prairie **rivers** network

2018 & 2019 Tree and Plant Health Monitoring Report

July 16, 2020

Prairie Rivers Network

Prairie Rivers Network is a state-wide conservation organization in Illinois. At Prairie Rivers Network, we protect water, heal land, and inspire change.

Using the creative power of science, law, and collective action, we join with people to protect and restore our rivers, to return healthy soils and diverse wildlife to our lands, and to transform how we care for the earth and for each other.

Acknowledgments

Numerous individuals contributed their time and expertise to this monitoring effort, and helped build awareness of this issue, including Seth Swoboda and family, Tom Swoboda, Steve Modert, Glen Schuetz, and Shelley Harper. Numerous other landowners volunteered their time to help monitor and document symptoms over the course of two years. This monitoring effort would not have been possible without their help.

Kim Erndt-Pitcher helped create and coordinate the monitoring program, educate and train volunteers, monitor, and was the lead for the report. Marty Kemper played a key role in the creation of this monitoring program, helped educate and train volunteers, spent countless hours monitoring, helped write the report and was the lead on data management. Lou Nelms helped monitor, write the report, build awareness of this issue, and was the lead on the development of the tissue sampling portion of this program.

Numerous Prairie Rivers Network staff also assisted in the production of this report. Andrew Rehn helped with data collection and management, Robert Hirschfeld, Jeff Kohmstedt, and Sarah Scott helped with design and editing.

Funding for this program was provided by The Lumpkin Family Foundation, Patagonia, and by membership donations. The recommendations and views expressed in this report are those of Prairie Rivers Network and do not necessarily represent the views of our funders and supporters.

Prairie Rivers Network

Tree and Plant Health Monitoring Report

2018-2019

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Executive Summary

In 2018, Prairie Rivers Network (PRN) launched a volunteer monitoring program to investigate the increase in landowner reports to our organization of suspected herbicide injury to trees and other broadleaf plants. The symptoms reported were indicative of exposure to plant growth regulator (PGR) herbicides. These reports coincide with increases in use of the volatile PGR herbicides 2, 4-D and dicamba for pre-planting weed control, as well as the widespread use of dicamba resistant soybeans and cotton which allow herbicides to be applied later in the growing season, over the top (OTT) of growing crops. When applied to crops, the herbicides kill the surrounding broadleaf plants, while only the crop, which has been genetically engineered to be resistant, remains unharmed. Formal herbicide injury complaints to the Illinois Department of Agriculture (IDOA) have also been steadily rising across the state during this time.

Our volunteer monitoring program is not intended to identify the cause of injuries in every plant, but merely to serve as a rapid ecological assessment in order to document the presence and prevalence of symptoms of possible off-target herbicide exposure. The visual symptoms our volunteer monitoring program documented are similar to the responses of trees and other plants that have been exposed to driftable rates of PGR herbicides in controlled studies. However, in order to verify exposure of herbicides in species or locations that were of particular interest, a small number of tree leaf samples were analyzed for PGR herbicides at a reputable lab.

During 2018 and 2019, our monitoring program revealed that symptoms of possible off-target herbicide injury were frequent and widespread, and present in a wide variety of plant types in the regions that were monitored. Locations were monitored in 21 Illinois counties. A total of 70 species, 55 of which are native to Illinois, were monitored and showed symptoms.

Ratings of symptom severity ranged from light to severe and varied by location and species. In 2018, 45 out of 49 locations monitored had at least one species with symptoms that were rated a 5 (moderate) or greater in severity. Of those 45, 29 locations had species with symptoms that were rated a 7 or higher (severe). In 2019, 59 of the 83 locations monitored had species with symptoms that were rated at a 5 or higher and of those 59 locations, 28 species had symptoms that were ranked at a level 7 or higher.

Tree leaf samples were collected and analyzed for herbicide residues. Results confirmed that 20 of 24 tree leaf samples had detectable levels of either 2, 4-D, and/or dicamba residues present at the time of sampling. All trees sampled also showed symptoms indicative of PGR herbicide exposure.

Prairie Rivers Network has been concerned with the continual declines in funding for our state's natural resource management and protection for many years. Reductions in agency and project funding, staff, ecological restoration projects, ecological assessments, and monitoring, leave few to no resources available for addressing emergent issues such as the ecological impacts of widespread pesticide use on our already highly stressed and fragmented ecosystems.

The questions about the ecological impacts of the widespread use of these volatile herbicides are more numerous than the answers we currently have. The purpose of this project is three-fold: 1. To glean information about the frequency, severity, and geographic range of symptoms that may be a result of herbicide exposure; 2. To raise awareness of the potential ecological risks widespread herbicide use may pose to the landscape; 3. To highlight the need for more financial and staff resources for ecological monitoring and protection.

Introduction

For several years Prairie Rivers Network (PRN) and partners have been receiving reports of plant and tree injury on both public and private lands. These injuries are symptomatic of herbicide exposure and may be due to drift and/or volatility. After numerous inquiries, it quickly became apparent that no public or private institution was performing any large-scale ecological monitoring of these symptoms in Illinois.

Prairie Rivers Network has been concerned with the steady declines in the funding of and number of staff in state and federal agencies as well as the reduction in ecological monitoring programs they oversee. Presently there are large gaps in data that were historically gathered by ecological monitoring programs. This lack of information impacts our ability to evaluate and monitor the health of Illinois ecosystems under the intense pressures of habitat loss, invasive species, pollution, and climate change. This reduction in labor, funding, and monitoring leaves few, if any resources available for addressing emergent issues such evaluating the ecological impacts of widespread pesticide use on our already highly stressed and fragmented ecosystems. In 1994, it was reported by state agencies in the Critical Trends Assessment Program that "forest fragmentation has reduced the ability of Illinois forests to maintain biological integrity" and "existing data suggest that the condition of natural ecosystems in Illinois is rapidly declining as a result of fragmentation and continual stress." Already in 1994, state agencies concluded that "data designed to monitor compliance with environmental regulations or the status of individual species are not sufficient to assess ecosystem health statewide." [1] Today, in 2020, funding and staff numbers have only decreased.

While off-target plant growth regulator herbicide injuries have occurred since as early as the 1950s, there has been a steady rise in herbicide related pesticide injury complaints throughout the Midwest in recent years. This coincides with rising occurrences of glyphosate herbicide-resistant weeds on crop land, which forced greater uses of 2,4-D and dicamba in early season "burn-down" herbicide applications, and the introduction of herbicide-resistant crops that allow for more use of dicamba and 2,4-D later into the growing season. In Illinois, official complaints of herbicide injury have been on the rise since 2017 (the first year over-the-top (OTT) applications of dicamba were used on dicamba resistant soybeans) with 2019 being a record year with well over 700 official complaints to the Illinois Department of Agriculture. These complaints highlight the fact that volatile herbicides such as dicamba and 2, 4-D are causing injuries far beyond buffer zones. The symptoms are not just being observed on non-dicamba resistant soybeans and specialty crops; recent news stories have highlighted the widespread symptoms of off-target herbicide damage to trees.[2] [3]

The Illinois Pesticide Act as administered by the Illinois Department of Agriculture (IDOA) was enacted to protect the environment and public health from unreasonable harm by regulating pesticides and ensuring their legal use according to product label law (regulated by the federal EPA). The Act charges IDOA to enforce product misuse via a complaint process providing property owners the opportunity to report exposures and damages. This process is designed primarily to address applicator error and spray particle drift to unintended off-target sites.

The complaint process is not a replacement for ecological monitoring, nor was it designed to address the current issues related to volatility, where misuse is not the cause of the injury. While not discussed in this report, it should be noted that it is widely accepted that only a small percentage of plant injuries symptomatic of herbicide exposure are reported to IDOA as complaints, and that the reasons for this are numerous and complex. And of this underrepresentation, the injuries to non-dicamba soybeans make up a high percentage of injuries reported over the past three years when reports related to OTT dicamba spraying increased significantly. Overall, the pesticide misuse complaint process has numerous shortcomings that limit its ability to serve as a reliable and trustworthy tool for gauging the severity, geographic range, and frequency of pesticide-related injuries resulting from both legal use and illegal misuse. Its effectiveness in protecting the environment from unreasonable harm is even less, given the rise in use of volatile herbicides such as 2, 4-D and dicamba across the agricultural landscape.

Prairie Rivers Network's Tree and Plant Health Monitoring Program was designed to be used by volunteers and interested landowners. Its purpose is not to replace the complaint process, nor is it designed to identify causes of reported symptoms. Its purpose is to help provide a better understanding of the frequency and distribution of a particular phenomenon - the presence of symptoms of possible off-target herbicide injury to native plants. Its goal is to gather baseline information, by means of a rapid ecological assessment, on the frequency, geographic distribution, severity, and timing of injuries symptomatic of off-target herbicide injury. It is our hope to use this information to build public awareness of an important issue. Additionally, the goal is to highlight the need for a state-run comprehensive ecological monitoring program that records and verifies symptoms of off-target herbicide injuries to broadleaf plants as well as to study the ecological impacts of all pesticides used on massive scales in the agro-industrial landscape - a growing critical trend. The implementation of the Illinois Pesticide Act falls far short in this regard.

The data collected will highlight the urgency of this issue and provide some insight into the scope of the problem. Just two years old, the project aims to provide information on the timing or season symptoms were observed, geography of symptoms, species involved, and provides a rating of the severity of observable (visible) symptoms of herbicide exposure. The visual monitoring does not identify specific causes of observed injuries. It simply helps to elucidate patterns that can suggest potential causes. This monitoring program has its limitations, which are discussed in further detail in the "Limitations on Monitoring Data" section.

The occurrence of this phenomenon (the timing, location, and severity of symptoms) varies from year to year. It will likely take at least 3-5 years to build a reasonable understanding of annual variations.

Symptoms in trees and other plants have been documented by recording visual observations of leaf and twig abnormalities on data sheets and by making an accompanying photographic record. In some cases, tissue samples were taken and sent off to a reputable lab where they were analyzed for a suite of five plant PGR herbicides Knowing where and when symptoms occur and do not occur is important to understanding the scope of the problem and provides an important baseline for understanding future trends.

Tree and Plant Health Monitoring

Our monitoring form was designed to be as comprehensive as possible without being overwhelming for the general volunteer or layperson. Detailed instructions can be found at www.prairierivers.org/monitoring. Sites were monitored with a rapid ecological assessment in mind. Due to time constraints, not all species showing symptoms at a particular site were necessarily documented, and thus would not have been recorded in our database. Volunteers had the opportunity to make additional notes on observations about the site. That information is not included in this report due to a high level of variability and complexity within the notes sections of monitoring forms.

General information collected included: recorder information, site location information, and general information about the area showing symptoms (shape, estimated size of the area, land use, and additional information the recorder felt important). For species observed with symptoms, volunteers recorded the number of individuals and % foliage affected – a numeric rating of the range and average injury (symptom) level – and the types of symptoms observed.

Symptom Classification

Determining if a site has potentially experienced injury related to exposure to PGR herbicides requires the presence of one or more species with specific symptoms. Symptoms were separated into two types (Indicative and Additional). They were also distinguished as either leaf or shoot symptoms. **Indicative leaf symptoms** include: curled/cupped, epinasty (sideways/upside down), strapped, tattered, twisted and deformed, irregular margins, and veins bleached and/or parallel. **Indicative shoot symptoms** include: elongated, coiled, or bent, and growth suppressed and deformed.

Additional symptoms were recorded if they were present with an indicative symptom. They were broken down into leaf symptoms and whole tree symptoms. **Additional leaf symptoms** include: chlorotic tissue, necrotic tissue, secondary growth. **Additional tree symptoms** included: tree death, tree dieback, and epicormic branching.

Photo documentation remains a critical part of our monitoring program. Recorders were asked to submit a photo of symptoms for each species they documented. An overall view of the tree or canopy was occasionally provided.

Symptom Ratings

Symptoms were rated according to the scale below. A rating of 10 was reserved for trees that leafed out and then died or appeared to be dying. Examples of each category are shown in a variety of species.

0 = No symptoms 1, 2 = Slight symptoms 3, 4 = Light symptoms 5, 6 = Moderate symptoms 7, 8 = Severe symptoms 9, 10 = Extreme symptoms

0 (Black Oak)

1, 2 (Sassafras)

3, 4 (Sugar Maple)

5, 6 (Redbud)

7, 8 (Red Oak)

9, 10 (Black Oak)

Symptom Ratings Continued

Examples of each category are shown in White oaks.

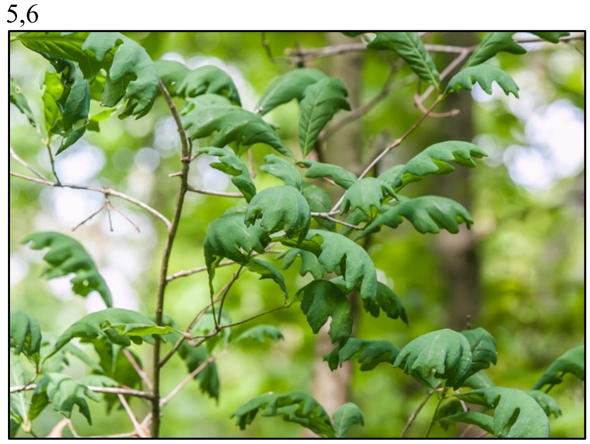
0 = No symptoms
1, 2 = Slight symptoms
3, 4 = Light symptoms
5, 6 = Moderate symptoms
7, 8 = Severe symptoms
9, 10 = Extreme symptoms

0

1,2

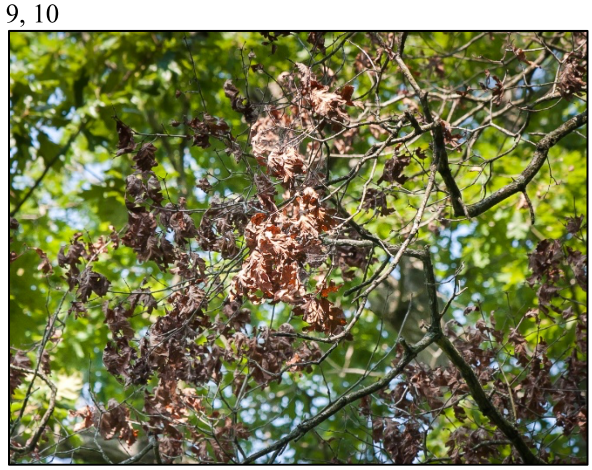
3, 4

5,6



7, 8

9, 10



Site Selection

Sites for monitoring were selected by volunteers. Examples include state and private natural lands, parks, cemeteries, and residential areas. Volunteers were asked to gain permission for access when monitoring on restricted public lands or when entering private lands that were not under the recorder's ownership.

Several sites were visited multiple times. This is especially valuable for sites where the observation occurred during an early growing season (soon after bud break).

Recording Observations

Observations that had photo documentation were imported into a database using a Google Form. Information was entered in several ways. Volunteers could enter information while in the field using a smartphone or they could note the information on a paper monitoring form and enter it into the Google Form at a later date. Most of the entries and photographs from the 2018 and 2019 growing seasons were submitted to PRN and were entered in manually. The information was then downloaded into an Excel spreadsheet and converted to an ACCESS database for analysis. Some aspects of the data were verified with volunteers in order to clear up data entry errors or omissions. Additionally, we omitted entries that did not contain photo documentation, except in cases of a missing photo for a single species where photo documentation at a site was complete for other monitored species.

Tissue Sampling

Leaf tissue samples were collected from a select number of sites during the 2019 growing season. Sites for tissue samples were selected for several reasons including distance from known agricultural fields, severity of symptoms, species of particular concern, or timing of occurrence of symptoms. All tissue analysis was performed on samples from trees; no herbaceous plant tissue was analyzed. Samples were taken from sites that had symptoms of PGR herbicide exposure across multiple families and species of trees, shrubs, vines and/or forbs. Based on literature review and our monitoring observations, target species emphasized oak, sycamore, redbud, and chestnut. Sample sites varied in distance to cropland. While both rural and urban forest sampling was planned, rural forests were prioritized in 2019.

No leaf tissue samples were taken from areas where there was evidence of chemical weed control use in the surrounding turf or surfaces directly around the tree. We obtained leaves from sites with a low likelihood of particle drift or potential for off-label application issues, with one exception. See "Results Part 3" for more information.

Due to the prevalence of symptoms of PGR herbicide injury in oaks and the perceived general increase in mortality in recent years, oaks were a plant group of particular interest. The oaks on a private residential site (093) were selected for sampling due to several years of damage and coinciding mortality. Sites 020 and 021 were picked because they had relatively light levels of symptoms. Additionally, several samples came from the state record post oak (site 033) which has reportedly shown symptoms of herbicide injury for several consecutive years.

White oak is of particular interest due its ecological importance. Site 032 was picked because it is a tree farm and has experienced multiple years of symptoms present in white oaks. Another site 082 was selected due to its location within a large forested tract that has experienced significant white oak mortality over a number of years. This tract is also well removed from farmland.

Sycamore trees (sites: 073, 044, 050, 072, 063, and 002) were sampled because of the frequent appearance of mid-season injuries in this species. Sycamores are an indeterminate species, in which symptoms of PGR exposure are expressed on the newest leaf growth at the tips of branches.

Redbud trees (sites 073 & 002) were sampled because of the known sensitivity of this species to PGR herbicides and the widespread appearance of symptoms.

A Chestnut tree (059) was selected due to the frequency of symptoms observed in this species in the southernmost counties of Illinois.

Volunteers were instructed to use new nitrile gloves in order to protect the collector and prevent cross contamination. Leaves representative of the affected area were collected using hand or pole trimmers that had been cleaned with 70% alcohol prior to use. Volunteers were instructed to collect at least one quart of leaves. A photographic record was made and the foliage was then placed into a sealed plastic bag. The location, species, date, time, and witness (if present) were recorded on the data sheet and/or on the bag. Samples were placed in a cooler on ice, or in a refrigerator for no more than 72 hours. Samples were shipped overnight early in the week to ensure they reached the lab before the weekend or a holiday. If samples could not be shipped immediately, then they were frozen and later shipped overnight on dry ice. Laboratory submission forms accompanied each sample.

Samples were analyzed for five plant PGR herbicides: dicamba, 2, 4-D, MCPA, clopyralid, and picloram. The lowest detectable concentrations of herbicides (or limit of detection) was 0.005 PPM for all 5 herbicides.

Data Limitations

As with many field studies, there are several limitations with our monitoring and tissue sampling data, and it is important to recognize them.

There is a certain level of subjectivity to our data collection, as is common in rapid ecological assessments. It is impossible to entirely remove subjectivity in field settings. However, in an effort to minimize subjectivity, we gave presentations on the symptoms of off-target plants affected by PGR herbicide, provided an overview of the monitoring program, and provided detailed instruction forms, which are available on our website. If at all possible, we also assisted volunteers monitoring their first site. While we established a method for rating the level of the foliage symptoms observed, each volunteer made their own judgement as to the severity of those symptoms, based on our rating guidelines.

Monitoring and tissue sampling takes significant resources, including finances, personnel, and time. The data is limited in geographic scope largely due to all of the aforementioned factors. Additionally, the species represented in this report are not all inclusive of the species, individuals, or plant types that had observable symptoms. Rather, the species in this report are included because those are the species the volunteer chose to monitor. Due to time constraints and volunteer knowledge of plant types, not all species with symptoms were documented at every site. Therefore, we consider this to be a rapid assessment of symptoms.

Additionally, since this is a monitoring effort, and not a controlled experiment, there is no way of knowing the source, rate, frequency, or timing of herbicide exposures to the trees that were sampled for our tissue analysis. There are numerous factors that can impact the length of time that pesticide residues remain at a detectable level in leaf tissue. These factors include (but are not limited to) the pesticide in question, weather conditions, plant species, rate of exposure(s), and interactions of more than one pesticide from either the mix used or from contact with other sources of particle or vapor drift.

Results Part 1: Symptom Monitoring

As previously stated the goal of this effort is to gather baseline information, by means of a rapid ecological assessment, on the frequency, geographic distribution, severity, and timing of injuries that are symptomatic of possible off-target herbicide exposure. Based on their time and skill-level, volunteers selected which species to monitor at a location. Therefore, there may have been other species demonstrating symptoms of possible PGR herbicide exposure present at each location that were not monitored.

The majority of plants monitored were trees. However, shrubs, woody vines, perennial forbs, and annual forbs were also monitored. Observers were asked to record the most prominent symptoms. There were 596 unique observations of species with injuries recorded during 2018 and 2019. Many species had more than one symptom. The most common symptoms observed in leaves were: curling and cupping, twisting and deformation, irregular margins, and sideways growth (epinasty). The most common symptoms observed in shoots were growth suppression or deformation. Of secondary symptoms, chlorosis was the most frequently observed. Necrosis, dieback, and death were also observed.

Site Overview

There were a total of 153 visits in 2018 and 2019 to 102 monitoring sites. Several sites were visited (monitored) more than once in a growing season. In addition, some of the sites were monitored in both years. Of the 49 sites in 2018, 47 had symptoms. All 81 sites monitored in 2019 had symptoms. Monitoring sites were located in 21 counties. Due to limited availability of volunteers, the majority of the sites monitored were located in Washington, Jackson, Logan and St. Clair counties. Volunteers were asked to estimate the size of a site if the exact acreage was unknown. Site size ranged from 1 to 50 and 40 acres respectively for 2018 and 2019 (Table 1).

Table 1: Total, Average, Minimum, and Maximum Acres for Sample Occurrences

	2018	2019	Combined
Number of sites monitored	49	81	102*
Number of visits to sites	51	102	153
Total acres	455	393	838
Average acres monitored per visit	10.6	6.6	8.2
Minimum acres monitored	1	1	-
Maximum acres monitored	50	40	-

* Total number of unique sites for both years combined; including four soybean fields and one orchard.

Rating System and Severity of Symptoms

A total of 70 species, 55 of which are native to Illinois, were monitored and showed symptoms. Twenty-six of the twenty-nine plant families represented are native to Illinois. This report focuses on non-crop plants, therefore we removed one monitoring report containing a large number of fruit trees (approx. 2000) which are a specialty crop, and 4 reports which were for symptoms on soybean fields. White oak and redbud were the most commonly monitored native species. The most commonly monitored species varied from 2018 to 2019. However, oaks are prominent in both years (Table 2).

A few sites were large enough to have more than one subunit or "location" monitored., (e.g., a site where two subunits were monitored represents two separate locations). Hence the number of locations monitored is greater than the number of sites monitored. Table 2 below includes information from all monitored locations.

Table 2: Ten Most Frequently Monitored Tree Species by Location

2018		2019	
Species	**Locations Monitored**	**Species**	**Locations Monitored**
White oak (Quercus alba)	26	Eastern redbud (Cercis canadensis)	36
Post oak (Quercus stellata)	25	Post oak (Quercus stellata)	33
Eastern redbud (Cercis canadensis)	23	Black oak (Quercus velutina)	32
Black oak (Quercus velutina)	21	White oak (Quercus alba)	26
Boxelder (Acer negundo)	17	Sycamore (Plantaus occidentalis)	25
Pin oak (Quercus palustris)	13	Boxelder (Acer negundo)	24
Bur oak (Quercus macrocarpa)	8	Poison ivy (Toxicodendron radicans)	22
Hickory sp. (Carya sp.)	7	Hickory sp. (Carya sp.)	22
Blackjack oak (Quercus marilandica)	6	Pin oak (Quercus palustris)	16
Sycamore (Plantaus occidentalis)	6	Elm sp. (Ulmus sp.)	15

Tables 3, 4, & 5 summarize the ratings of symptoms by plant type.

Table 3: Average Rating of Symptoms by Plant Type Across all Species and Locations

Year	Tree	Shrub	Woody Vine	Perennial Forb	Annual Forb
2018	3.1	5.5	1.2	2	5
2019	2.6	2.4	1.9	3.6	5

Table 4. Average Maximum Rating for Symptom by Plant Type Across all Species and Locations

Year	Tree	Shrub	Woody Vine	Perennial Forb	Annual Forb
2018	4.2	7	3.2	3	6
2019	3.4	3.1	2.8	5.1	6

In 2018, 45 out of 49 locations monitored had at least one species with symptoms that were rated a 5 (moderate) or greater. Of those 45, 29 locations had symptoms that were rated a 7 or higher (severe). In 2019, 59 of the 83 locations monitored had symptoms that were rated at 5 or higher and of those 59 locations, 28 had symptoms that were rated at a level 7 or higher.

Table 5. Locations with Severe Symptoms

Year	Number of locations monitored	Number of locations with symptoms rated 5 +	Number of locations with symptoms rated 7 +
2018	49	45	29
2019	83	59	28

As previously noted, volunteers were encouraged to monitor locations where multiple species, across many families and plant types were present. They were not encouraged to record every species they noticed with symptoms, rather to select several that were representative of the plants expressing symptoms at that site. While trees were the main focus of this monitoring project, other plant types were reported as well. Table 6 is a summary of the number of individuals reported showing symptoms by plant type.

Table 6. Total Individuals Monitored and with Symptoms by Plant Type

Plant type	Locations with plant type reported 2018	Locations with plant type reported 2019	Total Individuals monitored	Individuals with symptoms
Trees	49	82	8791	7670
Shrubs	2	9	161	159
Woody Vines	4	26	2006	1305
Perennial Forbs	2	6	1220	958
Annual Forbs	1	1	215	215
			12393	10307

Note: The number of individuals demonstrating symptoms at sites where some individuals are asymptomatic (i.e., symptom rating of "0") was estimated using the formula:

Number of symptomatic individuals = total number of individuals observed – ((1/highest symptom rating) x total number of individuals observed)

This formula weights the asymptomatic ("0") class more heavily than higher rated classes and weights the asymptomatic class more heavily at lower ranges of symptom severity (e.g., 0-3) than at higher ranges (e.g., 0-7). It provides a more conservative estimate of symptomatic individuals than a comparable "flat" frequency distribution. It generally agrees with observations in the field.

Table 7. Ranking of Average Maximum Symptom Rating for 15 Most Monitored Species - 2018		
Species	**Average Maximum Symptom Rating**	**Plant Type**
Ohio buckeye (Aesculus glabra)	7	Tree
Persimmon (Diospyros virginiana)	7	Tree
White oak (Quercus alba)	6.1	Tree
Blackjack oak (Quercus marilandica)	6	Tree
Hackberry (Celtis occidentalis)	6	Tree
Post oak (Quercus stellata)	5.7	Tree
Black oak (Quercus velutina)	5.2	Tree
Elm sp. (Ulmus sp.)	5	Tree
Red oak (Quercus rubra)	5	Tree
Kentucky coffeetree (Gymnocladus dioicus)	5	Tree
Hickory sp. (Carya sp.)	4.9	Tree
Box elder (Acer negundo)	4.9	Tree
Pin oak (Quercus palustris)	4.8	Tree
Sycamore (Platanus occidentalis)	4.2	Tree
Sugar maple (Acer saccharum)	4.2	Tree
Eastern redbud (Cercis canadensis)	4.2	Tree

Table 8. Ranking of Average Maximum Symptom Rating for 15 Most Monitored Species - 2019		
Species	**Average Maximum Symptom Rating**	**Plant Type**
Black-eyed susan (Rudbeckia hirta)	7	Perennial Forb
Ashy sunflower (Helianthus mollis)	7	Perennial Forb
Post oak (Quercus stellata)	6	Tree
Sweet coneflower (Rudbeckia subtomentosa)	6	Perennial Forb
White wild indigo (Baptisia lactea)	6	Perennial Forb
Eastern cottonwood (Populus deltoides)	5.5	Tree
White oak (Quercus alba)	5.2	Tree
American chestnut hybrid (Castanea sp.)	5	Tree
Cup plant (Silphium perfoliatum)	5	Perennial Forb
Rosinweed (Silphium integrifolium)	5	Perennial Forb
Kentucky coffeetree (Gymnocladus dioicus)	5	Tree
Swamp white oak (Quercus bicolor)	4.6	Tree
Eastern redbud (Cercis canadensis)	4.6	Tree
Black oak (Quercus velutina)	4.5	Tree
Box elder (Acer negundo)	4.1	Tree

Results Part 2: Herbicide Residue Analyses for Injured Plants

Trees that were symptomatic of PGR herbicide exposure were sampled during the 2019 growing season. With the exception of one location, volunteers had no knowledge of when possible exposures occurred. When symptoms of PGR herbicide were observed in multiple species, across multiple families at a location, a sample was taken from a symptomatic tree(s) according to protocol. In most cases, there was no knowledge of when symptoms began to be expressed.

Samples were analyzed for the presence of a suite of five plant PGR herbicides, which included Clopyralid, MCPA, dicamba, 2, 4-D, and Picloram. The limit of detection for all 5 herbicides was 0.005 PPM. Only 2, 4-D or dicamba residues were detected in collected samples. A total of 24 samples were collected from trees, of which 20 had detectable levels of PGR herbicides at the time of sampling. (One sample, with no detectable residue, was a second sample of the same tree that had detectable levels earlier in the year.) Twenty-three separate PGR herbicide residues were detected in those twenty samples. Seventeen of these samples had detectable residues of one herbicide at the time of sampling. Three of the samples had detectable levels of both 2, 4-D and dicamba. Four samples had no residues or had residues below the limit of quantification.

The twenty-four tissue samples were collected at fifteen monitored locations in six counties during the 2019 growing season. Thirteen of the monitored locations had samples taken where residue of at least one PGR herbicide was detected. Leaf tissue samples were collected from 6 counties (Table 9).

Table 9. Count of Tissue Sample Locations by County

County	Number Sample Locations	Number with positive PGR tissue sample
Ford	1	1
Jackson	2	2
Logan	3	3
Mason	1	1
Sangamon	1	1
Washington	7	5

Each sample was taken from a single species. All sampled trees demonstrated typical symptoms of PGR herbicide foliage injury. Samples consisted of foliage from a single tree or a composite of foliage from up to seven trees at each location. Sample numbers by species are presented below in Table 10.

Table 10. Frequency of samples with detectable levels of PGR herbicide residue

Species	Samples	2,4-D	Dicamba
Post oak (Quercus stellata)	7	7	2
White oak (Quercus alba)	6	4	-
Sycamore (Platanus occidentalis)	6	1	5
Eastern redbud (Cercis canadensis)	3	1	-
Swamp white oak (Quercus bicolor)	1	1	-
American chestnut hybrid (Castanea sp.)	1	1	1

Table 11 summarizes symptom severity rankings for monitored oak trees that were analyzed for PGR herbicide residue.

Table 11. Oak Tree Symptom Severity Ratings and PGR Herbicide Residue Results for Sampled Trees.

Site	Date	Species	Number Monitored and Sampled	Average Symptom Rating	Lowest Symptom Rating	Highest Symptom Rating	Residue Analysis Result PPM
093	5/14/2019	Post Oak (Quercus stellata)	3	6	6	7	0.05: 2, 4-D
033	5/14/2019	Post Oak (Quercus stellata)	1	4	4	4	0.035: 2, 4-D
020	5/15/2019	White Oak (Quercus alba)	7	5	4	7	0.015: 2, 4-D
093	5/27/2019	Post Oak (Quercus stellata)	3	6	4	9	0.069: 2, 4-D
033	5/27/2019	Post Oak (Quercus stellata)	1	5	5	5	0.078: 2, 4-D
082	5/27/2019	White Oak (Quercus alba)	6	3	1	4	0.006: 2, 4-D
051	5/28/2019	White Oak (Quercus alba)	5	3	1	5	0
032	5/28/2019	White Oak (Quercus alba)	6	6	5	8	0.016: 2, 4-D
020	5/29/2019	White oak (Quercus alba)	6	5	3	6	0.006: 2, 4-D
033	7/5/2019	Post oak (Quercus stellata)	1	5	5	5	0.036: 2, 4-D, 0.005: dicamba
033	7/18/2019	Post oak (Quercus stellata)	1	5	5	5	0.037: 2, 4-D, 0.005: dicamba
093	7/20/2019	Post oak (Quercus stellata)	3	6	5	6	0.033: 2, 4-D
021	7/20/2019	White oak (Quercus alba)	3	4	3	4	0
016	7/25/2019	Swamp white oak (Quercus bicolor)	1	6	6	6	0.009: 2, 4-D

Table 12 summarizes symptom severity rankings for monitored sycamore trees that were analyzed for PGR herbicide residue.

Table 12. Sycamore Symptom Severity Ratings and Dicamba Residue Levels for Sampled Trees

Site	Date	Number Monitored and Sampled	Average Symptom Rating	Lowest Symptom Rating	Highest Symptom Rating	Residue Analysis Result PPM
063	7/11/2019	1	4	4	4	0.071
044	7/18/2019	1	4	4	4	0.043
050	7/18/2019	1	4	4	4	0.064
072	7/18/2019	1	3	3	3	0.053
002	7/25/2019	1	3	3	3	0.019

Results Part 3: Distances from Trees with Herbicide Residues to Potential Sources of Drift

Satellite images from Google Earth supplemented by "on the ground" visual observations were used to estimate distance to closest potential drift sources (e.g., cropland, golf courses, etc.) for all tree leaf sample locations for 2019. The purpose here is not to identify the closest potential source as the actual source. Exposures could have occurred from the nearest location, or they could be a result of herbicide applications further away, and/or from more than one location. Our data for serially sampled oaks suggests multiple exposures may be commonplace throughout the growing season, which likely would originate from more than one source location.

Based on this information, the graph below provides our best estimated minimum distance to a potential source for all tree species and all locations where sample analysis found PGR herbicide residue. Distance measures are to cropland in all cases.

Figure 1 Shows the estimated distance to the closest potential drift source for trees that had detectable levels of PGR herbicide residue at the time of sampling.

Figure 1. Distance to Potential Drift Sources for all Trees with PGR Herbicide Residues

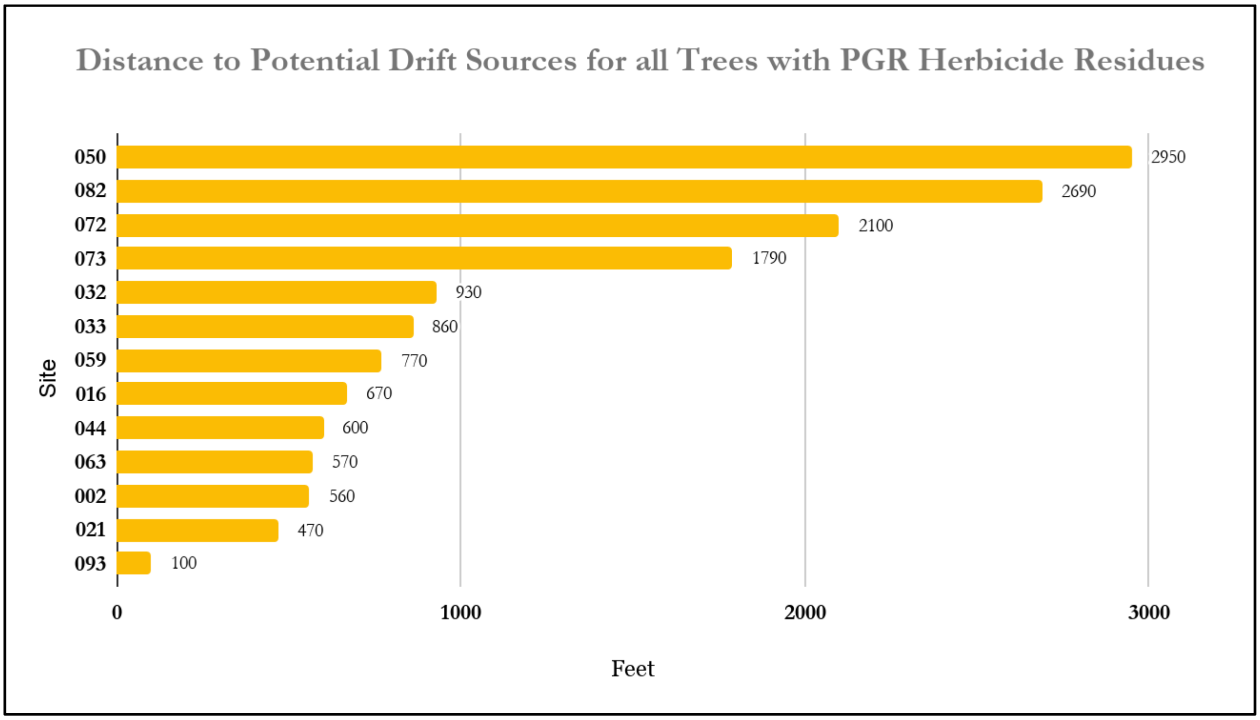


Figure 2 shows estimated distance to the closest potential drift source for oak trees that had detectable residues of PGR herbicides at the time of sampling. Distance measures are to cropland in all cases. Several locations were sampled multiple times throughout the growing season. One site, 033, had detectable levels of dicamba and 2, 4-D in two samples taken later in the growing season. Site 093 - a 40 acre residence with 20 acres of wooded pasture and lawn, and bordered by agricultural fields, has experienced several years of symptoms, including numerous cases of oak dieback and death.

Figure 2. Distance to Potential Drift Source for Oak Trees with 2, 4-D Residues

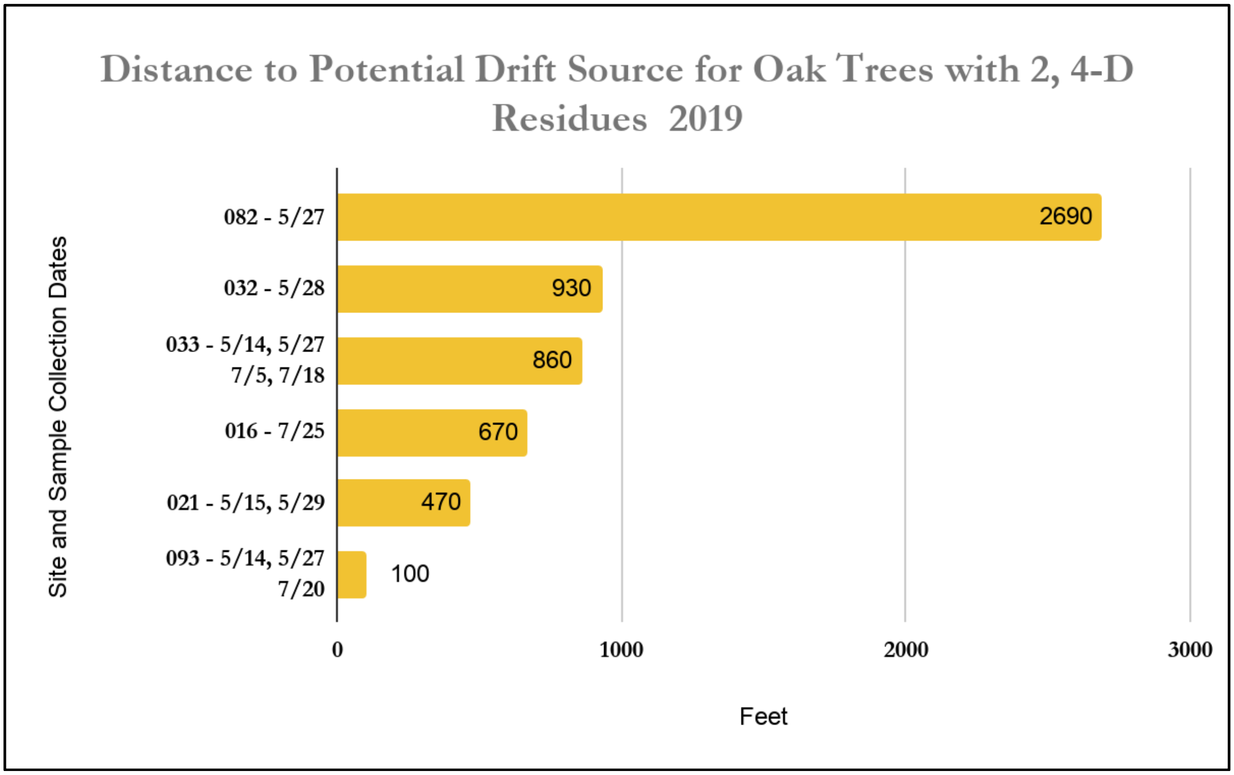
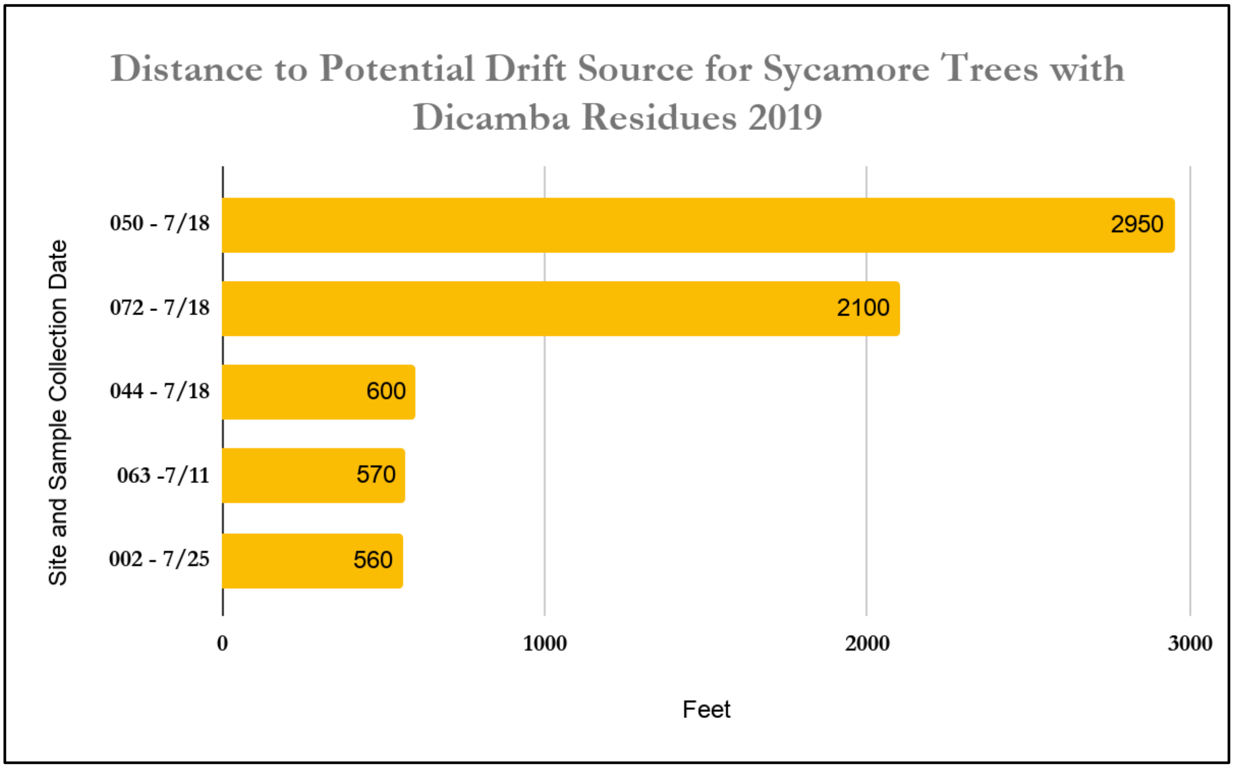


Figure 3 provides the distance data for sycamore tree locations which had detectable levels of dicamba residue. Five of the six leaf tissue samples that were taken for sycamore had dicamba residues. One sample, taken on June 12, 2019 which is not listed here, had detectable levels of 2, 4-D. Distance measures are to cropland in all cases. It is particularly noteworthy that, with the exception of 063, all sycamores listed in the figure below were located in urban environments.

Figure 3. Distance to Potential Drift Source for Sycamore Trees with Dicamba Residues



Conclusions

Monitoring began in the spring and continued until near the end of fall when leaves were falling from trees for both years. Symptoms of off-target herbicide injury appeared to be frequent and widespread, and present on a wide variety of plant types in both 2018 and 2019. It is important to note that volunteer efforts were extremely limited by personnel and time. Many volunteers reported seeing symptomatic trees in locations that they did not have the time, opportunity, or landowner permission to monitor. During the 2018 and 2019 growing season, symptoms could be observed throughout some rural towns.

There are numerous manuals and handbooks on tree health and diseases,[4] as well as published research that identify symptoms of herbicide injury.[5,6] The symptoms our volunteer monitoring program documented are similar to the responses of trees that have been exposed to driftable rates of PGR herbicides in controlled studies. There are certainly off-label uses of pesticides every year that cause avoidable injuries to private properties, specialty crops, or other non-target crops and plants. However, the increased use of these volatile PGR herbicides throughout the growing season coincides with record numbers of pesticide complaints throughout Illinois and the Midwest. The term "atmospheric loading" is increasingly used to describe mass movements of vapor drift, which land indiscriminately, harming unintended crops and plants. Many areas of the Midwest have suspected such incidences as the cause of widespread injury over the past few years, including this year in Iowa.[7] Our monitoring data and tissue analysis, combined with casual observations of the trained eye strongly suggest that volatility and vapor drift are a real issue here in Illinois.

Thorough analysis of the geography of exposures of trees monitored and sampled that had PGR herbicide residues is beyond the scope of this report. However, these results suggest large areas of the state including its plants, wildlife, and citizens, are within the range of the exposures documented here.

As mentioned previously, due to the appearance of recent increases in diseases, branch dieback, and whole tree mortality in several species of oaks (Quercus spp.), they were a species of concern in this monitoring program. Leaf curling, cupping, and stunting were among the symptoms that were reported in oaks starting in early to mid-May during both years. This suggests that early season or pre-planting weed control methods may be posing risks to these species which are often in the stages of bud swell and leaf unfolding during that time. Landowners and volunteers have documented an increase in dieback and mortality of oaks, particularly of white, pin, and post oak at sites where trees have shown symptoms of PGR herbicide exposure for multiple years. These observations raise the question of whether seasonal herbicide exposures are impacting oak health in numerous ways. The possibility that herbicide drift is weakening the health of these trees to a point where they are highly susceptible to other pests, pathogens, and environmental stressors, and thereby accelerating their demise, is very real and warrants thorough study.

Additionally, our data suggests that sycamores (Platanus sp.) appear to be particularly sensitive to PGR herbicides. The presence of anthracnose in spring has been prevalent over the past several years. Therefore it would be difficult to observe symptoms of PGR herbicides in trees which are experiencing temporary defoliation as a result of anthracnose. However, there has been a noticeable trend in the appearance of symptoms occurring mid-season on sycamore, after most trees have seemingly recovered from anthracnose, indicating that mid-season applications of PGR herbicides pose additional risks to this species. All of the sycamores that were monitored and sampled for tissue analysis were located in towns or rural areas, well removed from agricultural fields.

Responses to driftable rates of herbicides can vary and depend on numerous factors including the herbicide or combination of herbicides used, environmental stressors (drought, floods, temperature, etc.), plant health, species, and developmental stage. Research has shown that numerous non-target wild plants are sensitive to dicamba and other herbicides.[8, 9] Driftable rates of 2, 4-D and dicamba can reduce flower production and cause epinasty, stunting, and curved stems in ornamental plants[10] and plants exposed to driftable levels of PGR herbicides can have reduced or delayed flowering and may have reduced pollinator visitation.[8] Additionally, exposure to PGR herbicides can negatively impact seed production in wild plants.[11] This could potentially lead to profound impacts to ecosystems. For example if oak acorn production was reduced, it could have a serious and cascading effect on forest health, forest economics, and biodiversity.

The rise in pesticide misuse complaints to the Illinois Department of Agriculture and volunteer monitoring efforts like ours that have documented symptoms to a wide variety of non-crop trees and plants highlight the fact that there are many things we do not know about the ecological impacts of the widespread use of these herbicides throughout the growing season.

There are numerous questions that need to be answered. What are the rates, frequency and timing of herbicide exposures occurring to non-target landscapes? Are there additive or synergistic effects occurring when different pesticides are mixed in a tank or interact in the environment? What are the compounding or cumulative effects to plants that are exposed to multiple herbicides (and other pesticides) throughout the year? What are the non-visible impacts to wild plants? How are root health and nutrient transfer impacted? What does the broad scale use of these volatile herbicides mean for the trees and other plants that wildlife depend on for nectar, pollen, seeds, cones, forage, and shelter? Are plant communities shifting and if so, what are the ecological implications of such shifts? What are the impacts to wildlife that are exposed?

The list of questions is long and growing. Illinois needs a comprehensive monitoring system in place that can track the presence, absence, timing, frequency, and geographic distribution of these symptoms in trees and broadleaf plants. We need a greater understanding of how widespread pesticide use impacts aquatic and terrestrial ecosystems, coupled with more effective pesticide regulations and enforcement. Without a systematic approach, the Illinois Pesticide Act and its enforcement arm, IDOA, cannot assure the public that they are fulfilling their mission to prevent unreasonable harm from pesticides to the environment.

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