NO REFUGE

More Acres of America's National Wildlife Refuges Are Being Doused in Harmful Pesticides

Hannah Connor • Center for Biological Diversity • August 2020

ACKNOWLEDGMENTS

The author would like to express her gratitude to Jean Merrigan, paralegal for the Center for Biological Diversity's environmental health program, for her invaluable assistance in distilling and analyzing the pesticide-use data detailed in this report.

Lower Klamath Lake, Klamath Basin National Wildlife Refuge by Michael McCullough, CC-BY-NC

EXECUTIVE SUMMARY

America's 568 national wildlife refuges play a critical role in protecting fish, plants and other wildlife. The refuges include forests, wetlands and waterways vital to thousands of species, including more than 280 that are protected under the Endangered Species Act.

Yet industrial-scale commercial farming of crops like corn, soybeans and sorghum has become common on refuge lands, triggering escalating use of highly toxic pesticides that threaten the long-term health of these sensitive habitats and the wildlife that depends on them.

For this report we examined records we obtained, via the Freedom of Information Act, from the U.S. Fish and Wildlife Service. These records reveal extensive pesticide use for commercial agriculture on national wildlife refuges.

Key finding: More than 350,000 pounds of dangerous agricultural pesticides were sprayed on more than 363,000 acres of America's national wildlife refuges in 2018, a 34% increase over the acreage sprayed in 2016.

This amount from 2018 reflects data provided by the Fish and Wildlife Service at the point of responding to the Center's public records request and may not include all reporting data for that calendar year, according to communications with Service personnel.

This analysis updates the 2018 Center report, No Refuge, detailing refuge pesticide spraying. Highlights of the updated report, which assessed changes in refuge pesticide use between 2016 and 2018, include:

- **34% more refuge acreage sprayed:** The total acreage of pesticide use on refuge crops rose significantly, from 270,000 acres in 2016 to more than 363,000 acres in 2018, a 34% increase.

- **Greater than 70% increase in most dangerous pesticides:** Use of some of the most dangerous pesticides sprayed on the refuges surged between 2016 and 2018, including a 89% increase for dicamba, 74% increase for 2,4-D and 100% increase for paraquat, all which are known to harm endangered species and migrating birds.

- **35% jump in aerial spraying:** In 2018, 144,788 acres of refuge lands were aerially sprayed with 129,732 pounds of pesticides, including 2,4-D and the notoriously drift-prone dicamba, which is extremely toxic to fish, amphibians and crustaceans. That represented a 35% increase over the acreage sprayed in 2016.

The five national wildlife refuge complexes[1] in which pesticides were most applied for agricultural purposes in 2018 were:

Lake deer at Wapanocca National Wildlife Refuge, Central Arkansas Refuge Complex, courtesy USFWS

- **Klamath Basin National Wildlife Refuge Complex**[2] in California and Oregon, which allowed at least 84,497 pounds of pesticides to be applied, though final use amounts for 2018 may be higher;
- **Central Arkansas Refuges Complex**[3] in Arkansas, which allowed 55,300 pounds of pesticides to be applied;
- **Theodore Roosevelt National Wildlife Refuge Complex**[4] in Mississippi, which allowed 47,057 pounds of pesticides to be applied;
- **West Tennessee Refuge Complex**[5] in Tennessee, which allowed 27,937 pounds of pesticides to be applied;
- **Tennessee National Wildlife Refuge Complex**[6] in Tennessee, which allowed 22,047 pounds of pesticides to be applied.

Additional Findings About Expanded Pesticide Use on Refuges:

- **Dicamba:** Between 2016 and 2018, use of pesticides containing dicamba on refuges for agricultural purposes almost doubled, from approximately 2,797 pounds to 5,300 pounds annually. Dicamba has been called the "most controversial agrochemical product launched of the past decade" due to its tendency to drift and damage neighboring fields and natural areas, as well as its cancer risks and its threat to imperiled monarch butterfly populations. In June 2020 a federal appeals court panel found that the EPA and Monsanto had ignored widespread evidence of the pesticide's harm and ordered the agency to withdraw approval of newly approved products for soybeans and cotton.
- **Glyphosate:** In 2018 more than 69,143 agricultural acres in the refuge system were treated with 88,159 pounds of products containing glyphosate, the pesticide that has caused widespread decreases in milkweed plants, helping to trigger the 80% population decline of monarch butterflies over the past two decades. Its documented links to cancer resulted in Bayer reaching a tentative $10 billion settlement in June 2020 with more than 90,000 glyphosate users suffering from cancer.
- **2,4-D:** In 2018 more than 29,000 refuge acres were treated with 27,446 pounds of pesticide products containing 2,4-D, which is known to be toxic to mammals, birds, amphibians, crustaceans, reptiles and fish and is likely to jeopardize the continued existence of endangered and threatened salmonids. These use amounts were significantly higher than in 2016 and 2017, in which 15,819 pounds and 14,418 pounds were used consecutively

The National Wildlife Refuge System. Map compiled by the US Fish and Wildlife Service, Division of Realty, Washington, DC.

At the time the pesticide use amounts relevant to this report were collected, the refuge system was organized into eight regions:

- **Region 1, the Pacific Region:** Hawaii, Idaho, Oregon, Washington and the Pacific Island Territories;
- **Region 2, the Southwest Region:** Arizona, New Mexico, Oklahoma, and Texas;
- **Region 3, the Midwest Region:** Minnesota, Iowa, Missouri, Illinois, Indiana, Ohio, Michigan and Wisconsin;
- **Region 4, the Southeast Region:** North Carolina, South Carolina, Tennessee, Arkansas, Louisiana, Mississippi, Alabama, Georgia, Florida, Puerto Rico and the U.S. Virgin Islands;
- **Region 5, the Northeast Region:** Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, West Virginia and Virginia;
- **Region 6, the Intermountain Region:** Utah, Colorado, Kansas, Nebraska, South Dakota, North Dakota, Wyoming and Montana;
- **Region 7:** Alaska;
- **Region 8:** California and Nevada.

- **Paraquat dichloride:** In 2018 approximately 13,615 pounds of pesticides containing paraquat dichloride were used to treat more than 8,000 acres in the Southeast region. Paraquat is known to be toxic to crustaceans, mammals, fish, amphibians and mollusks, and is so lethal it is banned in 46 counties, including the European Union. These mounting paraquat use amounts were significantly higher than in 2016 and 2017, in which 6,800 pounds and 9,764 pounds were used consecutively.

RECOMMENDATIONS

The widespread use of pesticides for agricultural purposes on national wildlife refuges conflicts with the mission of the refuge system and creates a legacy of chemical pollution that threatens the long-term health of these essential ecosystems.

To ensure the preservation of the biological integrity, species diversity and overall health of the national wildlife refuges, the use of dangerous pesticides for commercial agricultural purposes should be discontinued.

INTRODUCTION

America currently maintains 568 national wildlife refuges, with at least one refuge in each U.S. state and territory and more than 100 refuges close to large urban areas.[7]

Each national wildlife refuge was created by congressional action, an executive action of the president of the United States, or a combination of the two for the benefit of wildlife and wildlife conservation.

The first refuge, the Pelican Island Refuge, was established in 1903 by President Theodore Roosevelt to protect pelicans and other birds with desirable plumes and feathers from hunting activities.[8] Since then the protection of migratory birds has remained a dominant purpose of the refuge system, with many refuges created specifically to act as an "inviolate sanctuary" for migratory birds.[9]

Refuges have also been created specifically for the critical purpose of protecting and providing habitat for threatened and endangered species listed as imperiled under the Endangered Species Act of 1973.[10] Refuges play a critical role in promoting the survival and recovery of species nationwide.

National wildlife refuges provide habitat for more than 700 species of birds, 220 species of mammals, 250 reptile and amphibian species, and more than 1,000 species of fish. Those species include more than 280 plants and animals protected by the Endangered Species Act.[11]

Historically the U.S. Fish and Wildlife Service, which manages the refuges, has allowed private farming on refuges in order to help prepare seed beds for native habitat, such as grasslands, and to provide food for migratory birds and other wildlife. Today, however, industrial farming and the heavy pesticide use that comes along with it are commonplace on refuge lands.

Whooping cranes courtesy Klaus Nigge, USFWS

Nationwide, every region of the refuge system except Alaska allows farming practices that often include the use of pesticides on commercial crops like corn, soy, wheat, rice and sorghum.

Starting in 2017 the U.S. Department of the Interior announced plans to begin reorganizing the boundary lines for the regions utilized by the agencies within the Department, including the Fish and Wildlife Service. In 2018 a plan for streamlining all Interior agencies into 12 common "unified Interior Region boundaries" became final. The Department and its agencies, including the Service, are in the process of shifting their previously utilized boundaries to conform with the new unified Interior Region boundaries.

The oversight and management of national wildlife refuges is controlled principally by the 1997 National Wildlife Refuge Improvement Act, which directed the Service to administer all refuges as "a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources."[12] To support this goal, Congress directed the Service to "provide for the conservation of fish, wildlife and plants," and "ensure" that the biological integrity, species diversity, and environmental health of the refuge system are prioritized and preserved. [13]

Refuges contain a diverse array of protected species and habitat types, including some that are rare and ecologically significant, especially low-elevation habitats that have been largely destroyed elsewhere by intensifying agriculture and development. The central purposes of the refuge system include wildlife conservation and environmental health. "[F]ish and wildlife will not prosper without high-quality habitat, and without fish and wildlife, traditional uses of refuges cannot be sustained."[14] Continuing protection for species and their habitats is, therefore, crucial to preserving and maintaining the nation's treasured natural heritage.[15] By opening refuges to intensive farming that utilizes toxic pesticides the Service has failed to carry out its primary purpose of protecting wildlife.

PURPOSE OF AGRICULTURE IN NATIONAL WILDLIFE REFUGES

Under the Refuge Act, the main questions considered in deciding which practices should be allowed on refuges are: (1) whether the proposed activity is consistent with the purpose of that refuge, (2) the mission of the refuge system, and (3) public safety.[16] To help answer those questions, the Act identifies "six primary public uses" to prioritize, assuming they are compatible with the refuge's principal conservation mandate; these wildlife-dependent recreational uses are wildlife observation and photography, fishing, hunting, environmental education and interpretation.[17]

Other uses, including economic uses such as row-crop farming (often termed "cooperative farming"), are not considered to be a priority for refuges, but have been permitted when found to be "compatible."[18] The Act defines a "compatible use" as one that does not "materially interfere with or detract from the fulfillment of the mission of the System or the purposes of the refuge."[19] In determining whether cooperative farming is a compatible use, the Service must identify that the activity is not only consistent with the purpose of the refuge, the mission of the refuge system and public safety, but whether the use conflicts with other resource or management objectives, including species and biodiversity objectives. Pursuant to these constraints, farming activities "are [considered] permissible habitat management practices only when prescribed in plans to meet wildlife or habitat management objectives, and only when more natural methods, such as fire or grazing by native herbivores, cannot meet refuge goals and objectives."[20]

Historically, refuges allowed farming in order to help prepare seed beds for native habitat and to provide food for migratory birds and other wildlife. For example, during migration, migratory birds — including endangered species like the whooping crane — rely on refuges to provide a safe and nontoxic place for resting and foraging during their journey. Indeed, as many refuges were established in whole or in part to serve as sanctuaries for migratory birds,[21] the refuges themselves are often crucial to bird migration and health. This is especially true along the four main U.S. north-south waterfowl migration corridors, also known as the Atlantic, Mississippi, Central and Pacific Flyways.[22] Ostensibly, cooperative farming is supposed to enable that objective.

But today the extensive use of pesticides in industrial farming, including row-crop agriculture, threatens these sensitive habitats and the very purpose of the refuge system.

Individual national wildlife refuges can sometimes be organized into National Wildlife Refuge Complexes. A National Wildlife Refuge Complex is an administrative grouping of two or more refuges, wildlife-management areas, or other refuge conservation areas primarily managed from one central office.[23] Refuges are generally grouped into these complexes because they are located in a similar ecological region, such as watershed or habitat type, and have related purpose and management needs.[24]

METHODOLOGY

The findings in this report were compiled from public records produced by the Service in response to a request by the Center for Biological Diversity under the Freedom of Information Act, 5 U.S.C. § 552. Subject to that request, the Service provided the Center with raw data on: (1) pesticides approved for use on refuges in 2017 and 2018; (2) the refuges on which those pesticides were used; (3) the number of acres (identified as "units") on each refuge treated with approved pesticides for any given year; and (4) the amount of pesticides applied.

For each pesticide requested for use on a refuge, the Service — usually through its environmental contaminant or national wildlife refuge staff at the field, regional or national levels — undertakes a "pesticide use proposal" process.[25] Once pesticides are approved, information on their uses, including amounts, must be reported annually to the Service.[26]

In response to the Center's Freedom of Information Act request, the Service indicated that the use amounts for 2018 would be a maximum at the time of the year the information was requested and did not yet include all reporting data for that calendar year.[27]

In the annual reports, pesticide-use amounts are reported in terms of total pesticide product used, which is based on trade name measurements rather than on the active chemical ingredients that make up the pesticide. In addition, application units for pesticide products are based on the form of the trade-name product (liquid or solid) and were, therefore, provided in either pounds or gallons, depending on the product in question. For consistency and to harmonize the differing units for ease of review, all pesticide-use amounts in this report have been consistently converted to pounds using the pure water conversion rate of 8.3 pounds to every 1 gallon.

For example, in this report it is estimated that more than 350,000 pounds of pesticides were used on refuge lands in 2018, down from over 457,500 pounds in 2017 and 490,000 pounds in 2016. This 2018 estimate is a conversion from the original units of measurement of 40,146 gallons and 17,078 pounds of pesticides. In this case the existing gallon amount was multiplied by 8.3 and then added to the existing pound amount.

While the total volume of pesticides went down, the total acreage of pesticide use went up significantly, rising from 270,000 to more than 363,000 acres — a 34% increase. In addition, the total use of some of the most dangerous pesticides, such as the highly volatile and drift-prone dicamba, increased significantly.

This conversion rate does not take into consideration the percentage of active ingredient in the trade-name pesticide. The rate also has not been adjusted based on the differences in molecular density of the pesticide products, both independently of, and in comparison to, water. As a result the estimates provided in this report are not a precise accounting of active ingredients or an exact pounds-to-gallons conversion.

Monarch butterfly on swamp milkweed in Michigan. Photo by Jim Hudgins/USFWS

Finally, for the purpose of this updated report, the Service provided the Center with use amounts per "unit size." This is a change from the prior reporting cycle, as detailed in the Center's May 2018 No Refuge report, in which the Service had provided its use amounts per "treated acre." However, the Service indicated that there is no substantive difference between the data contained in each category. The Center is therefore treating the two as interchangeable in this updated report. Because multiple pesticides may be approved for use on one acre, the acre counts in this report do not necessarily represent unique acres but rather represent an aggregate total.

Spreadsheets containing the data used to calculate the figures for this report, as collected from the Center's FOIA requests, are available upon request to the author.

FINDINGS ON AGRICULTURAL PESTICIDE USE IN NATIONAL WILDLIFE REFUGES

Overview

Based on the data provided to the Center by the Service, more than 350,000 pounds[28] of pesticides were used to treat almost 363,500 acres of refuges lands in 2018 for agricultural purposes, a number that is lower than pesticide application rates in previous years. In 2017 approximately 457,500 pounds[29] were applied to 338,500 acres; in 2016 at least 490,000 pounds[30] were applied to approximately 271,000 acres; in 2015 approximately 467,000 pounds[31] were applied to 309,457 acres; and in 2014 approximately 530,000 pounds were applied to 279,424 acres.

The most significant uses of pesticides for agricultural purposes in the refuge system are in the Southeast region (previously, Region 4) and the California-Great Basin region (previously, Region 8). In 2018 185,563 acres in then-Region 4 were treated with a total of 210,942 pounds[32] of approximately 60 pesticides — alone and in combination — for agricultural purposes. This number is up from 172,413 pounds on 147,396 acres in that region in 2016.

For then-Region 8, since the 2018 uses appeared to be incomplete at the time of collection, the Center looked to both the 2017 and 2018 uses for that region. In 2017 in then-Region 8, approximately 40 pesticides — alone and in combination — were used to treat 52,690 acres with a total of 248,107 pounds of pesticides for agricultural purposes. This number is slightly up from 237,059 pounds on 59,900 acres in that region in 2016, and lower than the use amounts identified at the time of reporting for 2018, 86,323 pounds on 73,419 acres. In all years a majority of the pesticide applications in then-Region 8 took place on the Klamath Basin National Wildlife Refuge Complex.

The crops most frequently correlated with agricultural pesticide use on refuges are corn, soybean, wheat, rice and sorghum. Although these monocultures may provide the farmer with a profitable way to grow crops on an industrial scale, monoculture farming triggers infestations that lead to increased pesticide use.

In 2018 in then-Region 3, for example, the following pesticides and pesticide combinations were approved for

use for agricultural purposes: 2,4-D, acetochlor, benzovindiflupy, clethodim, dicamba, flumiclorac-pentyl ester, flumioxazin, glyphosate, halosulfuron-methyl, imazapyr, lactofen, mesotrione, nicosulfuron, propanil, rimsulfuron, saflufenacil and triclopyr. This is not a comprehensive list.

In then-Region 4 in that same year, the following pesticides were approved for use for agricultural purposes: 2,4-D, acephate, acetochlor, acifluorfen, azoxystrobin, bensulfuron-methyl, bifenthrin, carbaryl, carfentrazone-ethyl, chlorantraniliprole, chlorimuron ethyl, clethodim, clomazone, dicamba, diflufenzopyr, fludioxonil, flumiclorac-pentyl ester, flumioxazin, flupyradifurone, fomesafen, glyphosate, halosulfuron-methyl, imazapyr, imazaquin, imazethapyr, isoxaflutole, lambda-cyhalothrin, mesotrione, methoxyfenozide, nicosulfuron, paraquat dichloride, penoxsulam, propanil, pyroxasulfone, rimsulfuron, saflufenacil, simazine, s-metolachlor, sulfentrazone, thiencarbazone-methyl, thifensulfuron-methyl and triclopyr. This is not a comprehensive list.

The revelation that so many toxic pesticides have been approved for use on commercial monocultures by private farmers inside our national wildlife refuges raises important questions about the increasing risks they pose for the wildlife those refuges were created to protect.

Detailed Findings

A. *The Aerial Spraying of Pesticides for Agricultural Use*

The Service currently allows pesticides to be aerially applied for agricultural purposes on national wildlife refuge lands. Aerial spraying is a concerning practice because the pesticide is applied at a greater height and can therefore be more prone to movement from wind and other climatic pressures. Pesticides that are aerially sprayed can lead to exposure of nontarget insects, plants and other species, including species the refuges were established to protect.

In 2018 pesticides were aerially sprayed in then-Regions 3, 4, 6 and 8, with the most extensive aerial spraying taking place in then-Regions 4 (Southeast) and 8 (Pacific). In that year a total of 144,788 acres of refuge lands were aerially treated for agricultural purposes with 129,732 pounds of pesticides. This use is up from 2017, when 98,452 pounds of pesticides were applied to 95,061 acres, and 2016, when 107,342 acres of refuge lands were aerially treated with 127,020 pounds of agricultural pesticides.

As further detailed below on a pesticide-specific basis, pesticides aerially sprayed on refuge lands in 2018 include, but are not limited to: aminopyralid, glyphosate, dicamba, 2,4-D, propanil, prosulfuron, paraquat dichloride, imazethapyr, halosulfuron-methyl and flupyradifurone. The aerial spraying of drift-prone pesticides like dicamba and 2,4-D is particularly concerning.

B. *Dicamba*

The pesticide dicamba is toxic to fish, amphibians and crustaceans, and has been detected in dozens of waterways across the country.[33] Further, as identified by the EPA, "[e]ven if only a small surface area of [a] plant is exposed to dicamba . . . there is a possibility that the plant may be severely damaged or die as a result."[34]

Indeed, in June 2020, the U.S. Court of Appeals for the 9th Circuit found the EPA's 2018 registration of certain dicamba formulas to be unlawful because it "substantially understated risks that it acknowledged and failed entirely to acknowledge other risks."[35] In ruling the pesticide approval unlawful, the court cited "enormous and unprecedented damage" caused by dicamba in the last few years, damage that has "torn apart the social fabric of many farming communities."[36]

Yet approved uses of dicamba for agricultural purposes in the refuge system include aerial spraying.

In 2018 approximately 5,300 pounds[37] of pesticides containing dicamba were used to treat more than 23,443 refuge acres for agricultural purposes, a significant increase from 2016 uses. Of those approximately 630[38] pounds were applied using aerial-spraying practices. Review of the data for these uses appears to indicate that multiple applications took place on one individual unit. As indicated in the Methodology section, the acre counts in this

Indiana bat courtesy USFWS

report do not necessarily represent unique acres but rather an aggregate total. For comparison, in 2016, approximately 2,797 pounds[39] of pesticides containing dicamba were used to treat more than 8,366 refuge acres for agricultural purposes; nearly half of those dicamba uses — approximately 1,328 pounds[40] — were applied using aerial spraying.

Dicamba has been called the "most controversial agrochemical product launched of the past decade," in large part because of its extreme predisposition to drift.[41] The pesticide's tendency to drift was spotlighted in 2017, when its widespread use on crops genetically altered to resist it resulted in close to 3,000 complaints by neighboring farmers whose crops were damaged by the pesticide. Damage from drifting dicamba was reported to soybean crops, fruit trees, vegetables, vineyards and forests stretching from the Great Plains across the Midwest and Southeast.[42] In 2017 approximately 3.6 million acres of that damage was to soybean crops alone.[43]

Researchers at the National Institutes of Health have determined that use of the pesticide dicamba can increase the risk of developing numerous cancers, including liver and intrahepatic bile duct cancers, acute and chronic lymphocytic leukemia, and mantle cell lymphoma.[44]

In addition, animal studies have found that dicamba can alter liver function in a way that is known to induce liver tumors and promote liver cancer in combination with other carcinogens.[45] Dicamba is also known to cause DNA mutations and induce oxidative stress, two pathways known to cause cancer, and its use harms monarch butterfly and other pollinator populations.[46]

As a result, dicamba use has been either banned or severely limited by several states, with Arkansas becoming a battleground state around the use of this hazardous pesticide.[47] The fact that dicamba use is being dramatically restricted in many states because of the risks it poses to natural resources should spur a reevaluation of whether its use is reasonable to allow on national wildlife refuges, especially through risky aerial spraying.

C. *Glyphosate*

Glyphosate is the active ingredient in Monsanto-Bayer's flagship pesticide Roundup. It is the most widely used pesticide in the world, with 300 million pounds applied on U.S. farmland each year.[48]

In 2018 at least 88,159 pounds[49] of pesticides containing glyphosate were used to treat approximately 69,143 agricultural acres in the refuge system; this is comparable to the amount of glyphosate used for agricultural purposes on refuges in 2017.[50] For comparison, 116,200 pounds[51] of pesticides containing glyphosate were used in 2016 to treat approximately 55,487 agricultural refuge acres.

Despite its popularity glyphosate is extremely controversial. In 2015 the World Health Organization's International Agency for Research on Cancer classified glyphosate — as well as the herbicides malathion and diazinon — as "probably carcinogenic to humans."[52] Following that finding more than three dozen lawsuits were filed against then-Monsanto by people claiming that Roundup was the cause of their non-Hodgkin's lymphoma.[53]

In 2019 a jury in one of those lawsuits awarded $2 billion in damages to plaintiffs Alva and Alberta Pilliod following a finding that Roundup was a "substantial factor" in causing their non-Hodgkin's lymphoma and that "there was

clear evidence that Monsanto, after learning of the dangers, 'made efforts to impede, discourage or distort scientific inquiry' by regulators who approved its use." The jury-awarded damages in that case were later reduced to $86.7 million.[54]

This was the latest in a series of cases that arrived at a similar result. In 2020 Bayer — the German chemical and pharmaceutical company that purchased Monsanto in 2016 — agreed to settle nearly 100,000 lawsuits filed against the company over claims Roundup causes cancer for $10.9 billion dollars.[55]

In 2017 the California Environmental Protection Agency became the first U.S. agency to list glyphosate as a known human carcinogen.[56]

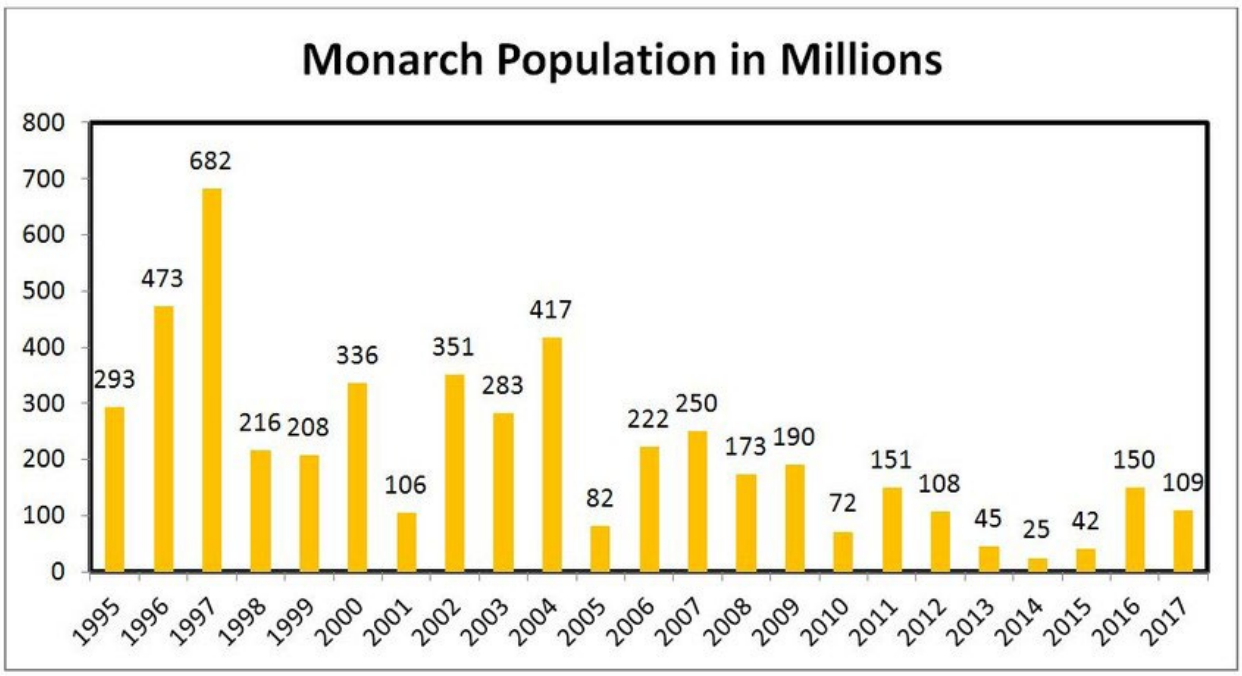
Glyphosate and its metabolites are commonly found in air, rainfall and surface-water samples near sites of use.[57] Glyphosate-resistant crops have also been shown to contain high levels of residual pesticide, which means that glyphosate and its residuals are likely being transferred into forage materials used by wildlife and birds on refuges.[58]

Compounding these concerns is the extensive use of glyphosate on non-refuge agricultural lands, which might lead wildlife and other species to seek sanctuary in refuges from the pesticide's presence and persistence in their environment. Excessive additional uses of this pesticide on refuge lands, however, indicate that those efforts may be in vain.

Use of glyphosate has been tied to widespread declines of milkweed, which is essential to monarch butterfly survival.[59] The threat this habitat loss poses to the continued existence of eastern monarch population cannot be overstated.

A recent yearly count of western monarch butterflies indicated a drastic decrease in population numbers, leaving the population at just 0.6% of 1980s population numbers.[60]

Eastern monarch populations are similarly estimated at desperately low numbers, with the most recent yearly count of monarch butterflies overwintering in Mexico indicating a 53% decrease in the area occupied by monarch butterflies since the previous year.[61] Such low population numbers are well below the threshold at which government scientists predict the migration could collapse,[62] requiring immediate action — including discontinuing dangerous pesticide use practices that damage monarch breeding and migratory habitat.[63]



Monarch butterfly population graph by Tierra Curry, Center for Biological Diversity

Northern bobwhite by panza.rayada, CC-BY-SA

Finally, because glyphosate is often applied to crops that have been genetically engineered to resist it, overuse of the pesticide has spurred growth of glyphosate-resistant "superweeds" across millions of U.S. acres.[64] These glyphosate-resistant superweeds choke out native habitat and erode species biodiversity. To date, at least 38 weed species across the world have evolved to develop a resistance to glyphosate.[65] Glyphosate-tolerant superweeds have caused land managers to turn to additional, and increasingly toxic, pesticides to combat their spread. That troubling trend is of special concern following the Service's change in 2018 to reverse course and allow genetically engineered crops to be grown in the refuge system, as discussed above.

D. *2,4-D*

In 2018 approximately 27,446 pounds[66] of pesticide containing 2,4-D, alone and in combination, were used to treat more than 29,000 refuge acres. This number is up significantly from 2016 and 2017 use amounts, which were 15,819 pounds[67] on 12,000 acres and 14,418 pounds[68] on 22,856 acres consecutively. In all years the Service approved 2,4-D for aerial application.

The pesticide 2,4-D is used as a systemic herbicide against broadleaf plants.[69] It is also an ingredient in the biological weapon known as Agent Orange, an herbicide and chemical defoliant infamous for its us by the U.S. military during the Vietnam War.[70] Due to its extreme toxicity, any drift from 2,4-D application may damage neighboring crops and wild plants. Considered to be acutely toxic or highly acutely toxic to mammals, birds, fish, amphibians, crustaceans and reptiles, 2,4-D may also harm endangered species and their habitats.[71]

In 2011, for example, the National Marine Fisheries Service issued a biological opinion under the Endangered Species Act on the EPA's proposed registration of pesticide products containing 2,4-D and its effects on endangered and threatened Pacific salmonids.[72] The agency found that 2,4-D "will have a detrimental effect on . . . riparian vegetation" that "provides shade, bank stabilization, sediment, chemical and nutrient filtering, and provides a niche for the terrestrial invertebrates that are also salmon prey items." It concluded that the EPA's proposed registration of 2,4-D was likely to jeopardize the continued existence of endangered and threatened salmonids and destroy their critical habitat.[73]

Blackwater National Wildlife Refuge Chesapeake Marshlands National Wildlife refuge complex courtesy Ray Paterra, USFWS

2,4-D is also understood to be an endocrine disrupter, meaning it can have harmful effects on the reproductive and immune systems that are capable of compromising populations of endangered species.[74]

In then-Region 4 in 2018, the Service authorized the use of more than 19,000 pounds[75] of pesticide containing 2,4-D, alone and in combination, on 14,698 acres of refuge land. Of those uses approximately 7,680 pounds[76] were approved for aerial spraying, covering a total area of 7,238 acres, numbers that represented a significant increase in then-Region 4 use and aerial application from earlier years.

The Service identified the following federally protected species as potentially affected by these aerial-spraying activities:

- Three mollusks, the endangered fat pocketbook, endangered pink mucket and threatened rabbitsfoot;
- One endangered fish, the pallid sturgeon;
- Three mammals, the threatened northern long-eared bat, threatened West Indian manatee and critically endangered red wolf;
- Five birds, the endangered least tern, threatened red knot, threatened piping plover, endangered ivory-billed woodpecker and endangered red-cockaded woodpecker;
- Four plants, the threatened sensitive joint-vetch, endangered rough-leaved loosestrife, endangered pondberry and threatened seabeach amaranth.

Cropland at Sonny Bono Salton Sea National Wildlife Refuge, Calif. Photo by Daniel Mayer, CC-BY-SA

E. *Paraquat Dichloride*

Paraquat dichloride (paraquat) is an extremely lethal pesticide that is linked to Parkinson's disease.[77] In 2008 an eight-year-old boy died after drinking from a Dr. Pepper bottle in his garage that had been used to store paraquat. In 2010 a 44-year-old man mistakenly drank paraquat, thinking it was fruit juice. He experienced difficulty breathing, vomited blood and died after 20 days of hospitalization.[78]

Paraquat is also toxic to mammals, fish, amphibians and mollusks.[79] These toxicity rankings are based on data from the EPA, which has also estimated that environmental concentrations of the pesticide are likely to exceed the "level of concern" for endangered species, and/or may cause indirect effects on endangered species by altering habitat or food sources.[80] Use of paraquat has been banned in 46 countries, including the European Union since 2007, largely due to human health concerns.[81] Further, because paraquat is prone to drift, its effects may not be localized to the application site, but may spread across a larger geographic area.[82]

Despite paraquat's well-documented risks, it continues to be used in the Southeast region of the refuge system. In 2018 paraquat was used to treat crops in the West Tennessee Refuge Complex, Pocosin Lakes National Wildlife Refuge, Lake Ophelia National Wildlife Refuge, and the Theodore Roosevelt National Wildlife Refuge Complex (a refuge named for the presidential founder of the refuge system). And it was approved for aerial application in the Pocosin Lakes, Lake Ophelia and Theodore Roosevelt refuges.

In total, in 2018, approximately 13,615 pounds[83] of pesticides containing paraquat were used to treat 8,019 acres in that region. This number is an increase from the 6,800 pounds[84] of pesticides containing paraquat that were used to treat 3,176 acres in that region in 2016, and the 9,764 pounds[85] that were used to treat 4,548 acres in the region in 2017.

Federally protected species in the crosshairs of these practices include the fat pocketbook (an endangered mollusk), northern long-eared bat (a threatened mammal), pallid sturgeon (an endangered fish), pondberry (an endangered plant), red wolf (an endangered mammal) and Indiana bat (an endangered mammal).

F. *Neonicotinoid Pesticide Use and Genetically Engineered Crops on Refuges*

Neonicotinoids are a class of pesticides derived from nicotine that affect the central nervous system of insects, resulting in paralysis and death. They include the pesticides imidacloprid, acetamiprid, clothianidin, dinotefuran, nithiazine, thiacloprid and thiamethoxam. As it relates to wildlife and biodiversity, neonicotinoids are most often associated with their negative effects on pollinator health (including wild bees, honeybees and other pollinators), causal link to bee colony collapse disorder, and toxicity to songbirds.[86]

As an example, in listing the once-common rusty patched bumble bee as endangered under the Endangered Species Act in 2017, the Service identified uses of neonicotinoids as "strongly implicated as the cause of the decline of bees in, and specifically for rusty patched bumble bees, due to the contemporaneous introduction of neonicotinoid use and the precipitous decline of the species . . . . The use of neonicotinoids rapidly increased as seed-applied products were introduced in field crops, marking a shift toward large-scale, preemptive insecticide use."[87] Studies further show that consumption of a single corn kernel treated with any of the common neonicotinoids could kill a songbird, and that just one-tenth of a treated corn kernel is enough to adversely affect a songbird's reproduction.[88]

Uses of genetically engineered crops are similarly problematic for wildlife health. Genetically engineered crops are crops that have been genetically manipulated to introduce a new trait that does not naturally occur in the plant. A majority of genetically engineered crops cultivated in U.S. agriculture have been overwhelmingly developed for the explicit purpose of establishing tolerance in the plant for the use of certain pesticides, such a glyphosate, with the result being that those crops are able to tolerate pesticide application amounts in otherwise lethal amounts. Currently in the United States, approximately 90% of corn and cotton and 94% of soybeans planted were GE, herbicide-resistant varieties.[89]

The way this type of cropping technology typically works is that a pesticide and the crop seeds that have been genetically engineered to tolerate that pesticide are sold together as a "cropping system." The crop's resistance to the pesticide then allows for an increased spraying of that pesticide during the farming season. The result of this marriage between pesticide and crop is that genetically engineered cropping systems have dramatically increased the overall use of pesticides in U.S. agriculture. For example, in the 16 years from 1996 to 2011, an extra 527 million pounds of herbicides are estimated to have been sprayed in U.S. agriculture because of genetically engineered crops.[90]

In addition to direct harm to wildlife and biodiversity as a result of the increased pesticide use that commonly accompanies reliance on genetically engineered cropping technologies, the use of these crops can also harm biological resources by contributing to the spread of "superweeds" that are resistant to the pesticide, and that choke out native vegetation.[91]

Acting to protect wildlife from these harmful effects, in 2014 the Service issued a policy to discontinue the use of neonicotinoid pesticides and genetically engineered crops for use in agricultural practices in the refuge system.[92] The policy went into effect in January 2016 and by 2018, according to data from the Service, these uses were discontinued across the refuge system except in a small number of exempted refuges. Not only did this represent an essential step for saving imperiled pollinators and other species, but it demonstrates that the refuge system can successfully transition away from pesticide use and continue to successfully meet the wildlife-management and conservation objectives of individual refuges and the refuge system.

Unfortunately in August 2018 the Service reversed course on its 2014 decision and once again allowed genetically engineered crops and neonicotinoid pesticides to be used for agricultural purposes in the refuge system.[93] The Service's 2018 decision is currently being challenged in federal court in the case of Center for Biological Diversity, et al. v. Bernhardt, Case No. 19-02898 (D.D.C. filed Sept. 26, 2019).

Given the timing of the Service's 2018 decision and the Center's subsequent court challenge, any reintroduction of these practices into the refuge system are not reflected in the summary data provided through this updated report.

Wheeler National Wildlife Refuge by Shawn Taylor, CC-BY

CASE STUDY: WHEELER NATIONAL WILDLIFE REFUGE COMPLEX

In Alabama, where industrial farming dominates the landscape, the refuge system affords critical protection for endangered species and foraging grounds for pollinators. Eleven refuges are located in whole or in part in Alabama, more than half of which are managed as a part of the Wheeler National Wildlife Refuge Management Complex (Wheeler Complex).[94]

The Wheeler Complex is composed of: Wheeler (est. 1938), Key Cave (est. 1997), Fern Cave (est. 1981), Sauta Cave (est. 1978), Watercress Darter (est. 1980), Cahaba River (est. 2002), and Mountain Longleaf (est. 2003) national wildlife refuges. Federally protected species that depend on the natural resources on the refuges in this complex include the endangered Alabama cavefish, endangered gray bat, endangered Indiana bat, threatened American Hart's-tongue fern, endangered watercress darter, endangered red-cockaded woodpecker, threatened finelined pocketbook clam, threatened triangular kidneyshell clam, endangered upland combshell clam, endangered Cahaba shiner, threatened goldline darter, endangered cylindrical lioplax snail and threatened round rocksnail snail.

Four refuges in the complex — Key Cave, Fern Cave, Sauta Cave and Watercress Darter — *were established specifically for the preservation of endangered species*.[95] Yet pesticides are commonly used on cooperative farms on this complex.

The Key Cave National Wildlife Refuge, for example, is the only known location of the Alabama cavefish (a small, blind colorless fish that inhabits the underground pools in Key Cave) and is also a priority-one maternity cave for the endangered gray bat.[96] In addition, Key Cave provides habitat for a variety of migratory and resident wildlife species, including the grasshopper sparrow, field sparrow, dickcissel, northern harrier, short-eared owl and northern bobwhite.[97]

In total at least 166 bird species have been sighted on the refuge.[98] Other common wildlife species include cottontail rabbits, coyotes, white-tailed deer, gray squirrels, eastern meadowlarks, mourning doves, horned larks and eastern bluebirds.[99]

In 2018, however, approximately 634 pounds[100] of pesticides were used to treat 567 acres of crops on Key Cave. This is an increase from 2016, when almost 490 pounds[101] of pesticides were used to treat 1,090 acres of crops on the refuge, but a decrease from 2015, when approximately 875 pounds[102] of pesticides were used to treat 844 acres on Key Cave. Those pesticides — of which more than 601 pounds[103] in 2018 and 610 pounds[104] in 2015 were pesticides containing glyphosate — were largely used on corn and soybean crops.

This egregious use of pesticides is made all the more tragic by Key Cave's history. Prior to being established as a refuge in 1997, Key Cave was owned by the Monsanto Company (now a part of the European chemical and pharmaceutical company Bayer[105]), which sold the tract to the Conservation Fund in 1992.[106] Historically the lands were used for growing cotton — agricultural practices that led to "severe soil erosion problems both on and off refuge lands" and caused the release of contaminant and sedimentation into the water system.[107] As a result, "[w]ater quality monitoring by the U.S. Geological Survey has identified a variety of agricultural pesticides in surface waters near the Wheeler National Wildlife Refuge[, which shares the refuge complex with Key Cave]. In addition, water-quality monitoring by the Service has identified detectable levels of atrazine in surface waters flowing onto [the complex]."[108] These are issues of particular concern on Key Cave because the Key Cave itself lies on the northern shore of Pickwick Lake, in a limestone karst area that contains numerous sinkholes and several underground cave systems. This makes the area's sinkholes an integral component of groundwater recharge for the cave — a cave that, as mentioned above, is the only known home of the endangered Alabama cavefish.

The threats posed by the pesticide use extend to the watershed level, where, according to the Fish and Wildlife Service:

> The Tennessee River Valley is comprised of several aquatic ecosystems that have been greatly deteriorated by human activities. Impacts to aquatic species and their habitat include: impoundment of free-flowing streams and rivers; habitat degradation from erosion and sedimentation; misuse of fertilizers, pesticides and herbicides; toxic chemical discharges from both point and non-point sources; and competition from exotic and/or invasive aquatic species. All of these events have led to degradation of aquatic ecosystems within the Tennessee River Valley and each refuge within the Wheeler Complex.
>
> One of the most damaging events to aquatic ecosystems in the Tennessee River Valley has been the previous use of organochlorine pesticides (e.g., DDT, PCB's, toxaphene, dieldrine, and lindane), which contain heavy metals, such as mercury. These chemicals were commonly used in farming operations (especially cotton) prior to being banned in the 1970s. These persistent chemicals were used throughout northern Alabama and can remain in the soil substrate for long periods of time. These chemicals have been linked to an assortment of contamination issues and continue to detrimentally impact fish and other aquatic-dependent resources, such as fish-eating birds, wood ducks and raccoons.[109]

In addition to concerns related to impacts on Alabama cavefish populations from continuing pesticide use on Key Cave, the gray bat, which is a federally protected endangered species found on the Key Cave refuge, "has become of particular concern. Its population decline is believed to be due primarily to human disturbances such as: vandalism, excessive pesticide use, overall insect prey declines due to pollution, and cave commercialization."[110]

Additionally, the northern bobwhite, "[o]ne of the grassland-dependent bird species of concern on the Wheeler and Key Cave refuges," has been facing population declines with the "North American Breeding Bird Survey data indicat[ing] that a rangewide decline of 3.0 percent annually has occurred between the years of 1966 and 2003."[111] According to the Service, "[w]hile many factors have contributed to this decline, including predators, pathogens, and pesticides, deteriorating habitat quality is the primary cause of decline."[112]

These are just a few of the many egregious examples of pesticide abuse for the benefit of row-crop, commercial agriculture in the refuge system.

RECOMMENDATIONS

To protect species diversity, including endangered plants and animals, and the overall health of our refuges, the Service must ban the use of dangerous pesticides for commercial agricultural purposes. In particular it must reinstitute its ban on the use of neonicotinoid pesticides and genetically engineered crops for agricultural purposes on refuges.

At a minimum the Service should emphasize land-use practices that are not reliant upon pesticide use and prioritize species and ecosystem health in the refuge system by eliminating all preventable and concerning uses of pesticides for commercial agricultural purpose, including:

- Aerial spraying of pesticides;
- Use of pesticides in ecologically sensitive areas;
- Use of pesticides in designated critical habitat for Endangered Species Act listed species;
- Use of pesticides in areas already impaired by historic chemical pollution;
- Use of pesticides in areas inhabited or relied upon by species sensitive to pesticide exposure, including birds, bats, beneficial insects and aquatic species;
- Use of toxic, drift prone pesticides like 2,4-D, dicamba and paraquat.

If the Service does not ban the continued use of pesticides for agricultural purposes, it should implement a comprehensive, system-wide monitoring program to consistently identify and immediately discontinue any uses that cause harm to species or contamination of refuge lands, including surface waters.

For areas where pesticide contamination has occurred, the Service should require cleanup and abatement of any activity determined to harm any refuge species or ecosystem, including by contributing to the pollution of surface waters.

CONCLUSION

"The mission of the Refuge System is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans."[113]

Instead of supporting this mission, the Service's continued approval of hazardous pesticides such as dicamba, 2,4-D, glyphosate and paraquat for non-priority, unessential row-crop production in the refuge system creates a legacy of chemical pollution and irreversible harm to plants and animals on these public lands. If the Service fails to discontinue these destructive practices it will accelerate the harm to America's imperiled species and the habitats we share with them, to the detriment of present and future generations of humans and wildlife alike.

ENDNOTES

1 "A National Wildlife Refuge Complex is an administrative grouping of two or more refuges, wildlife-management areas or other refuge conservation areas that are primarily managed from a central office location. Refuges are grouped into a complex structure because they occur in a similar ecological region, such as a watershed or specific habitat type, and have a related purpose and management needs." Fish and Wildlife Service (FWS), Tennessee National Wildlife Refuge Complex, About the Complex, https://www.fws.gov/refuge/Tennessee/About_the_Complex.html (last visited June22, 2020).

2 The Klamath Basin National Wildlife Refuge Complex includes Bear Valley National Wildlife Refuge, Upper Klamath National Wildlife Refuge, Klamath Marsh National Wildlife Refuge, Tule Lake National Wildlife Refuge, Lower Klamath National Wildlife Refuge, and Clear Lake National Wildlife Refuge. FWS, Tule Lake National Wildlife Refuge, About the Complex, https://www.fws.gov/refuge/Tule_Lake/About_the_Complex.html (last visited June22, 2020).

3 The Central Arkansas Refuges Complex includes Wapanocca National Wildlife Refuge, Cache River National Wildlife Refuge, Bald Knob National Wildlife Refuge, Big Lake National Wildlife Refuge, Logan Cave National Wildlife Refuge, and Holla Bend National Wildlife Refuge. FWS, Wapanocca National Wildlife Refuge, About the Complex, https://www.fws.gov/refuge/wapanocca/About_the_Complex/ (last visited June22, 2020).

4 The Theodore Roosevelt National Wildlife Refuge Complex includes the Theodore Roosevelt, Yazoo, Hold Collier, Panther Swamp, Morgan Brake, Mathews Break, and Hillside National Wildlife Refuges. FWS, Theodore Roosevelt National Wildlife Refuge, About the Complex, https://www.fws.gov/refuge/Theodore_Roosevelt/About_the_Complex.html (last visited June22, 2020).

5 The West Tennessee Refuge Complex includes Reelfoot National Wildlife Refuge, Chickasaw National Wildlife Refuge, Lower Hatchie National Wildlife Refuge, Hatchie National Wildlife Refuge and Lake Isom National Wildlife Refuge. FWS, West Tennessee National Wildlife Refuge Complex, https://www.fws.gov/westtnrefuges/ (last visited June22, 2020).

6 The Tennessee National Wildlife Refuge Complex includes the Tennessee National Wildlife Refuge and Cross Creeks National Wildlife Refuge. FWS, Tennessee National Wildlife Refuge, About the Complex, https://www.fws.gov/refuge/Tennessee/About_the_Complex.html (last visited June22, 2020).

7 Testimony of Robert Wallace, Ass't Sec. for Fish and Wildlife and Parks, Dep't of the Interior before the Senate Comm. on Env't and Public Works, 116 Cong. (Feb. 5 2020), available at https://www.doi.gov/ocl/oversight-fws.

8 Unnumbered Exec. Order (Mar. 14, 1903); FWS, Pelican Island National Wildlife Refuge: Comprehensive Conservation Plan, at 9 (Sept, 2006), available at https://www.fws.gov/southeast/planning/PDFdocuments/Pelican%20Island%20FINAL/Pelican%20Final%20CCP%20SigsBlocked.pdf; National Wildlife Refuge System Centennial Act of 2000, Pub. L. 106-408, 114 Stat. 1762.

9 16 U.S.C. § 715d.

10 16 U.S.C. § 1534.

11 FWS, Threatened and Endangered Species on National Wildlife Refuges Database, https://www.fws.gov/refuges/databases/ThreatenedEndangeredSpecies/ThreatenedEndangered_Display.cfm (last visited June 22, 2020).

12 16 U.S.C. § 668dd(a)(2) ("The mission of the Refuge System is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans.").

13 16 U.S.C. § 668dd(a)(4)(B).

14 Executive Order 12996, 61 Fed. Reg. 13647 (Mar. 28, 1996).

15 FWS, Biological Integrity, Diversity, and Environmental Health Policy, 601 FW 3, 3.15(B), available at https://www.fws.gov/policy/601fw3.pdf (explaining that the Refuge Act "clearly establishes that wildlife conservation is the singular National Wildlife Refuge System mission").

16 16 U.S.C § 668dd(a)(3)(B); see also id. § 668dd(d)(1)(A); id. § 668ee(2).
17 Id.
18 Id. § 668dd(a)(3)(C).
19 Id. § 668ee(1); see also 50 C.F.R. § 25.21.
20 FWS, Biological Integrity, Diversity, and Environmental Health Policy, 601 FW 3, 3.15(B).
21 16 U.S.C. § 715d.
22 U.S. Gov't Accountability Office, National Wildlife Refuges: Continuing Problems with Incompatible Uses Call for Bold Action, Report No. GAO/RCED-89-196 (1989), available at http://www.gao.gov/assets/150/148073.pdf.
23 FWS, Tennessee National Wildlife Refuge Complex, About the Complex, https://www.fws.gov/refuge/Tennessee/About_the_Complex.html (last visited June 22, 2020).
24 Id.
25 Relevant authorities for this PUP process include: Department of Interior, Pesticide Use Policy (517 DM 1); Service Integrated Pest Management Policy (569 FW 1); and the Federal Insecticide, Fungicide, Rodenticide Act.
26 See id.
27 Email from FWS to Center Staff Member (Feb. 27, 2020) ("Users must report all usage for a year by January 31st of the next calendar year. The reason for that deadline, of course, is that potentially, depending on the pesticide proposed for use and many other details, in GENERAL, pesticides may be used in all calendar months. The Pesticide Use Proposal System runs on the calendar year. To a large extent, the spreadsheets were all approved PUPs at the time of your request and our response; usage data would not have yet been reported for some uses.").
28 This number was converted from 40,146 gallons and 17,078 pounds.
29 This number was converted from 50,745.5 gallons and 36,363.7 pounds.
30 This number was converted from 56,905 gallons and 18,389 pounds.
31 This number was converted from 53,502 gallons and 23,156 pounds.
32 This number was converted from 24,508 gallons and 7,525 pounds.
33 See, e.g., EPA, Correction to the Amendments to the Dicamba RED, 15-19 (June 17, 2009), available at https://archive.epa.gov/pesticides/reregistration/web/pdf/dicamba_red.pdf.
34 EPA, Environmental Fate and Ecological Risk Assessment for the Reregistration of Dicamba and Dicamba Sodium, Potassium, Diglycoamine, Dimethylamine and Isopropylamine Salts 3 (Nov. 2005), available at http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2005-0479-0008.
35 Nat'l Family Farm Coal. v. EPA, 2020 U.S. App. LEXIS 17495, *5, 960 F.3d 1120 (9th Cir. June 3, 2020).
36 Id. at *6, *63.
37 This number was converted from 597.5 gallons and 340 pounds.
38 This number was converted from 76 gallons.
39 This number was converted from 337 gallons.
40 This number was converted from 160 gallons.
41 Dan Nosowitz, These Maps Show How Much Farmland Has Been Damaged by Dicamba Drift, Modern Farmer (Nov. 1, 2017), available at https://modernfarmer.com/2017/11/maps-show-much-farmland-damaged-dicamba-drift/.
42 University of Missouri, Integrated Pest Management, A Final Report on Dicamba-injured Soybean Acres (Oct. 30, 2017), available at https://ipm.missouri.edu/IPCM/2017/10/final_report_dicamba_injured_soybean/; Eric Lipton, Crops in 25 States Damaged by Unintended Drift of Weed Killer, New York Times (Nov. 1, 2017), available at https://www.nytimes.com/2017/11/01/business/soybeans-pesticide.html?_r=0.
43 Id.
44 Lerro, et al., Dicamba Use and Cancer Incidence in the Agricultural Health Study: an Updated Analysis, International Journal of Epidemiology, dyaa066, https://doi.org/10.1093/ije/dyaa066 (May 1, 2020), available at

https://academic.oup.com/ije/advance-article-abstract/doi/10.1093/ije/dyaa066/5827818?redirectedFrom=fulltext.

45 Espandiari, et al., The Herbicide Dicamba (2-methoxy-3, 6-dichlorobenzoic acid) is a peroxisome proliferator in rats, 26(1) Fundam Appl Toxicol. 85-90 (1995), available at https://www.ncbi.nlm.nih.gov/pubmed/7657066; Reddy and Lalwai, Carcinogenesis by Hepatic Peroxisome Proliferators: Evaluation of the Risk of Hypolipidemic Drugs and Industrial Plasticizers to Humans, 12(1) Crit Rev Toxicol. 1-58 (1983), available at https://www.ncbi.nlm.nih.gov/pubmed/6360536; Espandiari, et al., Promoting Activity of the Herbicide Dicamba (2-methoxy-3, 6-dichlorobenzoic acid) in Two Stage Hepatocarcinogensis, 14(1) Int J Oncol. 79-84 (1999), available at https://www.ncbi.nlm.nih.gov/pubmed/9863012.

46 Gonzalez, et al., Genotoxicity Analysis of the Phenoxy Herbicide Dicamba in Mammalian Cells in Vitro, 20(8) Toxicol. In Vitro. 1481-7 (2006), available at https://www.ncbi.nlm.nih.gov/pubmed/16828255; Gonzalez, et al., Dicamba-Induced Genotoxicity in Chinese Hamster Ovary (CHO) Cells is Prevented by Vitamin E, 15;163(1) J Hazard Mater. 337-43, doi: 10.1016/j.jhazmat.2008.06.09 (2009), available at https://www.ncbi.nlm.nih.gov/pubmed/18676083; Nathan Donley, A Menace to Monarchs: Drift-prone Dicamba Poses a Dangerous New Threat to Monarch Butterflies (2018), available at https://www.biologicaldiversity.org/species/invertebrates/monarch_butterfly/pdfs/Menace-to-Monarchs.pdf.

47 See, e.g., David Ramsey, Farmer Found Guilty In Shooting of Another Farmer in Dicamba Dispute, Arkansas Times (Dec. 15, 2017), available at https://www.arktimes.com/ArkansasBlog/archives/2017/12/15/farmer-found-guilty-in-shooting-of-another-farmer-in-dicambra-dispute.

48 U.S. Geological Survey, Pesticide National Synthesis Project, Estimated Annual Agricultural Pesticide Use, Pesticide Use Maps – Glyphosate, 2015, https://water.usgs.gov/nawqa/pnsp/usage/maps/show_map.php?year=2015&map=GLYPHOSATE&hilo=L&disp=Glyphosate (last visited Jan. 5, 2018); Charles Benbrook, Trends in Glyphosate Herbicide Use in the United States and Globally, 28:3 Environmental Sciences Europe, DOI 10.1186/s12302-016-0070-0 (2016), available at https://enveurope.springeropen.com/articles/10.1186/s12302-016-0070-0.

49 This number was converted from 10,622 gallons.

50 Approximately 10, 500 gallons of glyphosate were used in 2017.

51 This number was converted from 14,000 gallons.

52 WHO, IARC Monographs Volume 112: Evaluation of Five Organophosphate Insecticides and Herbicides (Mar. 20, 2015), available at http://www.iarc.fr/en/media-centre/iarcnews/pdf/MonographVolume112.pdf.

53 See, e.g., Weitz & Luxenberg, Roundup Litigation, https://www.weitzlux.com/environmental-pollution/roundup-litigation/; The Schmidt Firm, PLLC, Roundup Lawsuits Centralized in MDL in Northern California, https://www.schmidtlaw.com/roundup-lawsuits-centralized-in-mdl-in-northern-california/.

54 Bob Egeko, Alameda County Judge Reduces $2 Billion Jury Award in Monsanto Case to $86.7 Million, San Francisco Chronicle (July 25, 2019), available at https://www.sfchronicle.com/bayarea/article/Alameda-County-judge-reduces-2-billion-jury-14160796.php.

55 Patricia Cohen, Roundup Maker to Pay $10 Billion to Settle Cancer Suits, N.Y. Times (June 24, 2020), available at https://www.nytimes.com/2020/06/24/business/roundup-settlement-lawsuits.html.

56 CA EPA, Office of Environmental Health and Human Assessments, Glyphosate Listed Effective July 7, 2017, as Known to the State of California to Cause Cancer (June 26, 2017), available at https://oehha.ca.gov/proposition-65/crnr/glyphosate-listed-effective-july-7-2017-known-state-california-cause-cancer#_ftn3.

57 Center for Biological Diversity, Lost in the Mist: How Glyphosate Use Disproportionately Threaten California's Most Impoverished Counties, 2 (2015), available at https://www.biologicaldiversity.org/campaigns/pesticides_reduction/pdfs/LostInTheMist.pdf.

58 Id.

59 Center for Biological Diversity, Petition to Protect the Monarch Butterfly (Danaus Plexippus Plexippus) Under the Endangered Species Act, 7 (2014), available at http://www.biologicaldiversity.org/species/invertebrates/pdfs/Monarch_ESA_Petition.pdf ("A primary threat to the monarch is the drastic loss of milkweed caused by increased and later season use of the herbicide glyphosate in conjunction with widespread planting of genetically engineered, herbicide-resistant corn and soybeans in the Corn Belt region of the United States and to

planting of genetically-engineered cotton in California. In the Midwest, nearly ubiquitous adoption of, glyphosate-resistant 'Roundup Ready' corn and soybeans has caused a precipitous decline of common milkweed, and thus of monarchs, which lay their eggs only on milkweeds. The majority of the world's monarchs originate in the Corn Belt region of the United States where milkweed loss has been severe, and the threat that this habitat loss poses to the resiliency, redundancy, and representation of the monarch cannot be overstated.").

60 National Park Service, A Closer Look at the 2018-2019 Western Monarch Population Crash, and How to Help (Aug. 2019), available at https://www.nps.gov/articles/a-closer-look-at-the-2018-2019-western-monarch-population-crash.htm.

61 Center for Biological Diversity, Eastern Monarch Butterfly Population Plunges by More than Half: Population Overwintering in Mexico Falls Well Below Extinction Threshold (Mar. 13, 2020), available at https://biologicaldiversity.org/w/news/press-releases/eastern-monarch-butterfly-population-plunges-more-half-2020-03-13/; World Wildlife Fund, New Study Indicates a 53% Decrease in Area Occupied by Monarch Butterflies (Mar. 13, 2020), available at https://www.worldwildlife.org/stories/new-study-indicates-a-53-decrease-in-area-occupied-by-monarch-butterflies.

62 Id.

63 Pelton, et al., Western Monarch Population Plummets: Status, Probable Causes, and Recommended Conservation Actions, Frontiers in Ecology and Evolution (July 3, 2019), available at https://www.frontiersin.org/articles/10.3389/fevo.2019.00258/full (finding that "[i]n our analyses of long-term trends, insecticide and herbicide use were almost as tightly associated with monarch declines as overwinter habitat loss," and that "[r]estricting insecticide and herbicide use increases adult Lepidoptera abundance").

64 Union of Concerned Scientists, The Rise of Superweeds – and What to Do About It, 2 (2013), available at http://www.ucsusa.org/sites/default/files/legacy/assets/documents/food_and_agriculture/rise-of-superweeds.pdf.

65 Heap and Duke, Overview of Glyphosate-Resistant Weeds Worldwide, Pest Manag Sci., doi: 10.1002/ps.4760 (2017), available at https://www.ncbi.nlm.nih.gov/pubmed/29024306.

66 This number was converted from 3277 gallons and 239 pounds.

67 This number was converted from 1906 gallons.

68 This number was converted from 1737 gallons.

69 EPA, Reregistration Eligibility Decision for 2,4-D 3 (June 2005), available at https://nepis.epa.gov/Exe/ZyNET.exe/2000E8DY.TXT?ZyActionD=ZyDocument&Client=EPA&Index=2000+Thru+2005&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C00thru05%5CTxt%5C00000009%5C2000E8DY.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=hpfr&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL.

70 EPA, EPA Seeks Comment on Proposed Decision to Register Enlist Duo Herbicide Containing 2,4-D and Glyphosate, https://www.epa.gov/ingredients-used-pesticide-products/registration-enlist-duo (describing Agent Orange as "a mixture of two different herbicides 2,4,5-T and 2,4-D—as well as kerosene and diesel fuel").

71 See EPA, Preliminary Ecological Risk Assessment for Registration Review of 2,4-D, 3-4 (June 29, 2016).

72 See generally NFMS, Nat'l Oceanic and Atmospheric Assoc., Biological Opinion: EPA Registration of Pesticides 2,4-D, Triclopyr BEE, Duron, Linuron, Captan, and Chlorothalonil (June 30, 2011).

73 Id. at 628.

74 See, e.g., Mnif, et al., Effect of Endocrine Disruptor Pesticides: A Review, 8 Int. J. Environ. Res. Public Health 2265, 2291 (2011), available at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3138025/pdf/ijerph-08-02265.pdf.

75 This number was converted from 2273 gallons and 230 pounds.

76 This number was converted from 925.25 gallons.
77 Danny Hakim, This Pesticide is Prohibited in Britain. Why Is It Still Being Exported?, New York Times (Dec. 20, 2016), available at https://www.nytimes.com/2016/12/20/business/paraquat-weed-killer-pesticide.html; Paulo Prada, Paraquat: A Controversial Chemical's Second Act, Reuters (Apr. 2, 2015), available at https://www.reuters.com/article/brazil-pesticide-paraquat/paraquat-a-controversial-chemicals-second-act-idUSL2N0WY2V720150402.
78 U.S. EPA, Pesticide Worker Safety, Paraquat Dichloride: One Sip Can Kill, https://www.epa.gov/pesticide-worker-safety/paraquat-dichloride-one-sip-can-kill (last visited June 22, 2020).
79 See generally US. EPA, Reregistration Eligibility Decision (RED): Paraquat Dichloride, Office of Prevention, Pesticides & Toxic Substances, EPA-738-F-96-018 (1997).
80 Id.
81 Pesticide Action Network International, PAN International Consolidated List of Banned Pesticides, http://pan-international.org/pan-international-consolidated-list-of-banned-pesticides/ (last visited May 19, 2020); US EPA, Memorandum: Paraquat Dichloride; Proposed Interim Mitigation Decision, 4 (Mar. 2, 2016), available at https://www.regulations.gov/document?D=EPA-HQ-OPP-2011-0855-0031.
82 See Kansas State Extension Agronomy eUpdate, Issue 415 (Aug. 2, 2013), available at http://www.agronomy.k-state.edu/documents/eupdates/eupdate080213.pdf.
83 This number was converted from 1,640.5 gallons.
84 This number was converted from 822 gallons.
85 This number was converted from 1,176 gallons.
86 See Losey, J.E. and M. Vaughan, The economic value of ecological services provided by insects, 56(4) Bioscience 311–323 (2006); Van der Sluijs J.P., et al, Conclusions of the Worldwide Integrated Assessment on the risks of neonicotinoids and fipronil to biodiversity and ecosystem functioning. Environ Sci Pollut Res, doi:10.1007/s11356-014-3229-5 (2014); Douglas MR, Rohr JR., Tooker JF, Neonicotinoid insecticide travels through a soil food chain, disrupting biological control of non-target pests and decreasing soybean yield, Journal of Applied Ecology doi: 10.1111/1365- 2664.12372 (2014); EPA, Office of Prevention, Pesticides & Toxic Substances, Pesticide Fact Sheet: Clothianidin 2 (May 30, 2003), https://www3.epa.gov/pesticides/chem_search/reg_actions/registration/fs_PC-044309_30-May-03.pdf (stating that "assessments show that exposure to treated seeds through ingestion may result in chronic toxic risk to non-endangered and endangered small birds (e.g., songbirds) and acute/chronic toxicity risk to non-endangered and endangered mammals. Clothianidin has the potential for toxic chronic exposure to honey bees, as well as other nontarget pollinators, through the translocation of clothianidin residues in nectar and pollen.").
87 FWS, Final Rule, Endangered Species Status for Rusty Patched Bumble Bee, 82 Fed. Reg. 3,186 (Jan. 11, 2017), https://www.fws.gov/midwest/endangered/insects/rpbb/pdf/FRFinalListingRuleRPBB11Jan2017.pdf.
88 Pierre Mineau & Cynthia Palmer, The Impact of the Nation's Most Widely Used Insecticides on Birds, Am. Bird Conservancy (2013), www.abcbirds.org/abcprograms/policy/toxins/Neonic_FINAL.pdf; Florian Millot, et al., Field evidence of bird poisonings by imidacloprid-treated seeds: a review of incidents reported by the French SAGIR network from 1995 to 2014, Environ Sci Pollut Res, 1 (Dec. 27, 2016) ("The large-scale use of neonicotinoid insecticides has raised growing concerns about their potential adverse effects on farmland birds, and more generally on biodiversity. Imidacloprid, the first neonicotinoid commercialized, has been identified as posing a risk for seed-eating birds when it is used as seed treatment of some crops since the consumption of a few dressed seeds could cause mortality. But evidence of direct effects in the field is lacking. Here, we reviewed the 103 wildlife mortality incidents reported by the French SAGIR Network from 1995 to 2014, for which toxicological analyses detected imidacloprid residues. One hundred and one incidents totaling at least 734 dead animals were consistent with an agricultural use as seed treatment. Grey partridges (Perdix perdix) and "pigeons" (Columba palumbus, Columba livia and Columba oenas) were the main species found. More than 70% of incidents occurred during autumn cereal sowings. Furthermore, since there is no biomarker for diagnosing neonicotinoid poisonings, we developed a diagnostic approach to estimate the degree of certainty that these mortalities were due to imidacloprid poisoning. By this way, the probability that mortality was due to poisoning by imidacloprid treated seeds was ranked as at least "likely" in 70% of incidents. As a result, this work provides

clear evidence to risk managers that lethal effects due to the consumption by birds of imidacloprid-treated seeds regularly occur in the field. This in turn raises the question of the effectiveness of the two main factors (seed burying and imidacloprid-treated seeds avoidance) that are supposed to make the risk to birds negligible.").

89 Patricia Cohen, Roundup Maker to Pay $10 Billion to Settle Cancer Suits, N.Y. Times (June 24, 2020), available at https://www.nytimes.com/2020/06/24/business/roundup-settlement-lawsuits.html; USDA, Recent Trends in GE Adoption (last updated Sept. 18, 2019), https://www.ers.usda.gov/data-products/adoption-of-genetically-engineered-crops-in-the-us/recent-trends-in-ge-adoption.aspx ("Herbicide-tolerant (HT) crops, which tolerate potent herbicides (such as glyphosate, glufosinate, and dicamba), provide farmers with a broad variety of options for effective weed control. Based on USDA survey data, the percent of domestic soybean acres planted with HT seeds rose from 17 percent in 1997 to 68 percent in 2001, before plateauing at 94 percent in 2014. HT cotton acreage expanded from approximately 10 percent in 1997 to 56 percent in 2001, and reached a high of 98 percent in 2019. Adoption rates for HT corn grew relatively slowly immediately following the commercialization of GE seeds. However, adoption rates increased following the turn of the century. Currently, approximately 90 percent of domestic corn acres are produced with HT seeds.").

90 Charles Benbrook, Impacts of genetically engineered crops on pesticide use in the U.S. – the first sixteen years, 24 Envtl. Sci. Eur. 1, 3 (2012), available at http://www.enveurope.com/content/pdf/2190-4715-24-24.pdf; R. J. Seidler, Pesticide use on genetically engineered crops, Ag/Mag Blog, (Sept. 15, 2014), available at http://static.ewg.org/agmag/pdfs/pesticide_use_on_genetically_engineered_crops.pdf; Heinemann et al., Sustainability and innovation in staple crop production in the US Midwest, IJAS, 72-85 (2014).

91 Charles Benbrook, Impacts of Genetically Engineered Crops on Pesticide Use in the United States: The First Thirteen Years, at 3, 23, 31, 36 (2009) available at http://www.organic-center.org/reportfiles/GE13YearsReport.pdf; Mark Koba, Superweeds Sprout Farmland Controversy Over GMOs, NBC News (September 30, 2014), available at http://www.nbcnews.com/business/economy/superweeds-sprout-farmland-controversy-over-gmos-n214996.

92 FWS, Memorandum on the Use of Agricultural Practices in Wildlife Management in the National Wildlife Refuge System (July 17, 2014), available at https://www.centerforfoodsafety.org/files/agricultural-practices-in-wildlife-management_20849.pdf.

93 FWS, Withdrawal of Memorandum Titled, "Use of Agricultural Practices in Wildlife Management in the National Wildlife Refuge System" (July 17, 2014) (Aug. 02, 2018), available at https://www.biologicaldiversity.org/campaigns/pesticides_reduction/pdfs/2018-8-2-FWS-memo-GMO-Neonics-on-wildlife-refuges.pdf.

94 See FWS, Refuge Locator Map, Alabama, https://www.fws.gov/refuges/friends/friendsLocatorMaps/Alabama.html (last visited June 22, 2020).

95 FWS, Sauta Cave National Wildlife Refuge, About the Refuge, https://www.fws.gov/refuge/Sauta_Cave/about.html (last visited June 22, 2020) ("Sauta Cave NWR (known as Blowing Wind Cave NWR until 1999) is a 264 acre Refuge purchased in 1978 to provide protection for the federally endangered gray and Indiana bat and their critical habitat. "); FWS, Key Cave National Wildlife Refuge, Wildlife Management, https://www.fws.gov/keycave/management.html (last visited June 22, 2020) (establishing that Key Cave NWR was established in 1997 to ensure the biological integrity of Key Cave, and that "[t]he Refuge is the only known location of the Alabama cavefish which inhabits the underground pools in Key Cave . . . . Key Cave is also a priority one maternity cave for the endangered gray bat."); FWS, Fern Cave National Wildlife Refuge, About the Refuge, https://www.fws.gov/refuge/Fern_Cave/about.html (last visited June 22, 2020) ("Fern Cave National Wildlife Refuge was established in 1981, under the authority of the Endangered Species Act of 1973, to provide protection for the endangered gray and Indiana bats."); FWS, Watercress Darter National Wildlife Refuge, About the Refuge, https://www.fws.gov/watercressdarter/about.html (last visited June 22, 2020) ("Watercress Darter NWR, near Bessemer, Jefferson County, Alabama, was established by the Service in 1980 to provide protection for the endangered watercress darter.").

96 FWS, Key Cave National Wildlife Refuge, Wildlife Management, https://www.fws.gov/keycave/management.html (last visited June 22, 2020).

97 FWS, Wheeler National Wildlife Refuge Complex Comprehensive Conservation Plan and Environmen-

tal Assessment, 62 (2007).
98 Id.
99 Id.
100 This number was converted from 74 gallons and 18 pounds.
101 This number was converted from 58 gallons and 7 pounds.
102 This number was converted from 105 gallons and 2.85 pounds.
103 This number was converted from 72.5 gallons.
104 This number was converted from 73.7 gallons.
105 Bayer, Monsanto Acquisition, Frequently Asked Supplier Questions on Monsanto Acquisition, https://www.bayer.com/en/monsanto-acquisition.aspx (last visited June 29, 2020).
106 FWS, Wheeler National Wildlife Refuge Complex Comprehensive Conservation Plan and Environmental Assessment, 16 (2007).
107 Id. at 83.
108 Id.
109 Id. at 28.
110 Id.
111 Id.
112 Id. at 77.
113 16 U.S.C. § 668dd(a)(2).