., Longino, J.T., 2008. Global warming, elevational range shifts, and lowland biotic attrition in the wet tropics. *Science* 322, 258.
- Conrad, K.F., Warren, M.S., Fox, R., Parsons, M.S., Woilwod, I.P., 2006. Rapid declines of common, widespread British moths provide evidence of an insect biodiversity crisis. *Biol. Conserv.* 132, 279–291.
- Cooling, M., Hoffmann, B.D., 2015. Here today, gone tomorrow: declines and local extinctions of invasive ant populations in the absence of intervention. *Biol. Invasions* 17, 3351–3357.
- Cox, N.A., Temple, H.J., 2009. European Red List of Reptiles. Publications Office of the European Union, Luxembourg.
- Davis, A.L.V., Scholtz, C.H., Dooley, P.W., Bham, N., Kryger, U., 2004. Scarabaeine dung beetles as indicators of biodiversity, habitat transformation and pest control chemicals in agro-ecosystems. *S. Afr. J. Plant Soil* 100, 415–424.
- Desender, K., Turin, H., 1989. Loss of habitats and changes in the composition of the ground and tiger beetle fauna in four West European countries since 1950 (Coleoptera: Carabidae, Cicindelidae). *Biol. Conserv.* 48, 277–294.
- Desneux, N., Decourtye, A., Delpuech, J.-M., 2007. The sublethal effects of pesticides on beneficial arthropods. *Annu. Rev. Entomol.* 52, 81–106.
- Deutsch, C.A., Tewksbury, J.J., Huey, R.B., Sheldon, K.S., Ghalambor, C.K., Haak, D.C., Martin, P.R., 2008. Impacts of climate warming on terrestrial ectotherms across latitude. *Proc. Natl. Acad. Sci.* 105, 6668.
- DeWalt, R.E., Favret, C., Webb, D.W., 2005. Just how imperiled are aquatic insects? A case study of stoneflies (Plecoptera) in Illinois. *Ann. Entomol. Soc. Am.* 98, 941–950.
- Di Prisco, G., Cavaliere, V., Annoscia, D., Varricchio, P., Caprio, E., Nazzi, F., Gargiulo, G., Pennacchio, F., 2013. Neonicotinoid clothianidin adversely affects insect immunity and promotes replication of a viral pathogen in honey bees. *Proc. Natl. Acad. Sci.* 110, 18466–18471.
- Diamond, J.M., 1989. The present, past and future of human-caused extinctions. *Philos. Trans. R. Soc. Lond. Ser. B Biol. Sci.* 325, 469–477.
- Dirzo, R., Young, H.S., Galetti, M., Ceballos, G., Isaac, N.J.B., Collen, B., 2014. Defaunation in the Anthropocene. *Science* 345, 401–406.
- Dover, J.W., Spencer, S., Collins, S., Hadjigeorgiou, I., Rescia, A., 2011. Grassland butterflies and low intensity farming in Europe. *J. Insect Conserv.* 15, 129–137.
- Dudley, N., Alexander, S., 2017. Agriculture and biodiversity: a review. *Biodiversity* 18, 45–49.
- Dudley, N., Attwood, S.J., Goulson, D., Jarvis, D., Bharucha, Z.P., Pretty, J., 2017. How should conservationists respond to pesticides as a driver of biodiversity loss in agroecosystems? *Biol. Conserv.* 209, 449–453.
- Dunn, R.R., 2005. Modern insect extinctions, the neglected majority. *Conserv. Biol.* 19, 1030–1036.
- Dupont, Y.L., Damgaard, C., Simonsen, V., 2011. Quantitative historical change in bumblebee (*Bombus* spp.) assemblages of red clover fields. *PLoS One* 6, e25172.
- Egan, J.F., Bohnenblust, E., Goslee, S., Mortensen, D., Tooker, J., 2014. Herbicide drift can affect plant and arthropod communities. *Agric. Ecosyst. Environ.* 185, 77–87.
- Ekroos, J., Olsson, O., Rundlöf, M., Wätzold, F., Smith, H.G., 2014. Optimizing agri-environment schemes for biodiversity, ecosystem services or both? *Biol. Conserv.* 172, 65–71.
- Ellis, J., 2012. The honey bee crisis. *Outlooks Pest Manag.* 23, 35–40.
- Ellis, J.D., Evans, J.D., Pettis, J., 2010. Colony losses, managed colony population decline, and Colony Collapse Disorder in the United States. *J. Apic. Res.* 49, 134–136.
- Erhardt, A., Thomas, J.A., 1991. Lepidoptera as indicators of change in semi-natural grasslands of lowland and upland in Europe. In: Collins, N.M., Thomas, J. (Eds.), *The Conservation of Insects and Their Habitats*. Academic Press, London, pp. 2130236.
- FAO, 2015. FAOSTAT On-line Statistical Service. Food and Agriculture Organization of

- the United Nations.
- Figuerola, L.L., Bergue, E.A., 2015. Bumble bees (Hymenoptera: Apidae) of Oklahoma: past and present biodiversity. *J. Kansas Entomol. Soc.* 88, 418–429.
- Fischer, J., Brosi, B., Daily, G.C., Ehrlich, P.R., Goldman, R., Goldstein, J., Lindenmayer, D.B., Manning, A.D., Mooney, H.A., Pejchar, L., Ranganathan, J., Tallis, H., 2008. Should agricultural policies encourage land sparing or wildlife-friendly farming? *Front. Ecol. Environ.* 6, 380–385.
- Fochetti, R., de Figuerola, J.M.T., 2006. Notes on diversity and conservation of the European fauna of Plecoptera (Insecta). *J. Nat. Hist.* 40, 2361–2369.
- Foley, J.A., DeFries, R., Asner, G.P., Barford, C., Bonan, G., Carpenter, S.R., Chapin, F.S., Coe, M.T., Daily, G.C., Gibbs, H.K., Helkowski, J.H., Holloway, T., Howard, E.A., Kucharik, C.J., Monfreda, C., Patz, J.A., Prentice, I.C., Ramankutty, N., Snyder, P.K., 2005. Global consequences of land use. *Science* 309, 570.
- Forister, M.L., Cousens, B., Harrison, J.G., Anderson, K., Thorne, J.H., Waetjen, D., Nice, C.C., De Parsia, M., Hladik, M.L., Meese, R., van Vliet, H., Shapiro, A.M., 2016. Increasing neonicotinoid use and the declining butterfly fauna of lowland California. *Biol. Lett.* 12, 20160475.
- Fox, R., 2013. The decline of moths in Great Britain: a review of possible causes. *Insect Conserv. Divers.* 6, 5–19.
- Fox, R., Asher, J., Brereton, T., Roy, D., Warren, M., 2006. *The State of Butterflies in Britain and Ireland*. Pisces Publications, Newbury, U.K.
- Fox, R., Randle, Z., Hill, L., Anders, S., Wiffen, L., Parsons, M.S., 2011. Moths count: recording moths for conservation in the UK. *J. Insect Conserv.* 15, 55–68.
- Frankie, G.W., Rizzardi, M., Vinson, S.B., Griswold, T.L., 2009. Decline in bee diversity and abundance from 1972–2004 on a flowering leguminous tree, *Andira inermis* in Costa Rica at the interface of disturbed dry forest and the urban environment. *J. Kansas Entomol. Soc.* 82, 1–20.
- Franzén, M., Johannesson, M., 2007. Predicting extinction risk of butterflies and moths (Macrolepidoptera) from distribution patterns and species characteristics. *J. Insect Conserv.* 11, 367–390.
- Fuentes-Montemayor, E., Goulson, D., Park, K.J., 2011. Pipistrelle bats and their prey do not benefit from four widely applied agri-environment management prescriptions. *Biol. Conserv.* 144, 2233–2246.
- Fukui, M., 2012. Records of decrease in *Sympetrum* species population at Shizuoka Prefecture. *Nat. Insects* 47, 5–9.
- Fuller, R.J., Gregory, R.D., Gibbons, D.W., Marchant, J.H., Wilson, J.D., Baillie, S.R., Carter, N., 1995. Population declines and range contractions among lowland farmland birds in Britain. *Conserv. Biol.* 9, 1425–1441.
- Fuller, R.J., Norton, L.R., Feber, R.E., Johnson, P.J., Chamberlain, D.E., Joys, A.C., Mathews, F., Stuart, R.C., Townsend, M.C., Manley, W.J., Wolfe, M.S., Macdonald, D.W., Firbank, L.G., 2005. Benefits of organic farming to biodiversity vary among taxa. *Biol. Lett.* 1, 431–434.
- Furlan, L., Vasileiadis, V.P., Chiarini, F., Huiting, H., Leskovšek, R., Razinger, J., Holb, I.J., Sartori, E., Urek, G., Verschwele, A., Benvegnù, I., Sattin, M., 2017. Risk assessment of soil-pest damage to grain maize in Europe within the framework of Integrated Pest Management. *Crop Prot.* 97, 52–59.
- Futahashi, R., 2012. Recent decline of red dragonflies in Toyama Prefecture. *Nat. Insects* 47, 10–15.
- Gallai, N., Salles, J.-M., Settele, J., Vaissiere, B.E., 2009. Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. *Ecol. Econ.* 68, 810–821.
- Gardiner, M.M., Allee, L.L., Brown, P.M.J., Losey, J.E., Roy, H.E., Smyth, R.R., 2012. Lessons from lady beetles: accuracy of monitoring data from US and UK citizen-science programs. *Front. Ecol. Environ.* 10, 471–476.
- Gardner, J.D., Spivak, M., 2014. A survey and historical comparison of the Megachilidae (Hymenoptera: Apoidea) of Itasca State Park, Minnesota. *Ann. Entomol. Soc. Am.* 107, 983–993.
- Gaston, K.J., Fuller, R.A., 2007. Biodiversity and extinction: losing the common and the widespread. *Prog. Phys. Geogr. Earth Environ.* 31, 213–225.
- Gibbs, J., 2013. Neonicotinoids in Australia. (*The Australasian Beekeeper*).
- Gibbs, K.E., Mackey, R.L., Currie, D.J., 2009. Human land use, agriculture, pesticides and losses of imperiled species. *Divers. Distrib.* 15, 242–253.
- Gibbs, H.K., Ruesch, A.S., Achard, F., Clayton, M.K., Holmgren, P., Ramankutty, N., Foley, J.A., 2010. Tropical forests were the primary sources of new agricultural land in the 1980s and 1990s. *Proc. Natl. Acad. Sci.* 107, 16732–16737.
- Giger, W., 2009. The Rhine red, the fish dead—the 1986 Schweizerhalle disaster, a retrospective and long-term impact assessment. *Environ. Sci. Pollut. Res. Int.* 16, S98–S111.
- Gilburn, A.S., Bunnefeld, N., Wilson, J.M., Botham, M.S., Brereton, T.M., Fox, R., Goulson, D., 2015. Are neonicotinoid insecticides driving declines of widespread butterflies? *PeerJ* 3, e1402.
- Gomiero, T., Pimentel, D., Paoletti, M.G., 2011. Is there a need for a more sustainable agriculture? *Crit. Rev. Plant Sci.* 30, 6–23.
- Goulet, H., Masner, L., 2017. Impact of herbicides on the insect and spider diversity in eastern Canada. *Biodiversity* 18, 50–57.
- Goulson, D., Hanley, M.E., Darvill, B., Ellis, J.S., Knight, M.E., 2005. Causes of rarity in bumblebees. *Biol. Conserv.* 122, 1–8.
- Goulson, D., Nicholls, E., Botías, C., Rotheray, E.L., 2015. Bee declines driven by combined stress from parasites, pesticides, and lack of flowers. *Science* 347, 1255957.
- Grixti, J.C., Wong, L.T., Cameron, S.A., Favret, C., 2009. Decline of bumble bees (*Bombus*) in the North American Midwest. *Biol. Conserv.* 142, 75–84.
- Groenendijk, D., Ellis, W.N., 2011. The state of the Dutch larger moth fauna. *J. Insect Conserv.* 15, 95–101.
- Groenendijk, D., van der Meulen, J., 2004. Conservation of moths in The Netherlands: population trends, distribution patterns and monitoring techniques of day-flying moths. *J. Insect Conserv.* 8, 109–118.
- Gurr, G.M., Heong, K.L., Cheng, J.A., Catindig, J., 2012. Ecological engineering against insect pests in Asian irrigated rice. In: Gurr, G.M., Wratten, S.D., Snyder, W.E., Read, D.M.Y. (Eds.), *Biodiversity and Insect Pests: Key Issues for Sustainable Management*. John Wiley & Sons, Ltd., U.K., pp. 214–229.
- Haaland, C., Bersier, L.-F., 2011. What can sown wildflower strips contribute to butterfly conservation?: an example from a Swiss lowland agricultural landscape. *J. Insect Conserv.* 15, 301–309.
- Hahn, M., Schotthöfer, A., Schmitz, J., Franke, L.A., Brühl, C.A., 2015. The effects of agrochemicals on Lepidoptera, with a focus on moths, and their pollination service in field margin habitats. *Agric. Ecosyst. Environ.* 207, 153–162.
- Hajek, A.E., Hurlley, B.P., Kenis, M., Garnas, J.R., Bush, S.J., Wingfield, M.J., van Lenteren, J.C., Cock, M.J.W., 2016. Exotic biological control agents: a solution or contribution to arthropod invasions? *Biol. Invasions* 18, 953–969.
- Hallmann, C.A., Foppen, R.P.B., van Turnhout, C.A.M., de Kroon, H., Jongejans, E., 2014. Declines in insectivorous birds are associated with high neonicotinoid concentrations. *Nature* 511, 341–343.
- Hallmann, C.A., Sorg, M., Jongejans, E., Siepel, H., Hofland, N., Schwan, H., Stenmans, W., Müller, A., Sumser, H., Hörrn, T., Goulson, D., de Kroon, H., 2017. More than 75 percent decline over 27 years in total flying insect biomass in protected areas. *PLoS One* 12, e0185809.
- Harmon, J.P., Stephens, E., Losey, J., 2007. The decline of native coccinellids (Coleoptera: Coccinellidae) in the United States and Canada. *J. Insect Conserv.* 11, 85–94.
- Heimpel, G.E., Cock, M.J.W., 2018. Shifting paradigms in the history of classical biological control. *BioControl* 63, 27–37.
- Hembry, D.H., 2013. Herbarium specimens reveal putative insect extinction on the deforested island of Mangareva (Gambier Archipelago, French Polynesia). *Pac. Sci.* 67, 553–560.
- Henneman, M.L., Memmott, J., 2001. Infiltration of a Hawaiian community by introduced biological control agents. *Science* 293, 1314.
- Heong, K.L., Wong, L., Delos Reyes, J.H., 2015. Addressing planthopper threats to Asian rice farming and food security: fixing insecticide misuse. In: Heong, K.L., Cheng, J., Escalada, M.M. (Eds.), *Rice Planthoppers: Ecology, Management, Socio Economics and Policy*. Springer Netherlands, Dordrecht, pp. 65–76.
- Hickling, R., Roy David, B., Hill Jane, K., Thomas Chris, D., 2005. A northward shift of range margins in British Odonata. *Glob. Chang. Biol.* 11, 502–506.
- Hodde, M.S., 2004. Restoring balance: using exotic species to control invasive exotic species. *Conserv. Biol.* 18, 38–49.
- Honek, A., Martinkova, Z., Kindlmann, P., Ameixa Olga, M.C.C., Dixon Anthony, F.G., 2014. Long-term trends in the composition of aphidophagous coccinellid communities in Central Europe. *Insect Conserv. Divers.* 7, 55–63.
- Hopwood, J.L., 2008. The contribution of roadside grassland restorations to native bee conservation. *Biol. Conserv.* 141, 2632–2640.
- Houghton, D.C., Holzenthal, R.W., 2010. Historical and contemporary biological diversity of Minnesota caddisflies: a case study of landscape-level species loss and trophic composition shift. *J. N. Am. Benthol. Soc.* 29, 480–495.
- Huang, Z., 2012. Pollen nutrition affects honey bee stress resistance. *Terr. Arthropod Rev.* 5, 175–189.
- Hyonen, T., Salonen, J., 2002. Weed species diversity and community composition in cropping practices at two intensity levels: a six-year experiment. *Plant Ecol.* 159, 73–81.
- Isaac, N.J.B., Girardello, M., Brereton, T.M., Roy, D.B., 2011. Butterfly abundance in a warming climate: patterns in space and time are not congruent. *J. Insect Conserv.* 15, 233–240.
- Iwasa, M., Nakamura, T., Fukaki, K., Yamashita, N., 2005. Nontarget effects of ivermectin on coprophagous insects in Japan. *Environ. Entomol.* 34, 1485–1492.
- Jacobson, M.M., Tucker, E.M., Mathiassen, M.E., Rehan, S.M., 2018. Decline of bumble bees in northeastern North America, with special focus on *Bombus terricola*. *Biol. Conserv.* 217, 437–445.
- Jenderedjian, K., Hakobyan, S., Stapanian, M.A., 2012. Trends in benthic macroinvertebrate community biomass and energy budgets in Lake Sevan, 1928–2004. *Environ. Monit. Assess.* 184, 6647–6671.
- Jingui, H., Thuyet, D., Ueda, T., Watanabe, H., 2013. Effect of imidacloprid and fipronil pesticide application on *Sympetrum infuscatum* (Libellulidae: Odonata) larvae and adults. *Paddy Water Environ.* 11, 277–284.
- Johnson, R.M., Dahlgren, L., Siegfried, B.D., Ellis, M.D., 2013. Acaricide, fungicide and drug interactions in honey bees (*Apis mellifera*). *PLoS One* 8, e54092.
- Kadoya, T., Suda, S.-i., Washitani, I., 2009. Dragonfly crisis in Japan: a likely consequence of recent agricultural habitat degradation. *Biol. Conserv.* 142, 1899–1905.
- Kairo, G., Poquet, Y., Haji, H., Tchamitchian, S., Cousin, M., Bonnet, M., Pelissier, M., Kretzschmar, A., Belzunces, L.P., Brunet, J.-L., 2017. Assessment of the toxic effect of pesticides on honey bee drone fertility using laboratory and semifield approaches: a case study of fipronil. *Environ. Toxicol. Chem.* 36, 2345–2351.
- Kalkman, V.J., Boudot, J.-P., Bernard, R., Conze, K.-J., Kniff, G.D., Dyatlova, E., Ferreira, S.n., Jović, M., Ott, J.r., Riservato, E., Sahlén, G.r., 2010. *European Red List of Dragonflies*. Publications Office of the European Union, Luxembourg.
- Karatayev, A.Y., Burlakova, L.E., Padilla, D.K., Mastitsky, S.E., Olenin, S., 2009. Invaders are not a random selection of species. *Biol. Invasions* 11, 2009–2019.
- Kasai, A., Hayashi, T.I., Ohnishi, H., Suzuki, K., Hayasaka, D., Goka, K., 2016. Fipronil application on rice paddy fields reduces densities of common skimmer and scarlet skimmer. *Sci. Rep.* 6, 23055.
- Kellar, C.R., Hassell, K.L., Long, S.M., Myers, J.H., Golding, L., Rose, G., Kumar, A., Hoffmann, A.A., Pettigrove, V., 2014. Ecological evidence links adverse biological effects to pesticide and metal contamination in an urban Australian watershed. *J. Appl. Ecol.* 51, 426–439.
- Kenis, M., Auger-Rozenberg, M.-A., Roques, A., Timms, L., Péré, C., Cock, M.J.W., Settele, J., Augustin, S., Lopez-Vaamonde, C., 2009. Ecological effects of invasive alien insects. *Biol. Invasions* 11, 21–45.

- Kenta, T., Inari, N., Nagamitsu, T., Goka, K., Hiura, T., 2007. Commercialized European bumblebee can cause pollination disturbance: an experiment on seven native plant species in Japan. *Biol. Conserv.* 134, 298–309.
- King, C.B.A., Haines, W.P., Rubinoff, D., 2010. Impacts of invasive parasitoids on declining endemic Hawaiian leafroller moths (Omiodes: Crambidae) vary among sites and species. *J. Appl. Ecol.* 47, 299–308.
- King, R.S., Scoggins, M., Porras, A., 2016. Stream biodiversity is disproportionately lost to urbanization when flow permanence declines: evidence from southwestern North America. *Freshw. Sci.* 35, 340–352.
- Kingsford, R.T., Watson, J.E.M., Lundquist, C.J., Venter, O., Hughes, L., Johnston, E.L., Atherton, J., Gawel, M., Keith, D.A., Mackey, B.G., Morley, C., Possingham, H.P., Raynor, B., Recher, H.F., Wilson, K.A., 2009. Major conservation policy issues for biodiversity in Oceania. *Conserv. Biol.* 23, 834–840.
- Koh, L.P., Sodhi, N.S., Brook, B.W., 2004. Co-extinctions of tropical butterflies and their hostplants. *Biotropica* 36, 272–274.
- Koh, I., Lonsdorf, E.V., Williams, N.M., Brittain, C., Isaacs, R., Gibbs, J., Ricketts, T.H., 2016. Modeling the status, trends, and impacts of wild bee abundance in the United States. *Proc. Natl. Acad. Sci.* 113, 140–145.
- Korkeamäki, E., Suhonen, J., 2002. Distribution and habitat specialization of species at local extinction in dragonfly Odonata populations. *Ecography* 25, 459–465.
- Kosior, A., Celary, W., Olejniczak, P., Fijał, J., Król, W., Solarz, W., Plonka, P., 2007. The decline of the bumble bees and cuckoo bees (Hymenoptera: Apidae: Bombini) of Western and Central Europe. *Oryx* 41, 79–88.
- Kreutzweiser, D., Good, K., Chartrand, D., Scarr, T., Thompson, D., 2007. Non-target effects on aquatic decomposer organisms of imidacloprid as a systemic insecticide to control emerald ash borer in riparian trees. *Ecotoxicol. Environ. Saf.* 68, 315–325.
- Kreutzweiser, D.P., Good, K.P., Chartrand, D.T., Scarr, T.A., Thompson, D.G., 2008. Are leaves that fall from imidacloprid-treated maple trees to control Asian longhorned beetles toxic to non-target decomposer organisms? *J. Environ. Qual.* 37, 639–646.
- Krischik, V., Rogers, M., Gupta, G., Varshney, A., 2015. Soil-applied imidacloprid translocates to ornamental flowers and reduces survival of adult *Coleomegilla maculata*, *Harmonia axyridis*, and *Hippodamia convergens* lady beetles, and larval *Danaus plexippus* and *Vanessa cardui* butterflies. *PLoS One* 10, e0119133.
- Kulhanek, K., Steinhauer, N., Rennich, K., Caron, D.M., Sagili, R.R., Pettis, J.S., Ellis, J.D., Wilson, M.E., Wilkes, J.T., Tarpy, D.R., Rose, R., Lee, K., Rangel, J., vanEngelsdorp, D., 2017. A national survey of managed honey bee 2015–2016 annual colony losses in the USA. *J. Apic. Res.* 56, 328–340.
- Küry, D., 1997. Changes in the Ephemeroptera and Plecoptera populations of a Swiss Jura stream (Röserenbach) between 1935 and 1990. In: Landolt, P., Sartori, M. (Eds.), *Ephemeroptera & Plecoptera: Biology-Ecology-Systematics*. Mauron, Tinguely & Lachat, Fribourg, pp. 296–301.
- Kuussaari, M., Heliölä, J., Pöyry, J., Saarinen, K., 2007. Contrasting trends of butterfly species preferring semi-natural grasslands, field margins and forest edges in northern Europe. *J. Insect Conserv.* 11, 351–366.
- Lechenet, M., Dessaint, F., Py, G., Makowski, D., Munier-Jolain, N., 2017. Reducing pesticide use while preserving crop productivity and profitability on arable farms. *Nat. Plants* 3, 17008.
- Lindhe, A., Jeppsson, T., Ehnlstrom, B., 2011. Longhorn beetles in Sweden - changes in distribution and abundance over the last two hundred years. *Entomologisk Tidskrift* 131, 507.
- Lister, B.C., Garcia, A., 2018. Climate-driven declines in arthropod abundance restructure a rainforest food web. *Proc. Natl. Acad. Sci.* <https://doi.org/10.1073/pnas.1722477115>. (in press).
- Lobo, J.M., 2001. Decline of roller dung beetle (Scarabaeinae) populations in the Iberian peninsula during the 20th century. *Biol. Conserv.* 97, 43–50.
- Lobo, J.M., Lumaret, J.-P., Jay-Robert, P., 2001. Diversity, distinctiveness and conservation status of the Mediterranean coastal dung beetle assemblage in the Regional Natural Park of the Camargue (France). *Divers. Distrib.* 7, 257–270.
- Long, E.Y., Krupke, C.H., 2016. Non-cultivated plants present a season-long route of pesticide exposure for honey bees. *Nat. Commun.* 7, 11629.
- Losey, J.E., Vaughan, M., 2006. The economic value of ecological services provided by insects. *Bioscience* 56, 311–323.
- Lu, Z., Zhu, P., Gurr, G.M., Zheng, X., Chen, G., Heong, K.L., 2015. Rice pest management by ecological engineering: a pioneering attempt in China. In: Heong, K.L., Cheng, J., Escalada, M.M. (Eds.), *Rice Plinthoppers: Ecology, Management, Socio Economics and Policy*. Springer Netherlands, Dordrecht, pp. 161–178.
- Lumaret, J.-P., 1990. Atlas des Coléoptères Scarabéides Laparosticti de France. Secrétariat Faune Flore/MNHN, Paris, France.
- Lumaret, J.P., Galante, E., Lumberas, C., Mena, J., Bertrand, M., Bernal, J.L., Cooper, J.F., Kadiri, N., Crowe, D., 1993. Field effects of ivermectin residues on dung beetles. *J. Appl. Ecol.* 30, 428–436.
- Lundgren, J.G., Hesler, L.S., Clay, S.A., Fausti, S.F., 2013. Insect communities in soybeans of eastern South Dakota: the effects of vegetation management and pesticides on soybean aphids, bean leaf beetles, and their natural enemies. *Crop Prot.* 43, 104–118.
- Maes, D., Van Dyck, H., 2001. Butterfly diversity loss in Flanders (north Belgium): Europe's worst case scenario? *Biol. Conserv.* 99, 263–276.
- Manne, L.L., Brooks, T.M., Pimm, S.L., 1999. Relative risk of extinction of passerine birds on continents and islands. *Nature* 399, 258–261.
- Marlin, J.C., LaBerge, W.E., 2001. The native bee fauna of Carlinville, Illinois, revisited after 75 years: a case for persistence. *Conserv. Ecol.* 5.
- Marshall, E., Brown, V., Boatman, N., Lutman, P., Squire, G., Ward, L., 2003. The role of weeds in supporting biological diversity within crop fields. *Weed Res.* 43, 77–89.
- Marten, M., 2001. Environmental monitoring in Baden-Württemberg with special reference to biocoenotic trend-monitoring of macrozoobenthos in rivers and methodical requirements for evaluation of long-term biocoenotic changes. *Aquat. Ecol.* 35, 159–171.
- Mattila, N., Kaitala, V., Komonen, A., Kotiaho Janne, S., Pålvinen, J., 2006. Ecological determinants of distribution decline and risk of extinction in moths. *Conserv. Biol.* 20, 1161–1168.
- Maxwell, S.L., Fuller, R.A., Brooks, T.M., Watson, J.E.M., 2016. Biodiversity: the ravages of guns, nets and bulldozers. *Nature* 536, 143–145.
- May, R.M., 2010. Ecological science and tomorrow's world. *Philos. Trans. R. Soc. Lond. B Biol. Sci.* 365, 41–47.
- McCafferty, W.P., 1996. The Ephemeroptera species of North America and index to their complete nomenclature. *Trans. Am. Entomol. Soc.* 122, 1–54 (1890-).
- McCafferty, P.W., 2001. Status of some historically unfamiliar American mayflies (Ephemeroptera). *Pan Pac. Entomol.* 77, 210–218.
- McCafferty, P.W., Lenat, D.R., Jacobus, L.M., Meyer, M.D., 2010. The mayflies (Ephemeroptera) of the Southeastern United States. *Trans. Am. Entomol. Soc.* 136, 221–233 (1890-).
- McGuinness, C.A., 2007. Carabid beetle (Coleoptera: Carabidae) conservation in New Zealand. *J. Insect Conserv.* 11, 31–41.
- McKinney, M.L., 1999. High rates of extinction and threat in poorly studied taxa. *Conserv. Biol.* 13, 1273–1281.
- McKinney, M.L., 2006. Urbanization as a major cause of biotic homogenization. *Biol. Conserv.* 127, 247–260.
- Melero, Y., Stefanescu, C., Pino, J., 2016. General declines in Mediterranean butterflies over the last two decades are modulated by species traits. *Biol. Conserv.* 201, 336–342.
- Memmott, J., Waser, N.M., Price, M.V., 2004. Tolerance of pollination networks to species extinctions. *Proc. R. Soc. Lond. Ser. B Biol. Sci.* 271, 2605.
- Menéndez, R., Megías, A.G., Hill, J.K., Braschler, B., Willis, S.G., Collingham, Y., Fox, R., Roy, D.B., Thomas, C.D., 2006. Species richness changes lag behind climate change. *Proc. R. Soc. B Biol. Sci.* 273, 1465.
- Merckx, T., Feber, R.E., Riordan, P., Townsend, M.C., Bourn, N.A.D., Parsons, M.S., Macdonald, D.W., 2009. Optimizing the biodiversity gain from agri-environment schemes. *Agric. Ecosyst. Environ.* 130, 177–182.
- Mian, L.S., Mulla, M.S., 1992. Effects of pyrethroid insecticides on nontarget invertebrates in aquatic ecosystems. *J. Agric. Entomol.* 9, 73–98.
- Mickleburgh, S.P., Hutson, A.M., Racey, P.A., 2002. A review of the global conservation status of bats. *Oryx* 36, 18–34.
- Mineau, P., Callaghan, C., 2018. Neonicotinoid Insecticides and Bats: An Assessment of the Direct and Indirect Risks. Canadian Wildlife Federation, Ontario, Canada, pp. 87.
- Mineau, P., Whiteside, M., 2013. Pesticide acute toxicity is a better correlate of U.S. grassland bird declines than agricultural intensification. *PLoS One* 8, e57457.
- Misपाल, C., Allinson, M., Allinson, G., Iseki, N., Grant, C., Morita, M., 2004. DDT and metabolites residues in the southern bent-wing bat (*Miniopterus schreibersii bassanii*) of south-eastern Australia. *Chemosphere* 55, 997–1003.
- Mitchell-Jones, A.J., 1990. The distribution of bats in Britain 1982–87 as revealed by enquiries. *Mammal Rev.* 20, 145–157.
- Moron, D., Szentgyorgyi, H., Wantuch, M., Celary, W., Westphal, C., Settele, J., Woyciechowski, M., 2008. Diversity of wild bees in wet meadows: implications for conservation. *Wetlands* 28, 975–983.
- Mulé, R., Sabella, G., Robba, L., Manachini, B., 2017. Systematic review of the effects of chemical insecticides on four common butterfly families. *Front. Environ. Sci.* 5, 32.
- Nakamura, Y., 2011. Conservation of butterflies in Japan: status, actions and strategy. *J. Insect Conserv.* 15, 5–22.
- Nakanishi, K., Nishida, T., Kon, M., Sawada, H., 2014. Effects of environmental factors on the species composition of aquatic insects in irrigation ponds. *Entomol. Sci.* 17, 251–261.
- Nakanishi, K., Yokomizo, H., Hayashi, T.I., 2018. Were the sharp declines of dragonfly populations in the 1990s in Japan caused by fipronil and imidacloprid? An analysis of Hill's causality for the case of *Sympetrum frequens*. *Environ. Sci. Pollut. Res.* 25, 35352–35364.
- Nedbalová, L., Vrba, J., Fott, J., Kohout, L., Kopáček, J., Macek, M., et al., 2006. Biological recovery of the Bohemian Forest lakes from acidification. *Biol. Bratislava* 61, 453–465.
- Nemesio, A., 2013. Are orchid bees at risk? First comparative survey suggests declining populations of forest-dependent species. *Braz. J. Biol.* 73, 367–374.
- Newton, I., 2004. The recent declines of farmland bird populations in Britain: an appraisal of causal factors and conservation actions. *Ibis* 146, 579–600.
- Nieto, A., Alexander, K.N.A., 2010. European Red List of Saproxylous Beetles. Publications Office of the European Union, Luxembourg.
- Nieto, A., Roberts, S.P.M., Kemp, J., Rasmont, P., Kuhlmann, M., Criado, M.G.a., Biesmeijer, J.C., Bogusch, P., Dathe, H.H., Rúa, P.D.I., Meulemeester, T.D., Dehon, M., Dewulf, A., Ortiz-Sánchez, F.J., Lhomme, P., Pauly, A., Potts, S.G., Praz, C., Quaranta, M., Radchenko, V.G., Scheuchl, E., Smit, J., Straka, J., Terzo, M., Tomozii, B., Window, J., Michez, D., 2014. European Red List of Bees. Publications Office of the European Union, Luxembourg.
- Niyogi, D.K., Koren, M., Arbuckle, C.J., Townsend, C.R., 2007. Longitudinal changes in biota along four New Zealand streams: declines and improvements in stream health related to land use. *N. Z. J. Mar. Freshw. Res.* 41, 63–75.
- Öckinger, E., Hammarstedt, O., Nilsson, S.G., Smith, H.G., 2006. The relationship between local extinctions of grassland butterflies and increased soil nitrogen levels. *Biol. Conserv.* 128, 564–573.
- Ollerton, J., Winfree, R., Tarrant, S., 2011. How many flowering plants are pollinated by animals? *Oikos* 120, 321–326.
- Ollerton, J., Erenler, H., Edwards, M., Crockett, R., 2014. Extinctions of aculeate pollinators in Britain and the role of large-scale agricultural changes. *Science* 346, 1360–1362.
- Olson, A.R., Stewart, T.W., Thompson, J.R., 2016. Direct and indirect effects of human population density and land use on physical features and invertebrates of Iowa (USA)

- streams. *Urban Ecosyst.* 19, 159–180.
- Painter, M.K., Tennessen, K.J., Richardson, T.D., 1996. Effects of repeated applications of *Bacillus thuringiensis israelensis* on the mosquito predator *Erythemis simplicicollis* (Odonata: Libellulidae) from hatching to final instar. *Environ. Entomol.* 25, 184–191.
- Parmesan, C., Ryrholm, N., Stefanescu, C., Hill, J.K., Thomas, C.D., Descimon, H., Huntley, B., Kaila, L., Kullberg, J., Tammaru, T., Tennent, W.J., Thomas, Jeremy A., Warren, Martin, 1999. Poleward shifts in geographical ranges of butterfly species associated with regional warming. *Nature* 399, 579–583.
- Pascal-Lorber, S., Laurent, F., 2011. Phytoremediation techniques for pesticide contaminations. In: Lichtfouse, E. (Ed.), *Alternative Farming Systems, Biotechnology, Drought Stress and Ecological Fertilisation*, pp. 77–105.
- Paukkunen, J., Poyry, J., Kuussaari, M., 2018. Species traits explain long-term population trends of Finnish cuckoo wasps (Hymenoptera: Chrysididae). *Insect Conserv. Divers.* 11, 58–71.
- Pearson, D.L., Cassola, F., 1992. World-wide species richness patterns of tiger beetles (Coleoptera: Cicindelidae): Indicator taxon for biodiversity and conservation studies. *Conserv. Biol.* 6, 376–391.
- Pescador, M.L., Lenat, D.R., Hubbard, M.D., 1999. Mayflies (Ephemeroptera) of North Carolina and South Carolina: an update. *Fla. Entomol.* 82, 316–332.
- Petanidou, T., Vujic, A., Ellis, W.N., 2011. Hoverfly diversity (Diptera: Syrphidae) in a Mediterranean scrub community near Athens, Greece. *Ann. Soc. Entomologique France* 47, 168–175.
- Pettis, J.S., Rice, N., Joselow, K., vanEngelsdorp, D., Chaimanee, V., 2016. Colony failure linked to low sperm viability in honey bee (*Apis mellifera*) queens and an exploration of potential causative factors. *PLoS One* 11, e0147220.
- Pilling, E.D., Jepson, P.C., 1993. Synergism between EBI fungicides and a pyrethroid insecticide in the honeybee (*Apis mellifera*). *Pestic. Sci.* 39, 293–297.
- Pimentel, D., 1961. Species diversity and insect population outbreaks. *Ann. Entomol. Soc. Am.* 54, 76–86.
- Pimm, S.L., Raven, P., 2000. Extinction by numbers. *Nature* 403, 843.
- Pirk, C.W.W., Human, H., Crewe, R.M., vanEngelsdorp, D., 2014. A survey of managed honey bee colony losses in the Republic of South Africa–2009 to 2011. *J. Apic. Res.* 53, 35–42.
- Pocock, M.J.O., Jennings, N., 2008. Testing biotic indicator taxa: the sensitivity of insectivorous mammals and their prey to the intensification of lowland agriculture. *J. Appl. Ecol.* 45, 151–160.
- Pollard, E., Woivod, I.P., Greatorex-Davies, J.N., Yates, T.J., Welch, R.C., 1998. The spread of coarse grasses and changes in numbers of lepidoptera in a woodland nature reserve. *Biol. Conserv.* 84, 17–24.
- Potts, G.R., 1986. *The Partridge - Pesticides. Predation and Conservation*, Collins, London, UK.
- Potts, S.G., Roberts, S.P.M., Dean, R., Marris, G., Brown, M.A., Jones, R., Neumann, P., Settele, J., 2010. Declines of managed honey bees and beekeepers in Europe. *J. Apic. Res.* 49, 15–22.
- Poulin, B., Lefebvre, G., Paz, L., 2010. Red flag for green spray: adverse trophic effects of Bti on breeding birds. *J. Appl. Ecol.* 47, 884–889.
- Pretty, J., Bharucha, Z.P., 2015. Integrated Pest Management for sustainable intensification of agriculture in Asia and Africa. *Insects* 6, 152–182.
- Pretty, J., Toulmin, C., Williams, S., 2011. Sustainable intensification in African agriculture. *Int. J. Agric. Sustain.* 9, 5–24.
- Raup, D.M., Sepkoski Jr., J.J., 1986. Periodic extinction of families and genera. *Science* 231, 833–836.
- Reaser, J.K., Meyerson, L.A., Cronk, Q., De Poorter, M.A.J., Eldrege, L.G., Green, E., Kairo, M., Latasi, P., Mack, R.N., Mauremootoo, J., O'Dowd, D., Orapa, W., Sastroutomo, S., Saunders, A., Shine, C., Thrainsson, S., Vaiutu, L., 2007. Ecological and socio-economic impacts of invasive alien species in island ecosystems. *Environ. Conserv.* 34, 98–111.
- Relyea, R.A., Hoverman, J.T., 2008. Interactive effects of predators and a pesticide on aquatic communities. *Oikos* 117, 1647–1658.
- Ricciardi, A., Rasmussen, J.B., 1999. Extinction rates of North American freshwater fauna. *Conserv. Biol.* 13, 1220–1222.
- Roessink, I., Merga, L.B., Zweers, H.J., van den Brink, P.J., 2013. The neonicotinoid imidacloprid shows high chronic toxicity to mayfly nymphs. *Environ. Toxicol. Chem.* 32, 1096–1100.
- Roulston, T.A.H., Goodell, K., 2011. The role of resources and risks in regulating wild bee populations. *Annu. Rev. Entomol.* 56, 293–312.
- Roy, H.E., Brown, P.M.J., 2015. Ten years of invasion: *Harmonia axyridis* (Pallas) (Coleoptera: Coccinellidae) in Britain. *Ecol. Entomol.* 40, 336–348.
- Rutledge, C.E., O'Neil, R.J., Fox, T.B., Landis, D.A., 2004. Soybean aphid predators and their use in Integrated Pest Management. *Ann. Entomol. Soc. Am.* 97, 240–248.
- Samways, M.J., 1999. Diversity and conservation status of South African dragonflies (Odonata). *Odonatologica* 28, 13–62.
- Sánchez-Bayo, F., 2011. Impacts of agricultural pesticides on terrestrial ecosystems. In: Sánchez-Bayo, F., van den Brink, P.J., Mann, R. (Eds.), *Ecological Impacts of Toxic Chemicals*. Bentham Science Publishers, Online eBook, pp. 63–87.
- Sánchez-Bayo, F., Goka, K., 2014. Pesticide residues and bees – a risk assessment. *PLoS One* 9, e94482.
- Sánchez-Bayo, F., Goka, K., Hayasaka, D., 2016a. Contamination of the aquatic environment with neonicotinoids and its implication for ecosystems. *Front. Environ. Sci.* 4, 71.
- Sánchez-Bayo, F., Goulson, D., Pennacchio, F., Nazzi, F., Goka, K., Desneux, N., 2016b. Are bee diseases linked to pesticides? — a brief review. *Environ. Int.* 89–90, 7–11.
- Sato, S., Dixon, A.F.G., 2004. Effect of intraguild predation on the survival and development of three species of aphidophagous ladybirds: consequences for invasive species. *Agric. For. Entomol.* 6, 21–24.
- Schäfer, R.B., van den Brink, P.J., Liess, M., 2011. Impacts of pesticides on freshwater ecosystems. In: Sánchez-Bayo, F., van den Brink, P.J., Mann, R. (Eds.), *Ecological Impacts of Toxic Chemicals*. Bentham Science Publishers, Online eBook, pp. 111–137.
- Schirmel, J., Bundschuh, M., Entling, M.H., Kowarik, I., Buchholz, S., 2015. Impacts of invasive plants on resident animals across ecosystems, taxa, and feeding types: a global assessment. *Glob. Chang. Biol.* 22, 594–603.
- Schuch, S., Bock, J., Leuschner, C., Schaefer, M., Wesche, K., 2011. Minor changes in orthopteran assemblages of Central European protected dry grasslands during the last 40 years. *J. Insect Conserv.* 15, 811–822.
- Schuch, S., Wesche, K., Schaefer, M., 2012. Long-term decline in the abundance of leafhoppers and planthoppers (Auchenorrhyncha) in Central European protected dry grasslands. *Biol. Conserv.* 149, 75–83.
- Settle, W.H., Ariawan, H., Astuti, E.T., Cahyana, W., Hakim, A.L., Hindayana, D., Lestari, A.S., Pajarningsih, Sartanto, 1996. Managing tropical rice pests through conservation of generalist natural enemies and alternative prey. *Ecology* 77, 1975–1988.
- Sgolastra, F., Blasioli, S., Renzi, T., Tosi, S., Medrzycki, P., Molowny-Horas, R., Porrini, C., Braschi, I., 2018. Lethal effects of Cr(III) alone and in combination with propiconazole and clothianidin in honey bees. *Chemosphere* 191, 365–372.
- Shortall, C.R., Moore, A., Smith, E., Hall, M.J., Woivod, I.P., Harrington, R., 2009. Long-term changes in the abundance of flying insects. *Insect Conserv. Divers.* 2, 251–260.
- Simon-Delso, N., Martin, G.S., Bruneau, E., Minsart, L.-A., Mouret, C., Hautier, L., 2014. Honeybee Colony Disorder in crop areas: the role of pesticides and viruses. *PLoS One* 9, e103073.
- Smart, M., Pettis, J., Rice, N., Browning, Z., Spivak, M., 2016. Linking measures of colony and individual honey bee health to survival among apiaries exposed to varying agricultural land use. *PLoS One* 11, e0152685.
- Sorvari, J., Hakkarainen, H., 2007. Wood ants are wood ants: deforestation causes population declines in the polydomous wood ant *Formica aquilonia*. *Ecol. Entomol.* 32, 707–711.
- Stahlschmidt, P., Bruhl, C.A., 2012. Bats at risk? Bat activity and insecticide residue analysis of food items in an apple orchard. *Environ. Toxicol. Chem.* 31, 1556–1563.
- Stefanescu, C., Torre, I., Jubany, J., Páramo, F., 2011. Recent trends in butterfly populations from north-east Spain and Andorra in the light of habitat and climate change. *J. Insect Conserv.* 15, 83–93.
- Stefanescu, C., Aguado, L.O., Asís, J.D., Baños-Picón, L., Cerdá, X., García, M.A.M., Micó, E., Ricarte, A., Tormos, J., 2018. Diversidad de insectos polinizadores en la península ibérica. *Ecosistemas* 27, 9–22.
- Strong, L., 1992. Avermectins: a review of their impact on insects of cattle dung. *Bull. Entomol. Res.* 82, 265–274.
- Swengel, S.R., Swengel, A.B., 2015. Assessing abundance patterns of specialized bog butterflies over 12 years in northern Wisconsin USA. *J. Insect Conserv.* 19, 293–304.
- Swengel, S.R., Schlicht, D., Olsen, F., Swengel, A.B., 2011. Declines of prairie butterflies in the midwestern USA. *J. Insect Conserv.* 15, 327–339.
- Taylor, M.E., Morecroft, M.D., 2009. Effects of agri-environment schemes in a long-term ecological time series. *Agric. Ecosyst. Environ.* 130, 9–15.
- Temple, H.J., Cox, N.A., 2009. *European Red List of Amphibians*. Publications Office of the European Union, Luxembourg.
- Temple, H.J., Cuttelod, A., 2008. *The Status and Distribution of Mediterranean Mammals*. IUCN, Gland, Switzerland and Cambridge, UK.
- Temple, H.J., Terry, A., 2009. *European mammals: red list status, trends, and conservation priorities*. *Folia Zool.* 58, 248–269.
- Tesovnik, T., Cizelj, I., Zorc, M., Citar, M., Bozic, J., Glavan, G., Narat, M., 2017. Immune related gene expression in worker honey bee (*Apis mellifera carnica*) pupae exposed to neonicotinoid thiamethoxam and Varroa mites (*Varroa destructor*). *PLoS One* 12, e0187079.
- Thancharoen, A., Lankaew, S., Moonjuntha, P., Wongphanuwat, T., Sangtongpraow, B., Ngoenklang, R., Kittipadakul, P., Wyckhuys, K.A.G., 2018. Effective biological control of an invasive mealybug pest enhances root yield in cassava. *J. Pest. Sci.* 91, 1199–1211.
- Thomas, J.A., Telfer, M.G., Roy, D.B., Preston, C.D., Greenwood, J.J.D., Asher, J., Fox, R., Clarke, R.T., Lawton, J.H., 2004. Comparative losses of British butterflies, birds, and plants and the global extinction crisis. *Science* 303, 1879–1881.
- Thorp, R.W., Shepherd, M.D., 2005. Profile: subgenus *Bombus*. In: Shepherd, M.D., Vaughan, D.M., Black, S.H. (Eds.), *Red List of Pollinator Insects of North America*. The Xerces Society for Invertebrate Conservation, Portland, Oregon.
- Tierno de Figueroa, J.M., López-Rodríguez, M.J., Lorenz, A., Graf, W., Schmidt-Kloiber, A., Hering, D., 2010. Vulnerable taxa of European Plecoptera (Insecta) in the context of climate change. *Biodivers. Conserv.* 19, 1269–1277.
- Tilman, D., Fargione, J., Wolff, B., D'Antonio, C., Dobson, A., Howarth, R., Schindler, D., Schlesinger, W.H., Simberloff, D., Swackhamer, D., 2001. Forecasting agriculturally driven global environmental change. *Science* 292, 281–284.
- Tison, L., Hahn, M.-L., Holtz, S., Rößner, A., Greggers, U., Bischoff, G., Menzel, R., 2016. Honey bees' behavior is impaired by chronic exposure to the neonicotinoid thiacloprid in the field. *Environ. Sci. Technol.* 50, 7218–7227.
- Tixier, G., Guérol, F., 2005. Plecoptera response to acidification in several headwater streams in the Vosges Mountains (northeastern France). *Biodivers. Conserv.* 14, 1525–1539.
- Turin, H., den Boer, P.J., 1988. Changes in the distribution of carabid beetles in The Netherlands since 1880. II. Isolation of habitats and long-term time trends in the occurrence of carabid species with different powers of dispersal (Coleoptera, Carabidae). *Biol. Conserv.* 44, 179–200.
- Ueda, T., Jinguji, H., 2013. The ecological impact of the insecticides fipronil and imidacloprid on *Sympetrum frequens* in Japan. *Tombo* 55, 1–12.
- Underwood, R.M., vanEngelsdorp, D., 2007. Colony Collapse Disorder: have we seen this before? *Bee Cult.* 135, 13–15.
- van den Brink, P.J., Wijngaarden, R.P.A.V., Lucassen, W.G.H., Brock, T.C.M., Leeuwangh, P., 1996. Effects of the insecticide Dursban 4E (active ingredient chlorpyrifos) in

- outdoor experimental ditches: II. Invertebrate community responses and recovery. *Environ. Toxicol. Chem.* 15, 1143–1153.
- Van der Meij, T., Van Strien, A.J., Haysom, K.A., Dekker, J., Russ, J., Biala, K., Bihari, Z., Jansen, E., Langton, S., Kurali, A., Limpens, H., Meschede, A., Petersons, G., Presetnik, P., Prüger, J., Reiter, G., Rodrigues, L., Schorcht, W., Uhrin, M., Vintulis, V., 2015. Return of the bats? A prototype indicator of trends in European bat populations in underground hibernacula. *Mamm. Biol.* 80, 170–177.
- van der Sluijs, J.P., Amaral-Rogers, V., Belzunces, L.P., Bijleveld van Lexmond, M.F.I.J., Bonmatin, J.-M., Chagnon, M., Downs, C.A., Furlan, L., Gibbons, D.W., Giorio, C., Girolami, V., Goulson, D., Kreuzweiser, D.P., Krupke, C., Liess, M., Long, E., McField, M., Mineau, P., Mitchell, E.A.D., Morrissey, C.A., Noome, D.A., Pisa, L., Settele, J., Simon-Delso, N., Stark, J.D., Tapparo, A., Dyck, H.V., Praagh, J.v., Whitehorn, P.R., Wiemers, M., 2015. Conclusions of the Worldwide Integrated Assessment on the risks of neonicotinoids and fipronil to biodiversity and ecosystem functioning. *Environ. Sci. Pollut. Res.* 22, 148–154.
- van Dijk, T.C., van Staalduinen, M.A., van der Sluijs, J.P., 2013. Macro-invertebrate decline in surface water polluted with imidacloprid. *PLoS One* 8, e62374.
- van Dyck, H., van Strien, A.J., Maes, D., van Swaay, C.A.M., 2009. Declines in common, widespread butterflies in a landscape under intense human use. *Conserv. Biol.* 23, 957–965.
- van Ooik, T., Rantala, M.J., Saloniemi, I., 2007. Diet-mediated effects of heavy metal pollution on growth and immune response in the geometrid moth *Epirrita autumnata*. *Environ. Pollut.* 145, 348–354.
- van Strien, A.J., Meyling, A.W.G., Herder, J.E., Hollander, H., Kalkman, V.J., Poot, M.J.M., Turnhout, S., van der Hoorn, B., van Strien-van Liempt, W.T.F.H., van Swaay, C.A.M., van Turnhout, C.A.M., Verweij, R.J.T., Oerlemans, N.J., 2016. Modest recovery of biodiversity in a western European country: The Living Planet Index for the Netherlands. *Biol. Conserv.* 200, 44–50.
- van Swaay, C., Warren, M., Lois, G., 2006. Biotope use and trends of European butterflies. *J. Insect Conserv.* 10, 189–209.
- van Swaay, C., Cuttelod, A., Collins, S., Maes, D., Munguira, M.L.P., Šašić, M., Settele, J., Verovnik, R., Verstrael, T., Warren, M., Wiemers, M., Wynho, I., 2010. European Red List of Butterflies. Publications Office of the European Union, Luxembourg.
- vanEngelsdorp, D., Caron, D., Hayes, J., Underwood, R., Henson, M., Rennich, K., Spleen, A., Andree, M., Snyder, R., Lee, K., Roccasecca, K., Wilson, M., Wilkes, J., Lengerich, E., Pettis, J., Partnership, B.I., 2012. A national survey of managed honey bee 2010–11 winter colony losses in the USA: results from the Bee Informed Partnership. *J. Apic. Res.* 51, 115–124.
- Vaughan, N., 2008. The diets of British bats (Chiroptera). *Mammal Rev.* 27, 77–94.
- Vidau, C., Diogon, M., Aufauvre, J., Fontbonne, R., Viguès, B., Brunet, J.L., Texier, C., Biron, D.G., Blot, N., El-Alaoui, H., Belzunces, L.P., Delbac, F., 2011. Exposure to sublethal doses of fipronil and thiacloprid highly increases mortality of honeybees previously infected by *Nosema ceranae*. *PLoS One* 6, e21550.
- Vitousek, P.M., Mooney, H.A., Lubchenco, J., Melillo, J.M., 1997. Human domination of Earth's ecosystems. *Science* 277, 494–499.
- Vogel, V., Pedersen, J.S., Giraud, T., Krieger, M.J.B., Keller, L., 2010. The worldwide expansion of the Argentine ant. *Divers. Distrib.* 16, 170–186.
- Wardhaugh, K.G., Mahon, R.J., 1991. Avermectin residues in sheep and cattle dung and their effects on dung-beetle (Coleoptera: Scarabaeidae) colonization and dung burial. *Bull. Entomol. Res.* 81, 333–339.
- Warren, M.S., Hill, J.K., Thomas, J.A., Asher, J., Fox, R., Huntley, B., Roy, D.B., Telfer, M.G., Jeffcoate, S., Harding, P., Jeffcoate, G., Willis, S.G., Greatorex-Davies, J.N., Moss, D., Thomas, C.D., 2001. Rapid responses of British butterflies to opposing forces of climate and habitat change. *Nature* 414, 65.
- Way, M.J., Heong, K.L., 1994. The role of biodiversity in the dynamics and management of insect pests of tropical irrigated rice - a review. *Bull. Entomol. Res.* 84, 567–587.
- Weston, D.P., Asbell, A.M., Lesmeister, S.A., Teh, S.J., Lydy, M.J., 2014. Urban and agricultural pesticide inputs to a critical habitat for the threatened delta smelt (*Hypomesus transpacificus*). *Environ. Toxicol. Chem.* 33, 920–929.
- Weston, D.P., Schlenk, D., Riar, N., Lydy, M.J., Brooks, M.L., 2015. Effects of pyrethroid insecticides in urban runoff on Chinook salmon, steelhead trout, and their invertebrate prey. *Environ. Toxicol. Chem.* 34, 649–657.
- Wheeler, Q.D., 1995. Systematics and biodiversity. *Bioscience* 45, 21–28.
- White, P.J.T., Kerr, J.T., 2007. Human impacts on environment–diversity relationships: evidence for biotic homogenization from butterfly species richness patterns. *Glob. Ecol. Biogeogr.* 16, 290–299.
- Wickramasinghe, L.P., Harris, S., Jones, G., Vaughan, N., 2003. Bat activity and species richness on organic and conventional farms: impact of agricultural intensification. *J. Appl. Ecol.* 40, 984–993.
- Wickramasinghe, L.P., Harris, S., Jones, G., Vaughan, N., 2004. Abundance and species richness of nocturnal insects on organic and conventional farms: effects of agricultural intensification on bat foraging. *Conserv. Biol.* 18, 1283–1292.
- Wilcove, D.S., Rothstein, D., Dubow, J., Phillips, A., Losos, E., 1998. Quantifying threats to imperiled species in the United States. *Bioscience* 48, 607–615.
- Williams, P.H., 1982. The distribution and decline of British bumble bees (*Bombus* Latr.). *J. Apic. Res.* 21, 236–245.
- Williams, P., Osborne, J., 2009. Bumblebee vulnerability and conservation world-wide. *Apidologie* 40, 367–387.
- Williams, N.M., Crone, E.E., Roulston, T.a.H., Minckley, R.L., Packer, L., Potts, S.G., 2010. Ecological and life-history traits predict bee species responses to environmental disturbances. *Biol. Conserv.* 143, 2280–2291.
- Williams, G.R., Troxler, A., Retschnig, G., Roth, K., Yañez, O., Shutler, D., Neumann, P., Gauthier, L., 2015. Neonicotinoid pesticides severely affect honey bee queens. *Sci. Rep.* 5, 14621.
- Wilson, E.O., 2002. *The Future of Life*. Abacus, Time Warner Book Group, London, UK.
- Wilson, J., Morris, A., Arroyo, B., Clark, S., Bradbury, R., 1999. A review of the abundance and diversity of invertebrate and plant foods of granivorous birds in northern Europe in relation to agricultural change. *Agric. Ecosyst. Environ.* 75, 13–30.
- Wu-Smart, J., Spivak, M., 2016. Sub-lethal effects of dietary neonicotinoid insecticide exposure on honey bee queen fecundity and colony development. *Sci. Rep.* 6, 32108.
- Wyckhuys, K.A.G., Lu, Y., Morales, H., Vazquez, L.L., Legaspi, J.C., Eliopoulos, P.A., Hernandez, L.M., 2013. Current status and potential of conservation biological control for agriculture in the developing world. *Biol. Control* 65, 152–167.
- Wyckhuys, K.A.G., Hughes, A.C., Buamas, C., Johnson, A.C., Vasseur, L., Reymondin, L., Deguine, J.P., Sheil, D., 2019. Biological control of an agricultural pest protects tropical forests. *Commun. Biol.* 2, 10.
- Yang, X., Cox-Foster, D., 2007. Effects of parasitization by *Varroa destructor* on survivorship and physiological traits of *Apis mellifera* in correlation with viral incidence and microbial challenge. *Parasitology* 134, 405–412.
- Zahrádková, S., Soldán, T., Bojková, J., Helešic, J., Janovská, H., Sroka, P., 2009. Distribution and biology of mayflies (Ephemeroptera) of the Czech Republic: present status and perspectives. *Aquat. Insects* 31, 629–652.
- Zedková, B., Rádková, V., Bojková, J., Soldán, T., Zahrádková, S., 2015. Mayflies (Ephemeroptera) as indicators of environmental changes in the past five decades: a case study from the Morava and Odra River Basins (Czech Republic). *Aquat. Conserv.* 25, 622–638.
- Zwick, P., 1992. Stream habitat fragmentation — a threat to biodiversity. *Biodivers. Conserv.* 1, 80–97.
- Zwick, P., 2000. Phylogenetic system and zoogeography of the Plecoptera. *Annu. Rev. Entomol.* 45, 709–746.



131st MAINE LEGISLATURE

FIRST REGULAR SESSION-2022

Legislative Document

No. 8

H.P. 12

House of Representatives, December 30, 2022

**An Act to Increase Support for the Modernization of the Board of
Pesticides Control by Increasing the Annual Pesticide Registration
Fee**

Submitted by the Department of Agriculture, Conservation and Forestry pursuant to Joint Rule 204.

Reference to the Committee on Agriculture, Conservation and Forestry suggested and ordered printed.

A handwritten signature in cursive script that reads "R B. Hunt".

ROBERT B. HUNT
Clerk

Presented by Representative PLUECKER of Warren.

1 **Be it enacted by the People of the State of Maine as follows:**

2 **Sec. 1. 7 MRSA §607, sub-§6**, as amended by PL 2019, c. 243, §1, is further
3 amended to read:

4 **6. Registration fee; programs funded.** The applicant desiring to register a pesticide
5 must pay an annual registration fee of ~~\$160~~ \$200 for each pesticide registered for that
6 applicant. Annual registration periods expire on December 31st or in a manner consistent
7 with Title 5, section 10002, whichever is later.

8 The board shall monitor fee revenue and expenditures under this subsection to ensure that
9 adequate funds are available to fund board and related department programs and, to the
10 extent funds are available, to provide grants to support stewardship programs. The board
11 shall use funds received under this subsection to provide:

12 A. An annual grant of no less than \$135,000 to the University of Maine Cooperative
13 Extension, on or about April 1st, for development and implementation of integrated
14 pest management programs;

15 B. Funding for public health-related mosquito monitoring programs or other pesticide
16 stewardship and integrated pest management programs, if designated at the discretion
17 of the board, as funds allow after expenditures under paragraph A. The board may seek
18 the advice of the Integrated Pest Management Council established in section 2404 in
19 determining the most beneficial use of the funds, if available, under this subsection;
20 and

21 C. An annual grant of not less than \$65,000 to the University of Maine Cooperative
22 Extension, on or about April 1st, for the development and revision of training manuals
23 for applicator certification, licensing and recertification and to perform other aspects
24 of pesticide education programs. The University of Maine Cooperative Extension may
25 seek the advice of the board in establishing the pesticide education programs and shall
26 submit an annual report on the use of the funds under this paragraph, no later than
27 January 15th, to the board and the joint standing committee of the Legislature having
28 jurisdiction over pesticide education and certification matters.

29 The University of Maine may not charge overhead costs against grants under this
30 subsection.

31 By February 15th annually, the board shall submit a report to the joint standing committee
32 of the Legislature having jurisdiction over agriculture, conservation and forestry matters
33 detailing the grants funded by the fee under this subsection. The annual report must include
34 a recommendation by the board as to whether the amount of the fee is adequate to fund the
35 programs described in this subsection. The joint standing committee may report out a bill
36 to the Legislature based on the board's recommendations.

37 **SUMMARY**

38 This bill increases the annual fee to register a pesticide with the Department of
39 Agriculture, Conservation and Forestry, Board of Pesticides Control from \$160 to \$200.

IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF PENNSYLVANIA

UNITED STATES OF AMERICA,
Plaintiff,

v.

INHANCE TECHNOLOGIES LLC,

Defendant.

Civ. No. _____

COMPLAINT

Plaintiff, the United States of America (the “United States”), by the authority of the Attorney General and through the undersigned attorneys, and at the request of the Administrator of the United States Environmental Protection Agency (the “EPA”), files this Complaint and alleges as follows:

NATURE OF THE ACTION

1. This is a civil action brought pursuant to Section 17(a) of the Toxic Substances Control Act (“TSCA”), 15 U.S.C. § 2616(a), and the Declaratory Judgment Act, 28 U.S.C. § 2201, to obtain declaratory and injunctive relief against Inhance Technologies LLC (the “Defendant” or “Inhance”).

2. The Defendant has and continues to [REDACTED]

[REDACTED] in violation of TSCA and its implementing regulations.

3. [REDACTED]

[REDACTED]. Scientific studies have linked exposure to [REDACTED] with a range of adverse health impacts on humans and animals and harm to the environment.

4. The Defendant’s pertinent act or omissions violate Sections 5, 15, and 17 of TSCA, 15 U.S.C. §§ 2604, 2614, and 2616, respectively, and Part 721 of the regulations implementing TSCA, specifically, 40 C.F.R. §§ 721.25 and 721.35.

5. The Defendant has and continues to violate the statutory and regulatory provisions referenced in paragraph 4 by engaging in ongoing “significant new uses”

[REDACTED]

[REDACTED] Significant New Use Rule [REDACTED]

Rule”), [REDACTED], without complying with the applicable statutory and regulatory process for engaging in such significant new uses.

6. Under Section 5(a)(1) of TSCA, 15 U.S.C. § 2604(a)(1), no person may manufacture or process a chemical substance for a significant new use unless (1) that person submits a Significant New Use Notice (“New Use Notice”) to the EPA; (2) the EPA reviews that notice; and (3) the EPA makes a determination on that use under Section 5(a)(3) of TSCA, 15 U.S.C. § 2604(a)(3). Title 40 C.F.R. § 721.25 prescribes similar requirements for any person seeking to engage in a significant new use of a chemical substance.

7. Under Section 15 of TSCA, 15 U.S.C. § 2614, it is a prohibited act to fail or refuse to comply with any requirement of TSCA or any rule promulgated under TSCA. Under 40 C.F.R. § 721.35, it is a violation of Section 15 of TSCA to fail to comply with any provision of Title 40, Part 721 of the regulations implementing TSCA.

JURISDICTION AND VENUE

8. This Court has subject matter jurisdiction over the subject matter of this action pursuant to Section 17(a) of TSCA, 15 U.S.C. § 2616(a), and 28 U.S.C. §§ 1331 and 1345.

9. Venue is proper in this judicial district pursuant to Section 17(a) of TSCA, 15 U.S.C. § 2616(a), and 28 U.S.C. §§ 1391(b). An act, omission, or transaction constituting a

violation of Section 15 of TSCA, 15 U.S.C. § 2614, has occurred or the Defendant is found or transacts business in this judicial district.

PARTIES

10. The Plaintiff is the United States of America, acting at the request of the EPA, an agency of the United States.

11. The Defendant is a limited liability company formed in the State of Delaware and doing business in [REDACTED]

[REDACTED]

[REDACTED].

12. The Defendant is a “person,” as defined under 40 C.F.R. § 720.3(x), subject to the requirements of TSCA. 15 U.S.C. § 2601, *et seq.*

RELEVANT STATUTORY AND REGULATORY FRAMEWORK

13. TSCA establishes a scheme designed, among other things, to provide the EPA with the authority “to regulate chemical substances and mixtures that present an unreasonable risk of injury to health or the environment.” 15 U.S.C. § 2601(b)(2).

14. Pursuant to Section 5(a)(2) of TSCA, 15 U.S.C. § 2604(a)(2), the EPA is authorized to promulgate significant new use rules. Once the EPA determines in a significant new use rule that the manufacturing or processing of a chemical substance for a use constitutes “a significant new use” under TSCA, a manufacturer or processor must submit to EPA a New Use Notice for EPA review before manufacturing or processing the substance for that use. 15 U.S.C. § 2604(a)(1).

15. Pursuant to Section 5(a) of TSCA, 15 U.S.C. § 2604(a), no person may manufacture or process any chemical substance for a use which the EPA has determined is a significant new use under Section 5(a)(2) of TSCA, 15 U.S.C. § 2604(a)(2), unless (1) the person

submits to the EPA, at least 90 days before such manufacture or processing, a New Use Notice, as required by Section 5(a)(1)(B), 15 U.S.C. § 2604(a)(1)(B), and 40 C.F.R. § 721.25, of such person's intention to manufacture or process such substance; (2) such person complies with any applicable requirement imposed by Sections 5(b), (e), or (f) of TSCA, 15 U.S.C. §§ 2604(b), (e), or (f); (3) the EPA conducts a review of the notice; (4) the EPA makes a determination in accordance with Section 5(a)(3) of TSCA, 15 U.S.C. § 2604(a)(3); and (5) the EPA takes the actions required in association with that determination.

16. Under 40 C.F.R. § 721.25, each person who is required to submit a significant new use notice under Part 721 must submit the notice at least 90 calendar days before commencing manufacture or processing of a chemical substance identified for a significant new use. The submitter must comply with any applicable requirement of Section 5(b) of TSCA, 15 U.S.C. § 2604(b), and the notice must include the information and test data specified in Section 5(d)(1) of TSCA, 15 U.S.C. § 2604(d)(1).

17. Following the submission to the EPA of a New Use Notice, the EPA is required to review the New Use Notice to determine whether the relevant chemical substance or significant new use presents or may present an unreasonable risk of injury to health or the environment, without consideration of costs or other non-risk factors, including an unreasonable risk to a potentially exposed or susceptible subpopulation. Section 5(a)(3) of TSCA, 15 U.S.C. § 2604(a)(3).

18. If the EPA reviews the New Use Notice and determines that (A) the information available is insufficient to permit a reasoned evaluation of the health and environmental effects of a chemical substance with respect to which a notice is required, or (B) in the absence of sufficient information to permit the EPA to perform such an evaluation, the manufacture,

processing distribution in commerce, use, or disposal of such substance, may present an unreasonable risk of injury to health or the environment, without consideration of costs or other non-risk factors, or (C) such substance is or will be produced in substantial quantities, and such substance either enters or may reasonably be anticipated to enter the environment in substantial quantities or there is or may be significant or substantial human exposure to the substance, then the EPA must issue an order to prohibit or limit the manufacture, processing, or distribution in commerce of such substance to the extent necessary to protect against an unreasonable risk of injury to health or the environment, without consideration of costs or other non-risk factors, Section 5(e) of TSCA. 15 U.S.C. § 2604(e).

19. If the EPA determines that a chemical substance or significant new use with respect to which notice is required presents an unreasonable risk of injury to health or the environment, without consideration of costs or other non-risk factors, the EPA must take actions to the extent necessary to protect against such risk, including issuing a rule or order to prohibit or limit the manufacture, processing, or distribution in commerce of such substance. Section 5(f) of TSCA, 15 U.S.C. § 2604(f).

20. The EPA has promulgated a number of significant new use rules. *See generally* 40 C.F.R. § 721, subpart (E). These rules specify the types of uses of particular substances that qualify as “significant new uses” of those substances. *See generally* 40 C.F.R. § 721, subpart (E). Among the significant new use rules promulgated by the EPA is the [REDACTED] Rule [REDACTED].

21. [REDACTED]
[REDACTED]

[REDACTED]

[REDACTED]

22. The [REDACTED] Rule [REDACTED]

[REDACTED]

[REDACTED]

23. The [REDACTED] Rule [REDACTED]

[REDACTED] For example, one significant new use is

[REDACTED]

[REDACTED]

24. [REDACTED] Rule, Inhance's past and continuing manufacturing

[REDACTED] subject to that rule, [REDACTED]

[REDACTED]

[REDACTED]

[REDACTED] Rule. [REDACTED]

[REDACTED]

25. It is unlawful for any person to: (1) fail or refuse to comply with any requirement of TSCA or any rule promulgated, order issued, or consent agreement entered into under TSCA; (2) use for commercial purposes a chemical substance which such person knew or had reason to know was manufactured or processed in violation of Section 5 of TSCA, 15 U.S.C. § 2604; or (3) fail or refuse to submit notices as required by TSCA or any rule promulgated under the statute. Section 15 of TSCA, 15 U.S.C. § 2614.

26. Under 40 C.F.R. § 721.35, the failure to comply with any provision of Part 721 (Significant New Uses of Chemical Substances) is a violation of Section 15(1) of TSCA, 15

U.S.C. § 2614(1). Using a chemical substance for commercial purposes that a person knew or had reason to know was manufactured or processed in violation of Part 721 also is a violation of Section 15(2) of TSCA, 15 U.S.C. § 2614(2).

27. Pursuant to Section 17(a)(1), 15 U.S.C. § 2616(a) of TSCA, the district courts of the United States have jurisdiction over civil actions to (A) restrain any violation of Section 15 of TSCA, 15 U.S.C. § 2614; (B) restrain any person from taking any action prohibited under Section 5 of TSCA, 15 U.S.C. § 2604; (C) compel the taking of any action required by or under TSCA; and (D) direct any manufacturer or processor of a chemical substance subject to subject to a rule or order under Section 5 of TSCA, 15 U.S.C. § 2604, and distributed in commerce to (i) give notice of such fact to distributors in commerce of such substance, and to other persons in possession of such substances or exposed to such substances; (ii) to give public notice of such risk of injury; and (iii) either replace or repurchase such substance.

28. Under the Declaratory Judgment Act, 28 U.S.C. § 2201, where an actual case or controversy exists, a court may issue a binding decree that defines the rights and obligations of the parties.

GENERAL ALLEGATIONS

29. The Defendant is a company that uses [REDACTED]
[REDACTED]

[REDACTED]

30. [REDACTED]
[REDACTED]
[REDACTED]

31. Inhance manufactures for a significant new use [REDACTED]

[REDACTED] Rule as a byproduct of its [REDACTED] processes.

32. The term “byproduct” is defined under the TSCA regulations as “a chemical substance produced without a separate commercial intent during the manufacture, processing, use, or disposal of another chemical substance or mixture.” 40 C.F.R. § 720.3(d).

33. Between August and October 20, 2020, [REDACTED]

[REDACTED]
[REDACTED]
[REDACTED] Rule.

34. In December 2020, [REDACTED]

35. The EPA tested the [REDACTED] referred to in paragraph 34 and detected several [REDACTED] Rule in the [REDACTED]

36. On information and belief, the [REDACTED] that the EPA tested for the presence of [REDACTED] by Inhance.

37. On January 14, 2021, the EPA issued a subpoena to Inhance pursuant to Section 11(c) of TSCA, 15 U.S.C. § 2610(c), to obtain information concerning Inhance’s [REDACTED]

38. On February 1 and 8, 2021, Inhance responded to the EPA’s subpoena.

39. Based on the information Inhance provided, the EPA determined that Inhance’s processes for [REDACTED] results in the manufacturing for a significant new use of

[REDACTED] Rule [REDACTED]
[REDACTED]

40. On March 1, 2022, the EPA issued a Notice of Violation (“NOV”) to Inhance notifying Inhance that its process [REDACTED] [REDACTED] Rule and that Inhance’s manufacturing or processing of such [REDACTED] is a violation of the [REDACTED] Rule.

41. The NOV requested any information on any changes Inhance may have made to its [REDACTED] process and any information that would confirm that any such changes eliminated the manufacture of [REDACTED] subject to the [REDACTED] Rule.

42. The NOV further stated that if Inhance had not changed its process for [REDACTED] [REDACTED] to prevent the manufacture of [REDACTED] Inhance must immediately cease the manufacture of [REDACTED] subject to the [REDACTED] Rule and may not resume manufacture until it has submitted a New Use Notice and the EPA issues a determination on that New Use Notice.

43. Between April and August 2022, the EPA reviewed additional information submitted by Inhance and also determined that Inhance’s [REDACTED] is manufacturing [REDACTED] subject to the [REDACTED] Rule.

44. In August 2022, the EPA determined that the information Inhance provided on its [REDACTED] processes is inadequate to support a determination that the process does not result in the manufacture of [REDACTED] Rule.

45. On September 7, 2022, Inhance informed the EPA that, although it intended to submit New Use Notices regarding [REDACTED] Rule manufactured in

its [REDACTED] processes, Inhance did not intend to cease its [REDACTED] processes before or during the period of review of the New Use Notices.

46. The Defendant has [REDACTED] regarding the manufacture of

[REDACTED] Rule in Defendant's process for [REDACTED] [REDACTED].

47. The information and test data [REDACTED] indicates that Inhance's process for [REDACTED] continues to result in the production for a significant new use of [REDACTED] Rule.

48. Studies involving humans and animals have shown that certain [REDACTED] [REDACTED] Rule can bioaccumulate in the body (e.g., serum half-lives from months to years in humans and monkeys; hours to days or months in rodents).

49. Certain [REDACTED] Rule [REDACTED] examined in the studies referenced in paragraph 48 have been detected in [REDACTED] by Inhance.

50. Epidemiological studies in human populations and experimental animal studies show correlations between exposures to certain [REDACTED] and an array of cancer and non-cancer health effects, including to susceptible subpopulations (e.g., those in early developmental life and women of child-bearing age).

51. Inhance's past and continuing manufacturing for a significant new use of [REDACTED] [REDACTED] Rule may present an unreasonable risk of injury to the health of individuals exposed to the [REDACTED], the employees and workers involved in the manufacturing process at Inhance, and to the environment.

FIRST CLAIM FOR RELIEF
Declaratory Relief

52. Paragraphs 1 through 51 of the Complaint are incorporated herein by reference.

53. Pursuant to Section 5(a)(1) of TSCA, 15 U.S.C. § 2604(a)(1), no person may manufacture or process a chemical substance for a significant new use unless (1) that person submits a New Use Notice to the EPA, at least 90 days before such manufacture or processing; (2) the EPA reviews that notice; (3) the EPA makes a determination on that use under Section 5(a)(3) of TSCA, 15 U.S.C. § 2604(a)(3); and (4) the EPA “takes the actions required in association with that determination.”

54. The Defendant is a “person” under the regulations implementing TSCA. 40 C.F.R. § 720.3(x).

55. The Defendant is manufacturing or processing multiple [REDACTED] [REDACTED] Rule through its [REDACTED] activities for uses that the EPA has determined are significant new uses subject to the [REDACTED] Rule. [REDACTED].

56. The Defendant failed to submit to the [REDACTED], in accordance with Section 5(a)(1)(B) of TSCA, 15 U.S.C. § 2604(a)(1)(B), and 40 C.F.R. § 721.25, before manufacturing or processing [REDACTED] for a significant new use subject to the [REDACTED] Rule, of its intention to manufacture or process [REDACTED] for a significant new use subject to the [REDACTED] Rule.

57. The EPA has not issued determinations on the [REDACTED] by the Defendant, as required by Section 5(a)(1)(B) of TSCA, prior to Defendant manufacturing or processing [REDACTED] for a significant new use subject to the [REDACTED] Rule.

58. Because the EPA has not issued determinations on the [REDACTED] before the Defendant’s manufacturing or processing of [REDACTED] for a significant new use subject to the [REDACTED] Rule, the EPA has been denied the opportunity to conduct the review and

determination process before the Defendant's significant new uses of [REDACTED]

[REDACTED] Rule, as required by Section 5(a)(3) of TSCA. 15 U.S.C. § 2604(a)(3).

59. Pursuant to Section 15 of TSCA, 15 U.S.C. § 2614, it is unlawful for the Defendant to: (1) fail or refuse to comply with any requirement of TSCA or any rule promulgated under TSCA; (2) use for commercial purposes a chemical substance that such person knew or had reason to know was manufactured or processed in violation of Section 5, 15 U.S.C. § 2604; or (3) fail or refuse to submit notices as required by TSCA or any rule promulgated thereunder.

60. Under 40 C.F.R. § 721.35, it is a violation of Section 15 of TSCA, 15 U.S.C. § 2614, to fail to comply with any provision of Title 40, Part 721 of the regulations implementing TSCA.

61. An actual controversy exists between the United States and the Defendant. Pursuant to the Declaratory Judgment Act, 28 U.S.C. § 2201, the United States is entitled to a declaratory judgment that the Defendant has and continues to violate Section 15 of TSCA, 15 U.S.C. § 2614, by failing or refusing to comply with Section 5 of TSCA, 15 U.S.C. § 2604, and all applicable regulatory requirements, by manufacturing or processing [REDACTED] for a significant new use subject to the [REDACTED] Rule, before submitting notices to the EPA, and before the EPA has conducted the review and determination process required under Section 5(a)(1)(B) of TSCA, 15 U.S.C. § 2604(a)(1)(B), and all applicable regulatory requirements.

SECOND CLAIM FOR RELIEF
Injunctive Relief

62. Paragraphs 1 through 51 of the Complaint are incorporated herein by reference.

63. Pursuant to Section 5(a)(1) of TSCA, 15 U.S.C. § 2604(a)(1), no person may manufacture or process a chemical substance for a significant new use unless (1) that person

submits a New Use Notice to the EPA, at least 90 days before such manufacture or processing, (2) the EPA reviews that notice, (3) the EPA makes a determination on that use under Section 5(a)(3) of TSCA, 15 U.S.C. § 2604(a)(3), and (4) the EPA “takes the actions required in association with that determination.”

64. The Defendant is a “person” under the regulations implementing TSCA. 40 C.F.R. § 720.3(x).

65. The Defendant is manufacturing or processing multiple [REDACTED] subject to the [REDACTED] Rule through its [REDACTED] activities for uses that the EPA has determined are significant new uses subject to the [REDACTED] Rule. [REDACTED].

66. The Defendant failed to submit to the [REDACTED], in accordance with Section 5(a)(1)(B) of TSCA, 15 U.S.C. § 2604(a)(1)(B), and 40 C.F.R. § 721.25, before manufacturing or processing [REDACTED] for a significant new use subject to the [REDACTED] Rule, of its intention to manufacture or process [REDACTED] for a significant new use subject to the [REDACTED] Rule.

67. The EPA has not issued determinations on the [REDACTED] by the Defendant, as required by Section 5(a)(1)(B) of TSCA, prior to Defendant manufacturing or processing [REDACTED] for a significant new use subject to the [REDACTED] Rule.

68. Because the EPA has not issued determinations on the [REDACTED] before the Defendant’s manufacturing or processing of [REDACTED] for a significant new use subject to the [REDACTED] Rule, the EPA has been denied the opportunity to conduct the review and determination process before the Defendant’s significant new uses of [REDACTED] subject to the [REDACTED] Rule, as required by Section 5(a)(3) of TSCA. 15 U.S.C. § 2604(a)(3).

69. Pursuant to Section 15 of TSCA, 15 U.S.C. § 2614, it is unlawful for the Defendant to: (1) fail or refuse to comply with any requirement of TSCA or any rule promulgated under TSCA; (2) use for commercial purposes a chemical substance which such person knew or had reason to know was manufactured or processed in violation of Section 5, 15 U.S.C. § 2604; or (3) fail or refuse to submit notices as required by TSCA or any rule promulgated thereunder.

70. Under 40 C.F.R. § 721.35, it is a violation of Section 15 of TSCA, 15 U.S.C. § 2614, to fail to comply with any provision of Title 40, Part 721 of the regulations implementing TSCA.

71. Inhance's past and continuing manufacture of [REDACTED] for a significant new use subject to the [REDACTED] Rule may present an unreasonable risk of injury to the health of individuals exposed to its products, the employees and workers involved in the manufacturing process at Inhance, and the environment.

72. Pursuant to Section 17 of TSCA, 15 U.S.C. § 2616, the Defendant should be: (A) restrained from violating Section 15 of TSCA, 15 U.S.C. § 2614; (B) restrained from the manufacture or processing of [REDACTED] for a significant new use subject to the [REDACTED] Rule, until the EPA has conducted the review and determination process required under Section 5(a)(1)(B) of TSCA, 15 U.S.C. § 2604(a)(1)(B); and (C) directed to give notice of its manufacturing in violation of Section 5 of TSCA, 15 U.S.C. § 2604, to distributors in commerce of the [REDACTED] subject to the [REDACTED] Rule that it has produced for a significant new use, and, to the extent reasonably ascertainable, to other persons in possession of such [REDACTED] or exposed to such [REDACTED].

RELIEF SOUGHT

WHEREFORE, Plaintiff respectfully prays that this Court:

A. Enter a declaratory judgment that the Defendant has and continues to violate Section 15 of TSCA, 15 U.S.C. 2614, by failing or refusing to comply with Section 5 of TSCA, 15 U.S.C. § 2604, and all applicable regulatory requirements, by manufacturing or processing ██████ for a significant new use subject to the ██████ Rule, before submitting a notice to the EPA, and before the EPA has conducted the review and determination process required under Section 5(a)(1)(B) of TSCA, 15 U.S.C. § 2604(a)(1)(B), and all applicable regulatory requirements.

B. Award the United States injunctive relief to: (A) restrain the Defendant from any violation of Section 15 of TSCA, 15 U.S.C. § 2614; (B) restrain the Defendant from the manufacture or processing of ██████ for a significant new use subject to the ██████ Rule, except in compliance with TSCA; and (C) direct the Defendant to give notice of its manufacturing in violation of Section 5 of TSCA, 15 U.S.C. § 2604, to distributors in commerce of the ██████ subject to the ██████ Rule that it has produced for a significant new use, and, to the extent reasonably ascertainable, to other persons in possession of such ██████ or exposed to such ██████.

C. Order the Defendant to take other appropriate actions to remedy, mitigate, and offset the harm to public health and the environment caused by the violations of TSCA alleged above;

D. Award Plaintiff its costs of this action; and

E. Grant such other relief as this Court may deem just and proper.

Respectfully submitted,

FOR THE UNITED STATES OF AMERICA

TODD KIM

Assistant Attorney General
Environment and Natural Resources Division
United States Department of Justice

Dated: December 19, 2022

/s/ Richard Gladstein

RICHARD GLADSTEIN, D.C. Bar #362404

Senior Counsel

JONAH SELIGMAN, La. Bar #38890

Trial Attorney

Environmental Enforcement Section

Environment and Natural Resources Division

United States Department of Justice

P.O. Box 7611

Washington, D.C. 20044-7611

(202) 514-1711

Richard.Gladstein@usdoj.gov

Jonah.Seligman@usdoj.gov

JACQUELINE C. ROMERO
United States Attorney
Eastern District of Pennsylvania

Dated: December 19, 2022

/s/ Gregory B. David
GREGORY B. DAVID
Chief, Civil Division

/s/Erin Lindgren
ERIN E. LINDGREN
Assistant United States Attorney
Office of United States Attorney
615 Chestnut Street, #1250
Philadelphia, Pennsylvania 19106
Erin.Lindgren@usdoj.gov

Of Counsel:

N. LINSDAY SIMMONS
ALEXANDER DERGARABEDIAN
Attorney-Advisors
Chemical Risk and Reporting Enforcement Branch
Waste and Chemical Enforcement Division
Office of Civil Enforcement, OECA
U.S. Environmental Protection Agency
1200 Pennsylvania Ave., N.W.
Washington, D.C
(202) 564-3223
Simmons.lindsay@epa.gov
Dergarabedian.alexander@epa.gov