Prairie Weed Surveys

AGR1853

Final Report

2018/2024

Abstract/Summary

Weed surveys of annual crops have been regularly conducted in the Prairie Provinces since the 1970's. In the 1990's, a herbicide resistance survey program was also started in the Prairies. The objectives of the project are to complete the sixth set of weed surveys in the Prairie Provinces and summarize existing weed survey information.

A weed abundance survey was completed in the Prairie Provinces including 4098 fields of annual crops from 2019 to 2023. Saskatchewan was surveyed in 2019 and 2021, Manitoba in 2022 and Alberta in 2023. Crops surveyed included: spring wheat, barley, durum, oat, canola, flax, mustard, soybean, lentil, pea, chickpea, corn, pinto bean and sunflower. Weed data are summarized using a relative abundance index based on frequency, field uniformity and density. Similar methodology has been used since the 1970's, enabling the identification of shifts in weed communities. While the number one ranked weed, green foxtail, has not changed since the onset of the survey program, several weeds were identified as increasing. In particular, there was an increase in the relative abundance of volunteer canola in all three provinces, ranking in the top three weeds in each of the provinces in the current round of surveys. Other volunteer crops that have increased in abundance over time include: wheat, barley, and lentil. The increased presence of volunteer crops as weeds reflects both the increased acreage of these crops and diversification of crop rotations. Kochia also ranked higher than any previous survey in all provinces, likely due both to favourable weather and the spread of herbicide-resistant biotypes. Other weeds increasing include foxtail barley, round-leaved mallow, spiny annual sow-thistle, barnyard grass species and broad-leaved plantain. Some emerging regional species identified in this survey include golden dock and green pigweed in Manitoba, black medick in Saskatchewan and annual blue grass in Alberta.

Weeds identified as increasing in abundance can be targeted for attention by various agencies involved in weed science. The trends identified by the weed surveys are important to the research, industry, and extension communities for developing weed management recommendations for producers that are essential components of sustainable farming systems. Regular weed surveys are necessary to detect changes in weed populations. Further monitoring is necessary to determine if the high relative abundance of some species was related to weather in the survey year, or if these species are increasing in abundance due to other factors. Future surveys could also determine the impact of emerging herbicide resistant weeds, and any mitigation practices that are adopted.

Introduction

Weed surveys of annual crops have been regularly conducted in the Prairie Provinces since the 1970s (Leeson et al. 2005). The most recent series of Prairie Provincial weed surveys began with Saskatchewan in 2014/15 (Leeson 2016) followed by Manitoba in 2016 (Leeson et al. 2017) and Alberta in 2017 (Leeson et al. 2019). As the surveys have been conducted using a similar methodology, it is possible to determine changes in weed populations through time and identify potential new and emerging weed problems. Weeds identified as increasing in abundance can be targeted for attention by various agencies involved in weed science. The trends identified by the weed surveys are important to the research, industry, and extension communities for developing weed management recommendations for producers that are essential components of sustainable farming systems.

Weed resistance surveys were conducted pre-harvest on a subset of the fields surveyed starting in the 1990's (Beckie et al. 2007). Additionally, weed resistance surveys have been conducted post-harvest to document the range of glyphosate resistant kochia (Hall et al. 2014; Beckie et al. 2015).

In this project, the data collected in the most recent general and herbicide-resistant surveys of each Prairie Province (2014-2017) will be combined across jurisdictional boundaries. The survey data indicate that several weeds have recently increased in abundance in individual provinces and combining the data will reveal the scale of these changes. As five years will have passed since the previous surveys, new set of surveys will also be initiated to help quantify the spread of these species and help determine if changes are related to weather, or if these species are increasing in abundance due to other factors. Additionally, the weed surveys will help determine the impact of emerging herbicide resistant weeds, and any mitigation practices that are adopted.

Methods

Objective 1: Summarize existing weed survey information

Data will be combined from the 2014/15 Saskatchewan (2242 fields), 2016 Manitoba (658 fields) and 2017 Alberta (1232 fields) general weed surveys allowing the interpretation of trends across provincial boundaries. The distribution of the weeds will be mapped across provincial boundaries using GIS software. In order to detect changes over time, historic weed data (1970s to 2000s) will mapped using the same methodology. Data from the 2014 to 2017 weed resistance surveys will also be combined across provinces and maps will be produced illustrating the extent of the distribution of herbicide resistant weeds.

Objective 2: Conduct a new series of general weed surveys in the Prairie Provinces

The methodology for the weed surveys is similar to previous surveys, allowing us to determine trends over time. The survey included the most common annual crops in each province (canola, spring wheat, durum, soybean, pea, lentil, oat, barley, mustard, flax, and corn) as determined by Statistics Canada's estimated seeded areas of principal field crops. All annual crops that would be expected to have at least 20 fields surveyed across the each province were included. A target of 1200 fields in Alberta, 2200 fields in Saskatchewan and 600 fields in Manitoba was set based on the seeded acreage in each province.

In Manitoba, pinto beans, sunflower and field peas were included in the survey despite the relatively low acreage of these crops. These fields were surveyed in addition to the originally planned fields. The fields

were located using a similar methodology as the main survey; but with a target of 20 fields in each of these crops. The data from these crops in Manitoba were combined with other surveyed annual crops, but were downweighed to reflect the acreage seeded.

The fields were distributed using ecodistricts (areas with similar in landform, relief, surficial material, soil, vegetation and land use (Ecological Stratification Working Group 1995)) as the strata in a stratified random-sampling procedure, following the sampling procedure established for the 1990's surveys. The number of fields in an ecodistrict was allocated in proportion to the seeded area of the selected crops in the ecodistrict, relative to the total area seeded to selected crops in all ecodistricts based on the most recent available census data (Agriculture and Agri-Food Canada 2019).

Sites were randomly selected from all quarter sections (65 ha) that have greater than 16 cultivated hectares. Owners were then identified and contacted to seek permission to survey their land. Weeds that had not been controlled in the fields were counted in mid-July through to September. At this time, the weeds in the field are, in part, a result of the agronomic management decisions made by the farm operator at various times during the crop year. Counts at this time of the year show the size and extent of troublesome weed populations. Within each field, weeds are enumerated in 0.25-metre square quadrats (50 cm by 50 cm) at 20 locations in a set pattern, avoiding any edge effects. Samples were collected of each species in each field to facilitate identification of variants, new and rare species.

The weed data was summarized in a similar fashion to previous surveys to allow direct comparisons. A relative abundance index based on frequency, field uniformity and density is used to rank the species (Thomas 1985). Weed maps were prepared using ArcMap GIS 10.2 from Environmental Systems Research Institute, Inc.. Inverse Distance Weighting was used to estimate frequency of the species by interpolating presence/absence data. The interpolation included all sites within used a fixed radius of 0.2° (approximately 22 km) extended if necessary to include a minimum of twenty sites. The sites were given a weight of inverse of the square root of the distance to the interpolated point. The data presented is smoothed using nearest neighbour focal statistics, based on the means within a three cell radius.

Results

Herbicide Resistance Surveys (2014-2017)

The third round of pre-harvest herbicide resistance (HR) surveys conducted in Saskatchewan in 2014/2015, Manitoba in 2016, and Alberta in 2017, included 798 randomly selected cropped fields across 28 million ha (Beckie et al. 2020). Of the fields where wild oat was collected, 69% had an HR biotype: 62% acetyl-CoA carboxylase inhibitor (group 1)-HR (Appendix A1), 34% acetolactate synthase inhibitor (group 2)-HR (appendix A2), and 27% group 1+2-HR (Appendix A3)(vs. 44, 12, and 8%, respectively, in the previous second-round surveys from 2007 to 2009). The increase in group 2 resistance is the result increased selection pressure due to the reliance on this mode of action to manage group 1 resistance. Group 1 HR green foxtail was found in 25% of sampled fields (Appendix A4). The rise of group 2 resistance in green foxtail (11% of sampled fields, Appendix A5)and yellow foxtail (17% of Manitoba fields, Appendix A6), which was not detected in the previous survey round, parallels the results for wild oat resistance. There are no POST options to control group 1+2-HR wild oat in wheat or barley. Various group 2-HR populations of broadleaf weeds were confirmed, with cleavers (Appendix A7), chickweed and stinkweed being most abundant. These

surveys bring greater awareness of HR weeds at local and regional levels, and highlight the increasing urgency to preserve herbicide susceptibility in our key economic weed species.

Herbicide resistance surveys were also conducted on a subset of the fields included in the general survey from 2019 to 2023 in a separate project. Further increases in the prevalence of herbicide resistant weeds were documented in Saskatchewan (Geddes et al. 2024) and Manitoba (Geddes et al. unpublished) with results from Alberta pending final testing. All the herbicide resistance data from the 1990's to present have been collated to aid in the understanding of the development and spread of herbicide resistance in the Prairie Provinces. This information will be available to the public on the Prairie Weed Monitoring Network website (Prairie Weed Monitoring Network 2024).

General Weed Surveys (1970's-2023)

Saskatchewan

The two years of the Saskatchewan survey had extremely different weather conditions, impacting the weed populations. In 2019, the precipitation across most of the agricultural area of Saskatchewan was above normal, however, it was relatively dry until late June. This resulted in late weed flushes and the highest median weed densities ever recorded (Figure 1). In contrast, in 2021 the majority of the province had below normal precipitation and the median weed densities were the lowest ever recorded. Weed species responded differentially to the dry conditions in 2021. The frequency of several weed species were lower in 2021 than 2019, resulting in lower relative abundances in 2021 (Tables 1&2). The more drought tolerant species had similar frequencies in 2021 and 2019 and higher relative abundances in 2021. These data indicate potential shifts in the weed communities that could happen with climate change.

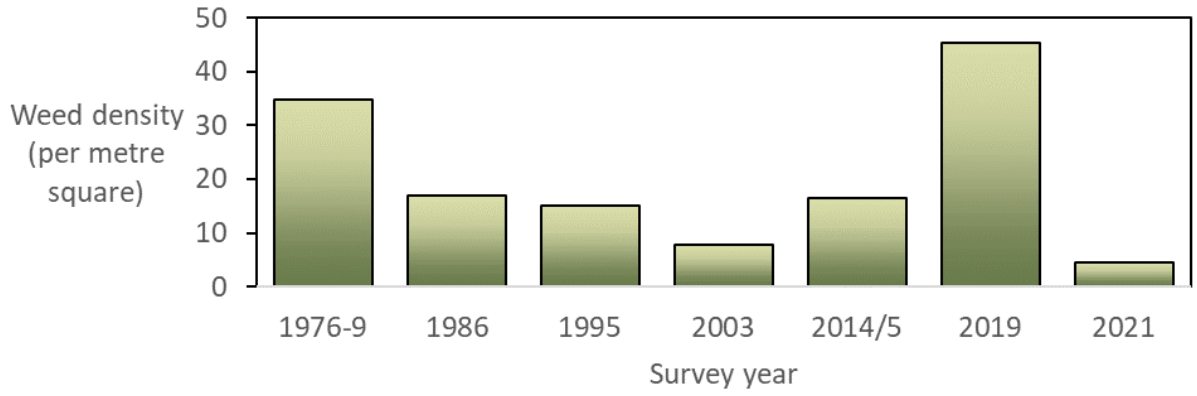

Figure 1. Median weed density in each survey.

Table 1. Top 20 weeds found in Saskatchewan 2019

Rank	Species	Frequency (%)	Field Uniformity		Field Density (#/m^2)			Relative Abundance
			All	Occurrence	All	Occurrence	High	
1	Green foxtail	34.1	15.7	45.9	16.8	49.3	3334.4	42.8
2	Canola	37.1*	19.8	53.2	8.7	23.4	521.8	32.2
3	Wild oats	31.8	13.9	43.7	5.6	17.7	458.4	22.9
4	Wild buckwheat	49.9*	14.8	29.7	1.8	3.6	77.6	20.1
5	Lamb's-quarters	31.8	9.0	28.3	2.3	7.2	425.0	14.5
6	Spiny annual sow-thistle	24.2*	8.9	36.7	3.1	12.6	450.4	14.4
7	Kochia	27.8	7.6	27.4	2.5	9.1	272.4	13.4
8	Wheat	18.7*	7.6	40.9	1.8	9.4	89.4	10.6
9	Stinkweed	16.6*	5.2	31.5	2.1	12.4	282.4	9.3
10	False cleavers	19.4*	6.1	31.6	1.0	5.4	125.2	8.6
11	Canada thistle	24.7	3.9	15.7	0.4	1.5	21.2	7.1
12	Barnyard grass species	11.0	3.3	29.7	1.9	17.5	228.0	7.0
13	Narrow-leaved hawk's-beard	15.1*	3.7	24.6	0.7	4.8	106.4	5.9
14	Perennial sow-thistle	14.7*	3.6	24.4	0.5	3.4	55.2	5.4
15	Dandelion	16.7*	2.9	17.2	0.4	2.3	67.0	5.2
16	Wild mustard	7.6	3.0	39.1	1.3	16.9	402.0	5.2
17	Shepherd's-purse	12.4*	2.6	21.1	0.6	5.0	172.8	4.7
18	Lentils	8.2*	3.8	46.3	0.6	7.5	59.6	4.6
19	Annual spurge species	9.7*	2.5	25.5	0.5	5.2	84.6	3.9
20	Round-leaved mallow	10.8	2.3	21.5	0.4	4.0	65.8	3.9

* Significantly higher frequency in 2019 than 2021

Table 2. Top 20 weeds found in Saskatchewan 2021

Rank	Species	Frequency (%)	Field Uniformity		Field Density (#/m^2)			Relative Abundance
			All	Occurrence	All	Occurrence	High	
1	Green foxtail	30.3	13.0	42.8	10.0	32.8	1389.0	62.6
2	Wild oats	27.6	9.3	33.5	3.3	11.8	165.6	31.3
3	Kochia	27.9	7.2	25.7	1.6	5.9	184.4	22.7
4	Lamb's-quarters	26.5	6.5	24.5	1.4	5.4	411.2	20.6
5	Wild buckwheat	25.9*	6.1	23.4	0.6	2.5	68.6	16.9
6	Canada thistle	26.0	5.1	19.7	0.7	2.7	62.4	16.1
7	Canola	13.9*	4.0	28.7	1.2	8.7	340.6	13.3
8	Wheat	12.6*	3.1	24.3	0.4	3.2	39.4	8.7
9	Wild mustard	5.3	2.1	39.7	0.7	14.1	122.4	6.9
10	Russian thistle	6.9	1.7	24.1	0.6	8.7	122.8	6.2
11	Barnyard grass species	7.9	1.9	24.0	0.3	3.8	61.8	5.6
12	Dandelion	9.0*	1.8	20.2	0.2	2.0	21.6	5.3
13	Stinkweed	5.1*	1.1	22.1	0.6	11.4	315.6	5.1
14	Redroot pigweed	7.4	1.6	21.3	0.3	3.5	92.4	4.9
15	Round-leaved mallow	7.7	1.5	19.1	0.2	2.3	19.4	4.6
16	Spiny annual sow-thistle	7.1*	1.2	17.2	0.1	2.0	22.6	4.0
17	Perennial sow-thistle	7.0*	1.1	15.8	0.1	2.1	53.4	3.8
18	False cleavers	6.5*	1.2	18.7	0.1	2.2	29.6	3.8
19	Black medick	3.0*	0.7	25.2	0.4	12.8	208.4	3.2
20	Annual spurge species	5.8*	1.0	16.9	0.1	1.6	17.4	3.2

* Significantly higher frequency in 2019 than 2021

Despite the varying weather conditions in 2019 and 2021, comparisons with historical data were still able to identify shifts in weed communities in Saskatchewan (Table 3). As in all previous surveys, green foxtail was the most abundant weed in 2019/21. Several species have consistently declined in relative abundance since the first surveys including: bluebur, cow cockle, Persian darnel, rose, prostrate pigweed, flixweed, night-flowering catchfly and pale smartweed. Chickweed had a large decline in relative abundance in 2021; likely attributable to the dry conditions.

Russian thistle, redroot pigweed and quackgrass had previously been identified as declining, but increased in relative abundance in 2021 in comparison to 2019. While these species increased in relative abundance rank, they did not increase in actual abundance, instead they tolerated the dry conditions better than other species. Both Russian thistle and redroot pigweed are C4 species, adapted for high temperature and drought conditions. As a perennial, quackgrass may be expected to be more resilient to annual fluctuations in weather; therefore, increasing in relative abundance rank in comparison to more sensitive annual species. Despite the increase in rank in 2021, these species are still declining, found at lower abundances in the more recent surveys. However, if dry condition persist, these species may become more important. Herbicide resistance may also contribute to a potential rebound of both Russian thistle and redroot pigweed.

Several species that have been increasing over time were also quite tolerant of the dry conditions in 2021, with no decrease in frequency and a corresponding increase in relative abundance. These species include round-leaved mallow, kochia, barnyard grass species and foxtail barley. As these species have increased since the surveys began and showed high drought tolerance, they should be watched particularly if dry conditions exist. Kochia was the third most abundant weed in Saskatchewan in 2021, likely due both to favourable weather and the spread of resistant biotypes.

Black medick, spring wheat, lentil, broadleaf plantain and dandelion were found in lower frequencies in 2021 but had similar or higher relative abundance ranks in 2021 than 2019. These species were affected by the drought, but not a severely as other species. Black medick is notable for reaching the top 20 for the first time in this round of surveys, due largely to it's expanding range westward.

Low cudweed, spiny annual sow-thistle, false cleavers, and canola were more sensitive to the dry conditions, with lower frequencies and abundances in 2021 than 2019. Despite any drops in frequency or relative abundance of these species in 2021, they are still increasing over time when comparing the rank to previous dry survey years in 2003 and 1986. Volunteer canola was the second most abundant species in 2019, displacing wild oat for the first time.

Table 3. Relative abundance rank of weed species that been in the top twenty species in at least one survey.

Weed species	1976-1979	1986	1995	2003	2014-2015	2019	2021	Change*
Black medick	109	29	73	45	33	27	19	90
Low cudweed			121	86	19	37	59	62
Spiny annual sow-thistle		72	50	34	6	6	16	56
Round-leaved mallow	44	37	38	31	22	20	15	29
Barnyard grass	34	33	28	12	12	12	11	23
False cleavers	40	25	15	13	7	10	18	22
Foxtail barley	42	67	40	26	16	22	23	19
Canola	25	23	11	14	4	2	7	18
Broad-leaved plantain	52	55	60	65	20	34	35	17
Spring wheat/durum	24	26	20	9	13	8	8	16
Kochia	17	28	13	8	15	7	3	14
Dandelion	23	36	14	11	10	15	12	11
Annual spurge species	29	19	17	32	34	19	20	9
Flax	38	16	24	19	26	29	32	6
Canada thistle	11	10	5	4	5	11	6	5
Lamb's-quarters	5	6	6	5	8	5	4	1
Green foxtail	1	1	1	1	1	1	1	0
Wild oats	2	2	2	2	2	3	2	0
Wild mustard	9	11	9	15	21	16	9	0
Wild buckwheat	3	3	3	3	3	4	5	-2
Field horsetail	19	15	18	16	29	28	22	-3
Russian thistle	6	5	8	10	30	23	10	-4
Narrow-leaved hawk's-beard	20	32	29	20	9	13	25	-5
Perennial sow-thistle	10	13	7	17	17	14	17	-7
Redroot pigweed	7	7	10	7	23	21	14	-7
Quack grass	33	27	16	24	45	53	40	-7
Shepherd's-purse	16	9	12	18	14	17	24	-8
Stinkweed	4	4	4	6	11	9	13	-9
Hemp-nettle	21	18	25	22	27	35	33	-12
Pale smartweed	14	12	22	23	24	24	28	-14
Night-flowering catchfly	15	24	36	33	31	32	29	-14
Flixweed	13	20	23	21	50	33	38	-25
Chickweed	28	21	26	29	18	25	54	-26
Prostrate pigweed	31	17	35	55	68	54	57	-26
Rose species	18	22	31	49	92	148	55	-37
Persian darnel	22	34	19	27	55	57	64	-42
Cow cockle	8	8	21	25	54	50	70	-62
Bluebur	12	14	27	30	74	69	80	-68

*Change in rank from first record to 2021.

Manitoba

In 2022, most of Manitoba experienced a very wet spring leading to delayed seeding. This may have resulted in good control of early weed flushes contributing to the lowest median weed densities since the survey began (Figure 2).

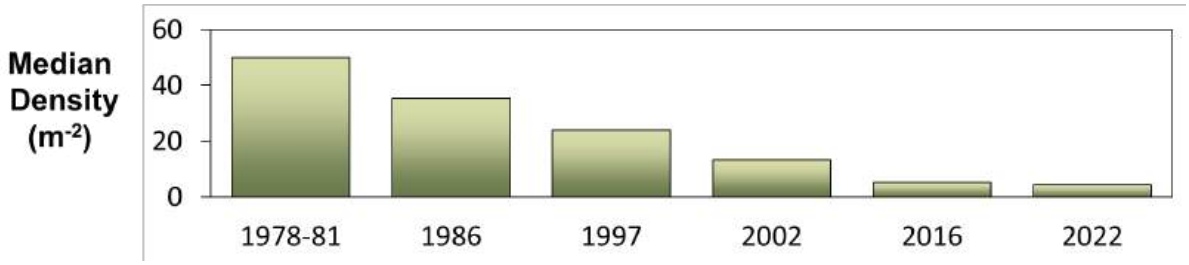

Figure 2. Median weed density in each Manitoba provincial weed survey.

The weeds found in Manitoba in 2022 were ranked based on relative abundance (Table 4) and compared to previous surveys (Table 5). Green foxtail was the most abundant weed in Manitoba in each survey since the 1970's. Wild buckwheat has ranked second in Manitoba since 2016. Volunteer canola ranked third in Manitoba in 2022, the highest rank ever recorded for this species in Manitoba. Increased relative abundance of volunteer canola was also noted in the 2019-21 Saskatchewan survey. This can be partially attributed to increased canola acreage. Lamb's-quarters and redroot pigweed ranked fourth and fifth in the 2022 Manitoba survey. These two species have been in the top 20 most abundant species since the survey began; however, they were found at their highest relative abundance in 2022.

Three species were found in the top twenty for the first time in the 2022 Manitoba survey (foxtail barley, golden dock and green pigweed). Foxtail barley had been increasing since 1997, while golden dock and green pigweed were first identified in the 2016 survey. Prior to 2016, the annual golden dock was not distinguished from other perennial dock species. Also prior to 2016, green pigweed may have been misidentified as redroot pigweed. Even considering possible misidentification, both of these species have increased in relative abundance.

Kochia, biennial wormwood, round-leaved mallow, volunteer wheat and yellow foxtail were also found at their highest relative abundance in 2022. The increase in abundance of kochia and yellow foxtail may be partially attributed to increased presence of herbicide resistant biotypes. Change in abundance of volunteers is driven by acreage seeded to the crops. Biennial wormwood, behaving as an annual, has been increasing in all the Prairie provinces. Round-leaved mallow has also been noted as increasing in Saskatchewan. Spiny annual sow-thistle, broad-leaved plantain, dandelion, false cleavers and barnyard grass species have also increased since the initial surveys, but declined in 2022 in comparison to 2016. This may be attributable to weather in the survey years.

Several species previously identified as decreasing in relative abundance continued to decline in Manitoba in 2022. Wild oats, Canada thistle and pale smartweed have been ranked amongst the top 20 species in each survey in Manitoba but ranked lower in 2022 than in previous surveys. Fourteen other species found in the top twenty in earlier surveys have since declined in abundance (Table 5). Each of these species was previously identified as declining in relative abundance.

Table 4. Top 20 weeds found in annual crops in Manitoba in 2022

		Frequency	Field Uniformity		Field Density (#/m^2)			Relative
Rank	Species	(%)	All	Occurrence	All	Occurrence	High	Abundance
1	Green foxtail	38.8	13.1	33.8	5.9	15.3	563.4	56.4
2	Wild buckwheat	49.4	11.3	22.8	1.4	2.7	105.4	30.1
3	Canola	31.5	9.7	30.8	1.1	3.6	43.8	23.5
4	Lamb's-quarters	27.4	5.2	19.0	1.0	3.6	184.0	16.9
5	Redroot pigweed	28.7	5.2	18.1	0.5	1.8	17.2	14.5
6	Yellow foxtail	7.2	1.9	26.6	1.3	18.6	400.4	11.3
7	Barnyard grass species	17.7	3.1	17.7	0.5	3.0	48.2	10.1
8	Wheat	14.4	3.9	27.0	0.5	3.4	38.6	9.9
9	Wild oats	17.4	3.5	20.0	0.4	2.5	51.4	9.9
10	Round-leaved mallow	17.0	2.4	14.2	0.2	1.1	12.0	7.2
11	Foxtail barley	10.9	1.8	16.8	0.5	4.3	75.4	6.9
12	Kochia	13.3	2.3	17.1	0.3	2.2	19.8	6.9
13	Pale smartweed	9.8	1.7	16.8	0.4	4.4	61.4	6.3
14	Canada thistle	16.9	1.9	11.2	0.1	0.8	11.6	6.2
15	Broad-leaved plantain	12.5	2.1	17.0	0.2	1.8	17.6	6.1
16	Dandelion	11.4	1.7	15.0	0.1	1.3	15.4	5.0
17	Golden dock	7.8	1.4	18.0	0.2	2.3	35.0	4.1
18	Biennial wormwood	9.9	1.3	12.6	0.1	0.9	6.4	3.9
19	Green pigweed	5.1	1.2	22.8	0.3	5.0	79.6	3.8
20	Thyme-leaved spurge	7.5	1.1	15.2	0.1	1.7	19.8	3.5

Table 5. Relative abundance rank of weed species that been in the top twenty species in Manitoba in at least one survey.

Weed Species	1978-81	1986	1997	2002	2016	2022	Change
Foxtail barley	81	54	83	64	22	11	70
Golden dock	85*	66*	55*	42*	26	17	68
Spiny annual sow-thistle	77	74	36	14	15	21	56
Yellow foxtail	48	40	27	30	6	6	42
Green pigweed					48	19	29
Biennial wormwood	45	55	44	49	20	18	27
Canola	29	28	19	9	5	3	26
Broad-leaved plantain	39	52	31	35	11	15	24
Kochia	31	30	24	17	30	12	19
Round-leaved mallow	25	23	21	16	10	10	15
Wheat	20	19	22	12	9	8	12
Dandelion	26	36	20	10	7	16	10
False cleavers	34	21	14	15	17	26	8
Barnyard grass species	13	27	11	4	3	7	6
Redroot pigweed	9	8	5	6	8	5	4
Lamb's-quarters	7	6	9	7	14	4	3
Wild buckwheat	3	3	3	3	2	2	1
Green foxtail	1	1	1	1	1	1	0
Thyme-leaved spurge	19	26	23	21	28	20	-1
Wild oats	2	2	2	2	4	9	-7
Canada thistle	5	9	4	5	13	14	-9
Pale smartweed	4	5	7	8	12	13	-9
Shepherd's-purse	21	17	13	27	27	30	-9
Field horsetail	18	18	26	23	21	29	-11
Night-flowering catchfly	10	13	15	18	16	22	-12
Chickweed	32	15	12	22	18	44	-12
Perennial sow-thistle	8	11	8	20	19	28	-20
Wild mustard	6	4	6	11	23	33	-27
Dog mustard	30	20	37	41	62	66	-36
Hemp-nettle	17	14	16	24	33	59	-42
Quack grass	12	12	10	13	38	57	-45
Flax	15	7	18	25	74	62	-47
Barley	22	16	29	26	69	72	-50
Stinkweed	11	10	17	19	34	76	-65
Russian thistle	14	24	33	57	96	86	-72
Bluebur	16	25	51	60	-	-	-102

* Golden dock was not distinguished from other dock species until 2016.

Alberta

A total of 1121 fields of annual crops including spring wheat, canola, barley, field pea, durum, oat, and lentil were surveyed. The comparison of the relative abundance of weeds in 2023 with results from previous provincial surveys enables the identification of recent shifts in species' ranks and relative abundance. In comparison to the previous two surveys, the total weed densities were slightly higher in 2023 (Figure 3), due, in part, to wet conditions in the northern areas.

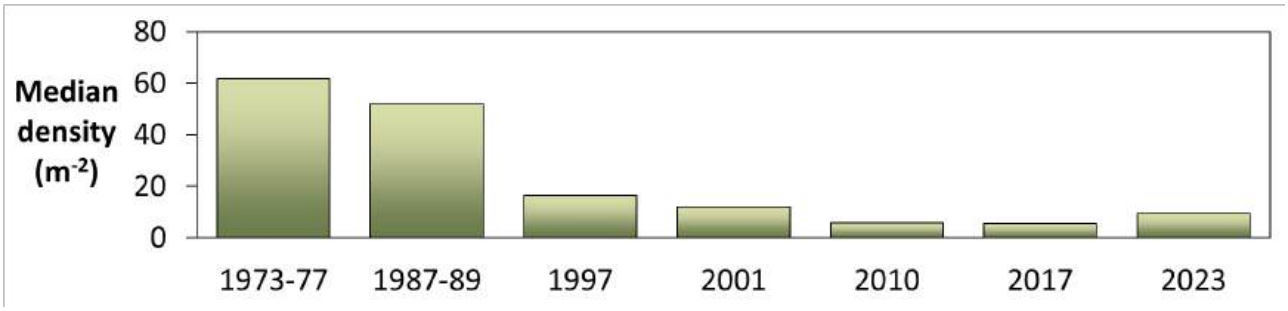

Figure 3. Median weed density in each Alberta provincial weed survey.

Chickweed was the most abundant weed in Alberta in 2023, as observed in the previous survey, due to the high density and uniformity in occurrence fields (Table 6). As observed in Manitoba and Saskatchewan, volunteer canola also increased in abundance in Alberta. Volunteer canola ranked second in 2023, moving into the top three most abundant weeds in Alberta for the first time. Wild buckwheat ranked third, followed by wild oats, and lamb's-quarters. Volunteer canola, wild oats, wild buckwheat and lamb's-quarters were more widespread than chickweed in Alberta but were found in lower densities.

Annual blue grass and broad-leaved plantain were found in the top twenty for the first time in Alberta in 2023 (Table 7). Foxtail barley, spiny annual sow-thistle, wheat, kochia and barley continued to steadily increase, ranking higher in 2023 than any previous survey. False cleavers has also increased since the earlier surveys, but did not increase in relative abundance rank in 2023 relative to 2017. Low cudweed has increased over time, but its relative abundance rank tends to fluctuate being more abundant in wet years.

Table 6. Top 20 weeds found in annual crops in Alberta in 2023

Rank	Species	Frequency (%)	Field Uniformity		Field Density (#/m^2)			Relative Abundance
			All	Occurrence	All	Occurrence	High	
1	Chickweed	19.2	9.4	48.9	7.9	41.3	842.8	33.3
2	Canola	31.0	12.8	41.4	3.6	11.6	186.4	27.3
3	Wild oats	27.2	8.5	31.2	4.3	15.9	1145.6	24.7
4	Wild buckwheat	43.2	11.8	27.4	1.7	3.9	391.2	24.1
5	Lamb's-quarters	30.1	7.9	26.2	1.3	4.2	86.0	16.8
6	Wheat	15.6	6.4	40.9	1.8	11.2	195.0	13.6
7	False cleavers	17.7	4.9	27.6	1.3	7.1	306.0	11.4
8	Spiny annual sow-thistle	18.4	4.8	26.0	0.8	4.4	103.6	10.3
9	Kochia	13.2	3.8	29.1	1.1	8.2	276.0	9.1
10	Green foxtail	7.0	2.7	38.4	1.8	25.1	297.8	8.5
11	Dandelion	16.7	3.7	22.1	0.5	3.0	141.8	8.2
12	Field horsetail	12.4	3.0	23.8	0.7	6.0	79.2	7.3
13	Canada thistle	18.3	2.6	14.2	0.3	1.6	31.0	7.1
14	Shepherd's-purse	12.5	3.1	24.7	0.6	4.6	52.4	6.9
15	Hemp-nettle	12.9	3.1	23.8	0.4	3.2	40.6	6.5
16	Barley	7.4	2.3	30.9	1.0	13.0	262.4	6.1
17	Low cudweed	7.3	1.6	21.5	0.8	11.6	84.8	5.2
18	Annual blue grass	2.8	0.6	22.2	1.4	50.1	992.0	4.8
19	Broad-leaved plantain	8.1	1.4	17.3	0.4	4.7	161.8	4.0
20	Foxtail barley	6.5	1.1	17.1	0.5	7.6	297.6	3.7

Table 7. Relative abundance rank of weed species that been in the top twenty species in Alberta in at least one survey.

Weed Species	1970's	1980's	1997	2001	2010	2017	2023	Change
Foxtail barley		92	40	31	26	22	20	72
Annual blue grass		64			77	27	18	46
False cleavers	41	28	9	7	6	6	7	34
Low cudweed		47	25	39	12	19	17	30
Spiny annual sow-thistle		37	27	15	10	11	8	29
Wheat		29	21	20	19	7	6	23
Kochia	25	23	23	19	17	15	9	16
Broad-leaved plantain	29	41	33	38	39	36	19	10
Canola/rapeseed	12	19	20	16	4	4	2	10
Barley		25	26	25	31	18	16	9
Shepherd's-purse	21	9	6	11	16	17	14	7
Chickweed	6	5	1	3	7	1	1	5
Dandelion	15	18	10	10	5	10	11	4
Pineappleweed	34	30	18	23	25	40	32	2
Field horsetail	14	10	11	13	15	12	12	2
Lamb's-quarters	5	6	8	6	8	3	5	0
Wild buckwheat	3	1	3	1	1	2	4	-1
Wild oats	2	3	2	2	2	5	3	-1
Canada thistle	9	12	5	5	3	9	13	-4
Common groundsel	32	15	15	24	35	42	37	-5
Narrow-leaved hawk's-beard	22	13	12	17	11	16	28	-6
Green foxtail	4	4	17	8	18	8	10	-6
Hemp-nettle	7	8	7	9	9	13	15	-8
Clover species		16	24	26	24	24	27	-11
Perennial sow-thistle	17	17	14	18	14	28	30	-13
Russian thistle	13	7	29	22	28	29	26	-13
Redroot pigweed	10	14	19	21	20	23	23	-13
Pale smartweed	8	11	13	12	22	20	22	-14
Corn spurry	11	22	22	27	21	25	29	-18
Stinkweed	1	2	4	4	13	14	24	-23
Quack grass	23	21	16	14	23	31	54	-31
Wild mustard	16	35	47	36	40	45	48	-32
Flixweed	18	24	37	30	30	52	66	-48
Bluebur	19	20	28	28	43	58	71	-52
Tartary buckwheat	20	27	38	73	34	67		-109

Prairie Provinces

When the data was combined across the Prairie Provinces, green foxtail was identified as the most abundant weed (Table 8) as in each of the previous surveys (Table 9). Green foxtail was the most abundant weed in oat, corn and flax crops and ranked second in wheat, field pea and lentil crops (Table 10). While green foxtail is found throughout the Prairies, it is most frequently found in Saskatchewan and Manitoba (Appendix B1).

Table 8. Top 20 weeds found in annual crops in the Prairie Provinces from 2019 to 2023

		Frequency	Field Uniformity		Field Density (#/m^2)			Relative
Rank	Species	(%)	All	Occurrence	All	Occurrence	High	Abundance
1	Green foxtail	23.8	10.1	42.2	8.7	36.4	3334.4	37.4
2	Canola	26.8	11.5	42.8	3.9	14.7	521.8	26.4
3	Wild oats	26.6	9.3	35.2	3.8	14.2	1145.6	24.0
4	Wild buckwheat	39.6	10.5	26.5	1.3	3.3	391.2	21.3
5	Lamb's-quarters	28.1	7.2	25.5	1.5	5.4	425.0	16.5
6	Kochia	20.8	5.4	26.0	1.5	7.1	276.0	13.2
7	Chickweed	7.6	3.3	43.4	2.5	32.5	842.8	11.2
8	Wheat	14.9	5.3	35.6	1.1	7.6	195.0	10.9
9	Spiny annual sow-thistle	14.7	4.2	28.7	1.1	7.4	450.4	9.8
10	Canada thistle	21.5	3.5	16.2	0.4	1.9	62.4	8.9
11	False cleavers	13.3	3.6	27.1	0.7	5.3	306.0	8.0
12	Dandelion	13.5	2.7	19.7	0.3	2.4	141.8	6.2
13	Barnyard grass species	8.7	2.1	24.5	0.9	10.3	228.0	6.1
14	Stinkweed	8.0	2.2	27.8	0.8	9.9	315.6	5.8
15	Redroot pigweed	10.0	2.2	21.9	0.5	4.7	198.8	5.4
16	Shepherd's-purse	9.0	1.9	21.5	0.4	4.2	172.8	4.7
17	Field horsetail	7.9	1.7	21.1	0.4	4.6	79.2	4.2
18	Wild mustard	4.3	1.6	37.0	0.6	13.3	402.0	3.9
19	Narrow-leaved hawk's-beard	7.2	1.5	21.5	0.3	3.9	106.4	3.7
20	Foxtail barley	7.7	1.3	16.6	0.3	3.9	297.6	3.6

Volunteer canola ranked second overall (Table 8,9), reflecting the increases in this species seen in each of the provinces. With the expansion of canola production into drier areas, volunteer canola is now found as a weed throughout most of the survey area (Appendix B2). Volunteer canola was the most abundant weed in wheat, barley, soybean, field pea and lentil crops in the 2019-23 survey (Table 10).

Across all annual crops, wild oats and wild buckwheat ranked third and fourth, slightly lower than previous surveys, displaced by volunteer canola (Table 9). Lamb's-quarters ranked fifth, a position it has held in five of the six surveys. The consistent presence of green foxtail, wild oat, wild buckwheat and lamb's-quarter in the top five most abundant weeds in the past fifty years reflects the widespread distribution (Appendix B1, B3-5) and resilience of these species.

Kochia was the sixth most abundant weed across the Prairie Provinces in 2019-23 surveys (Table 8), the highest rank it has reached since the 1970's (Table 9). Over the survey years there has been some fluctuation in the abundance rank of kochia due in part to its adaption for drier conditions; however, overall it has rapidly been increasing in abundance; and becoming a problem in all of the Prairie Provinces (Appendix B6). While it is generally more troublesome in the drier grassland areas of the Prairies, it's range

has been expanding north. The rapid evolution of herbicide resistance in this species highlights the need to develop alternative weed management solutions.

Table 9. Relative abundance rank of weed species that been in the top twenty species in the Prairie Provinces in at least one survey.

Weed species	1970's	1980's	1995-97	2001-03	2014-17	2019-23	Change
Spiny annual sow-thistle	133	54	38	22	9	9	124
False cleavers	44	29	11	10	7	11	33
Foxtail barley	46	77	44	32	18	20	26
Wheat	28	31	22	11	11	8	20
Kochia	25	27	20	9	16	6	19
Broad-leaved plantain	43	51	42	47	20	26	17
Canola/rapeseed	18	21	18	14	4	2	16
Barnyard grass species	27	35	24	16	13	13	14
Dandelion	21	26	14	12	10	12	9
Narrow-leaved hawk's-beard	26	16	21	23	12	19	7
Shepherd's-purse	22	11	9	19	15	16	6
Chickweed	10	7	6	7	8	7	3
Green foxtail	1	1	1	1	1	1	0
Lamb's-quarters	5	5	7	5	5	5	0
Field horsetail	17	13	19	18	24	17	0
Wild buckwheat	3	2	3	3	2	4	-1
Wild oats	2	3	2	2	3	3	-1
Canada thistle	9	10	5	4	6	10	-1
Wild mustard	11	14	15	24	26	18	-7
Flax	32	20	27	26	30	39	-7
Redroot pigweed	6	8	10	8	17	15	-9
Stinkweed	4	4	4	6	14	14	-10
Perennial sow-thistle	12	15	8	20	22	22	-10
Hemp-nettle	14	12	16	17	25	25	-11
Night-flowering catchfly	19	25	31	33	27	33	-14
Russian thistle	7	6	17	15	31	23	-16
Pale smartweed	8	9	13	13	19	24	-16
Common groundsel	40	17	23	29	67	61	-21
Quack grass	24	19	12	21	40	50	-26
Corn spurry	20	32	35	40	42	47	-27
Flixweed	16	24	29	27	54	45	-29
Cow cockle	13	22	32	35	60	74	-61
Bluebur	15	18	30	31	76	83	-68

Chickweed, ranked as the most abundant weed in Alberta, was ranked seventh when the data was combined across the three prairie provinces (Table 8). Chickweed is associated with wetter conditions, found more abundant in Saskatchewan in 2019 than 2021; and abundant in wetter areas of Alberta in 2023 (Appendix

B7). Although there have been some regional fluctuations in chickweed populations that can be linked to weather, there has not been any recent changes in relative abundance (Table 9). This weed needs to be monitored due to its ability to flourish under wet conditions and the presence of Group 2 HR biotypes.

Table 10. Relative abundance rank of weed species that been in the top five in the major annual crops Prairie Provinces in 2019 to 2023.

Weed species	Spring wheat	Barley	Oats	Corn	Canola	Flax	Soybean	Field peas	Lentils
Volunteer canola/rapeseed	1	1	8	9	14	5	1	1	1
Green foxtail	2	3	1	1	6	1	3	2	2
Volunteer wheat	30	14	15	33	1	11	8	7	5
Wild oats	4	2	4	39	2	2	4	3	3
Wild buckwheat	3	5	3	2	4	3	2	6	6
Lamb's-quarters	7	7	2	3	3	10	7	5	10
Kochia	5	6	11	8	9	4	10	4	4
Redroot pigweed	17	15	6	4	17	12	13	19	27
Chickweed	6	4	18		8	24		27	
Spiny annual sow-thistle	8	11	33	37	7	9	5	9	7
Canada thistle	9	8	5	24	13	7	14	8	11
False cleavers	10	12	30		5	17	31	12	30
Round-leaved mallow	27	22	21	5	18	8	6	24	21

Volunteer wheat was the eighth most abundant weed across the Prairie Provinces (Table 8). This volunteer was also noted to have increased in abundance in each of the provinces; and is widespread throughout the region (Appendix B8). It was the most abundant weed in canola (Table 10). The increase in volunteer wheat can be partially attributed to crop diversification; facilitating the identification of this weed in crops other than wheat. Other volunteers have also increased in frequency in the two most recent surveys including, lentil, alfalfa, field pea, oat, and soybean.

Spiny annual sow-thistle is also a widespread weed (Appendix B9) that ranked ninth across the three provinces (Table 8). While the relative abundance of spiny annual sow-thistle did not change from 2014 to 2023, it had the largest change in rank since the 1970's (Table 9). False cleavers, foxtail barley, broad-leaved plantain, barnyard grass species and dandelion have also all increased since the 1970's; however, as seen with spiny annual sow-thistle, the relative abundance rank in the 2019-2023 survey was similar or lower than in the 2014-17 surveys (Table 9). Of these species, false cleavers and broad-leaved plantain are more common in the wetter northern areas (Appendix B10, B11); while foxtail barley and dandelion are more widespread (Appendix B12, B13). Due to difficulty identifying immature specimens two species of barnyard grass are combined in the survey results, as a whole the complex is found throughout the Prairies (Appendix B14); however, the introduced barnyard grass species is more common in Manitoba (Appendix B15). Additional surveys are required to determine if these species will continue to increase under favourable weather conditions.

Several species that were more abundant at the provincial scale also increased in frequency across the prairie provinces since the early 2000's. These species are of concern as they may be expected to expand their range. Annual blue grass is found in the Boreal Transition, primarily in Alberta (Appendix B16). Low cudweed is found primarily in Saskatchewan and Alberta in both the Boreal Transition and Peace River areas

(Appendix B17). Low cudweed was more abundant in wet conditions; and could be expected to spread if weather is favourable. Both round-leaved mallow and black medick are common in Manitoba, eastern Saskatchewan and western Alberta (Appendix B18, B19). Biennial wormwood is common in Manitoba and Saskatchewan with a few populations in Alberta (Appendix B20). Golden dock and green pigweed are most common in Manitoba with a few occurrences in the other two provinces (Appendix B21,B22); while yellow foxtail is moving into Saskatchewan from Manitoba (Appendix B23).

Other locally abundant species of note that have increased in frequency across the prairie provinces since the early 2000's include annual brome species and stink grass. Downy brome and Japanese brome are combined in the summaries as annual brome species, due to difficulties distinguishing between immature specimens. Both of the species are of concern due to the recent identification glyphosate resistant downy brome (Geddes and Pittman 2022) and group 2 resistant Japanese brome (Geddes unpublished). The annual brome species were widespread in western Saskatchewan and Alberta, but not frequently found (Appendix B24). Stink grass has a very limited distribution in south eastern Manitoba and southwestern Saskatchewan (Appendix B25) but has also developed herbicide resistance (Geddes unpublished).

Conclusions and Recommendations

Quantitative field surveys of weed populations are used to reveal the current size, extent, and order of importance of species in provinces, ecoregions and jurisdictional areas. Tracking the increase or decrease in weed populations and the changes in the composition and structure of weed communities will indicate the extent by which various weeds are spreading or being controlled and thus the effectiveness of weed management programs. Weed survey data can provide an objective basis for developing ecologically and economically sustainable strategies to manage agricultural weeds. The data are used to set research and education priorities, develop recommendations, and design weed management strategies in the research, extension, and agri-business communities. Relating trends in weed populations and communities to the use of specific agronomic and weed control practices or to cropping systems will identify possible reasons that certain weeds have become more or less of a problem on an ecoregion, crop, or provincial basis. Predicting shifts in weed populations and communities that might occur because of anticipated changes in agronomic practices, weed control management, climate, and agricultural policy will allow agricultural agencies to develop weed management strategies that meet the future needs of farmers.

Regular weed surveys are necessary to detect changes in weed populations. Further monitoring is necessary to determine if the high relative abundance of some species was related to weather in the survey year, or if these species are increasing in abundance due to other factors. Future surveys could also determine the impact of emerging herbicide resistant weeds, and any mitigation practices that are adopted.

Acknowledgements

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Appendix A

2014 to 2017 Herbicide Resistance Maps

Figure A1. Group 1 (acetyl CoA carboxylase inhibitor)-resistant wild oat (white circle) across the prairie provinces, 2014/15 to 2017.

Figure A2. Group 2 (acetolactate synthase inhibitor)-resistant wild oat (white circle) across the prairie provinces, 2014/15 to 2017.

Figure A3. Group 1 (acetyl CoA carboxylase inhibitor) plus group 2 (acetolactate synthase inhibitor)-resistant wild oat (white circle) across the prairie provinces, 2014/15 to 2017

Figure A4. Group 1 (acetyl CoA carboxylase inhibitor)-resistant green foxtail (white circle) across the prairie provinces, 2014/15 to 2017.

Figure A5. Group 2 (acetolactate synthase inhibitor)-resistant green foxtail (white circle) across the prairie provinces, 2014/15 to 2017.

Figure A6. Group 1 (acetyl CoA carboxylase inhibitor)-resistant yellow foxtail (white circle); and group 2 (acetolactate synthase inhibitor)-resistant yellow foxtail in Manitoba.

Figure A7. Group 2 (acetolactate synthase inhibitor)-resistant cleavers (white circle) in Alberta and Saskatchewan.

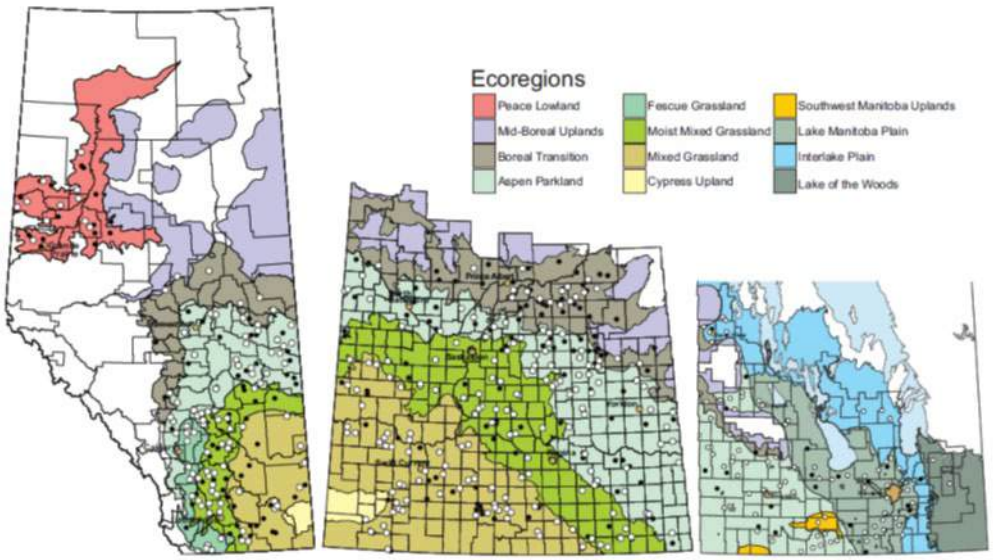

Figure A1. Group 1 (acetyl CoA carboxylase inhibitor)-resistant wild oat (white circle) across the prairie provinces, 2014/15 to 2017 (left to right: Alberta, Saskatchewan, Manitoba).

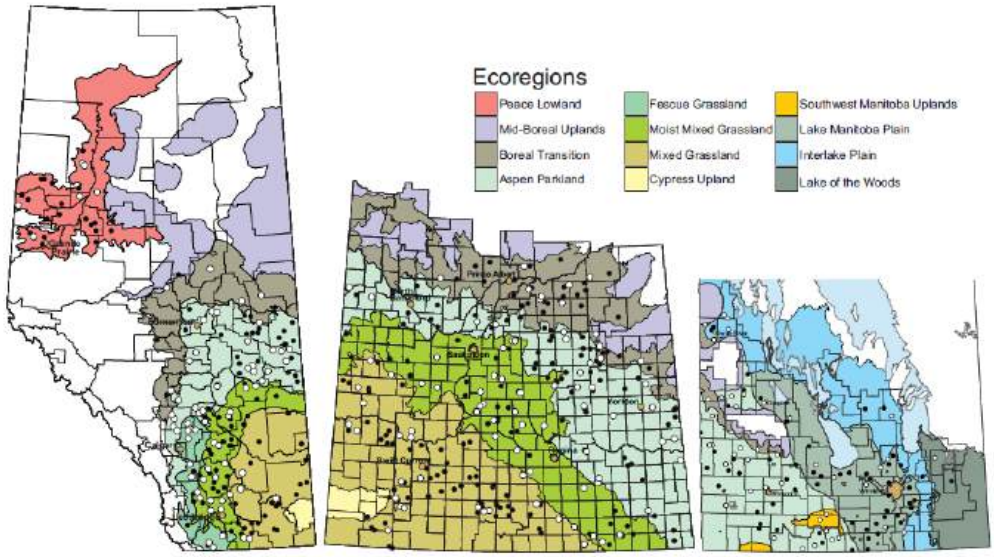

Figure A2. Group 2 (acetolactate synthase inhibitor)-resistant wild oat (white circle) across the prairie provinces, 2014/15 to 2017 (left to right: Alberta, Saskatchewan, Manitoba).

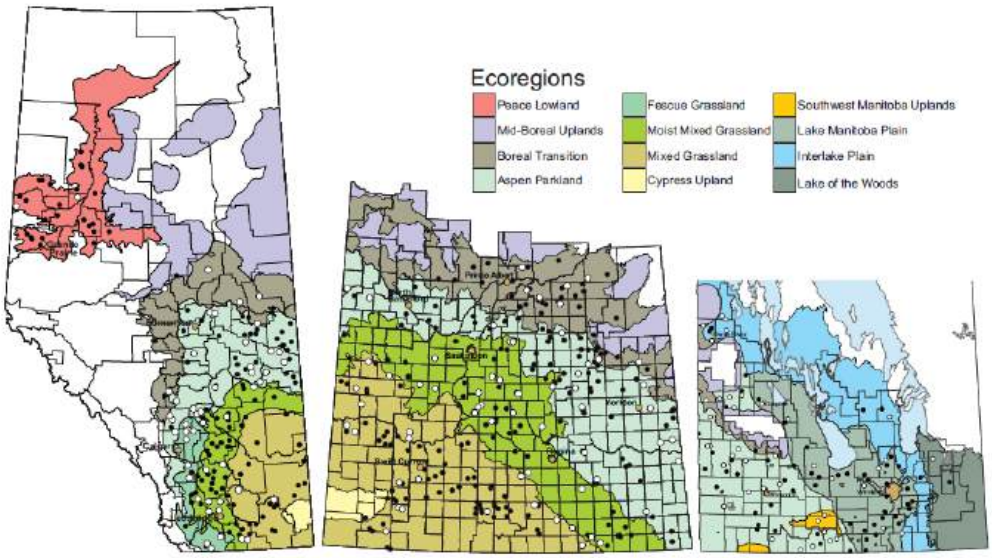

Figure A3. Group 1 (acetyl CoA carboxylase inhibitor) plus group 2 (acetolactate synthase inhibitor)-resistant wild oat (white circle) across the prairie provinces, 2014/15 to 2017

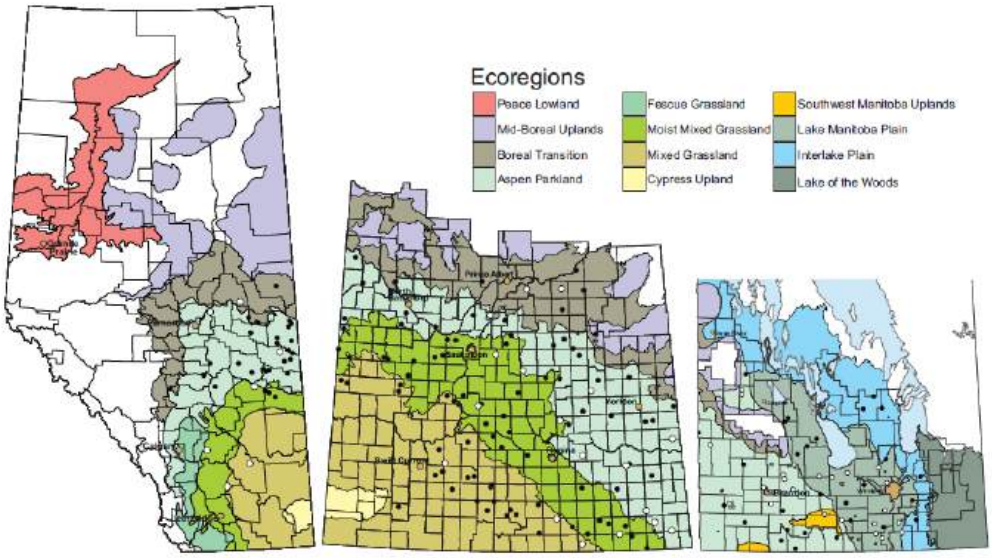

Figure A4. Group 1 (acetyl CoA carboxylase inhibitor)-resistant green foxtail (white circle) across the prairie provinces, 2014/15 to 2017 (left to right: Alberta, Saskatchewan, Manitoba).

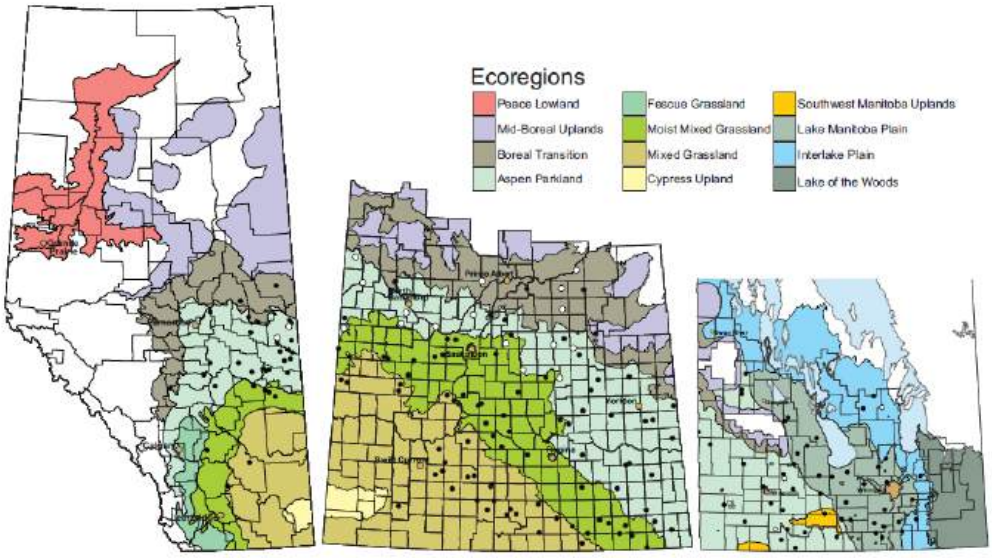

Figure A5. Group 2 (acetolactate synthase inhibitor)-resistant green foxtail (white circle) across the prairie provinces, 2014/15 to 2017 (left to right: Alberta, Saskatchewan, Manitoba).

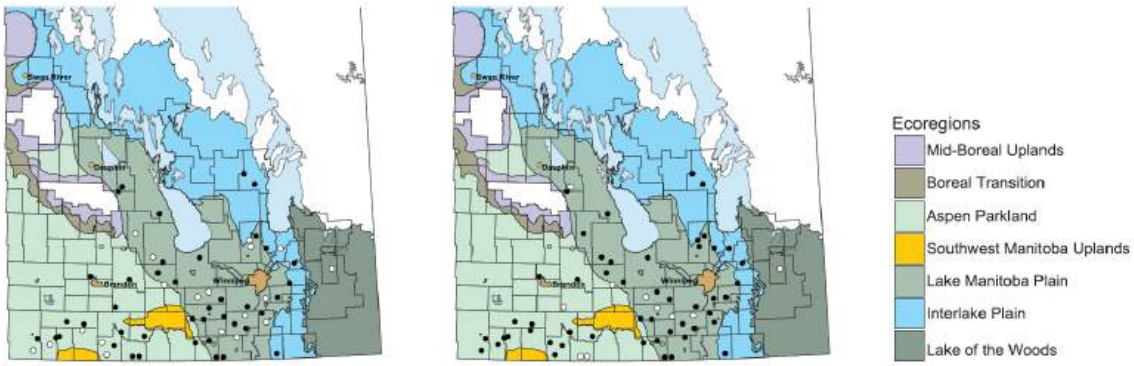

Figure A6. Group 1 (acetyl CoA carboxylase inhibitor)-resistant yellow foxtail (white circle on left map); and group 2 (acetolactate synthase inhibitor)-resistant yellow foxtail in Manitoba (right map).

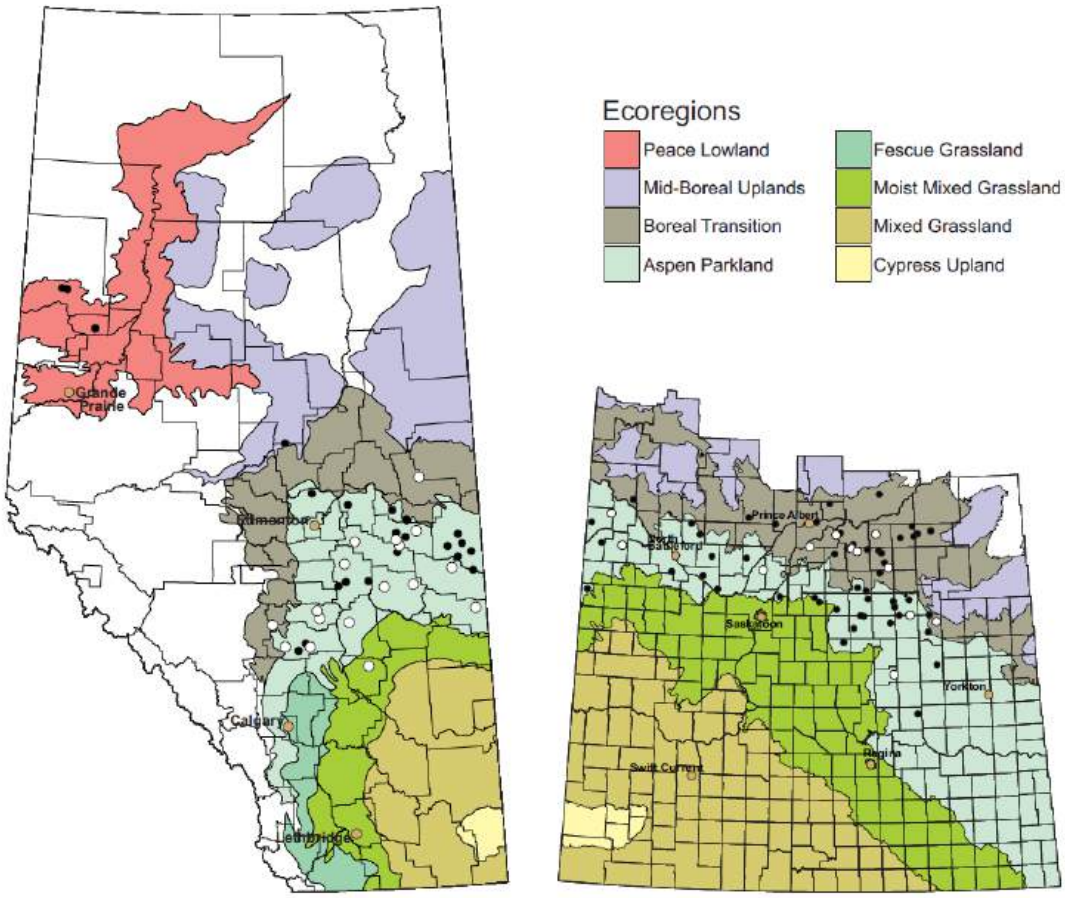

Figure A7. Group 2 (acetolactate synthase inhibitor)-resistant cleavers (white circle) in Alberta and Saskatchewan.

Appendix B

Weed Distribution Maps

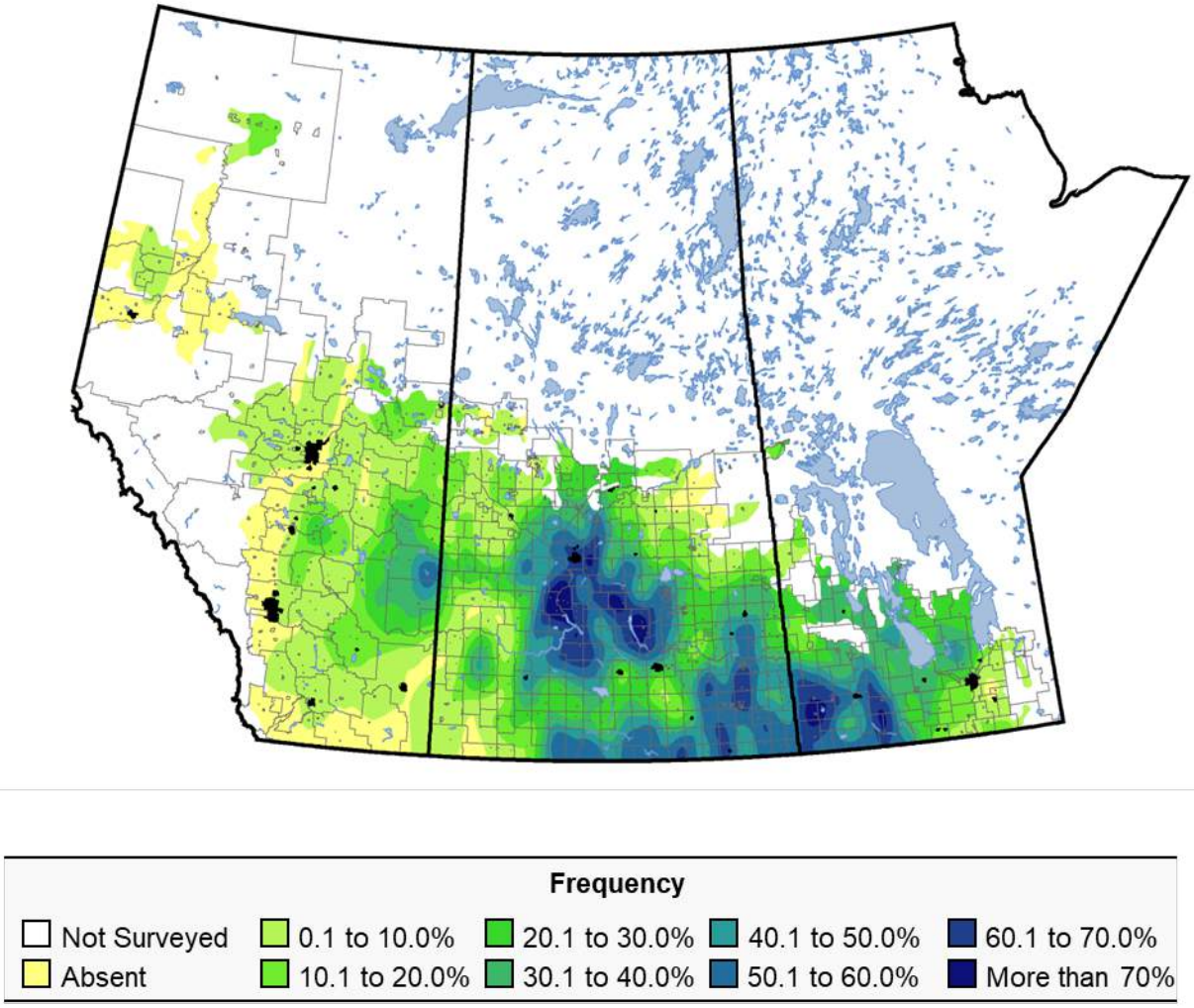

Figure B1. Distribution of green foxtail based 2019 to 2023 weed surveys.

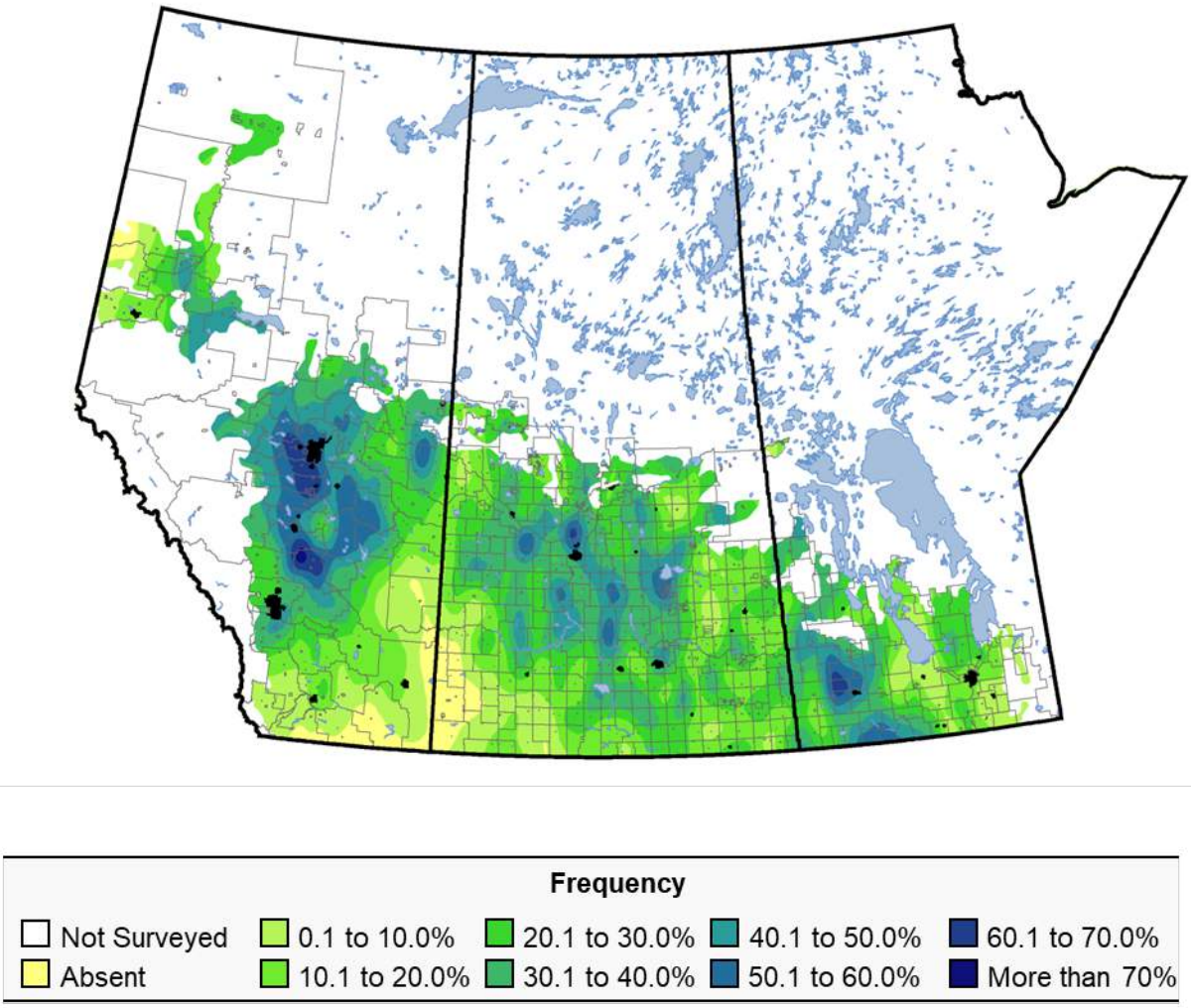

Figure B2. Distribution of volunteer canola based 2019 to 2023 weed surveys.

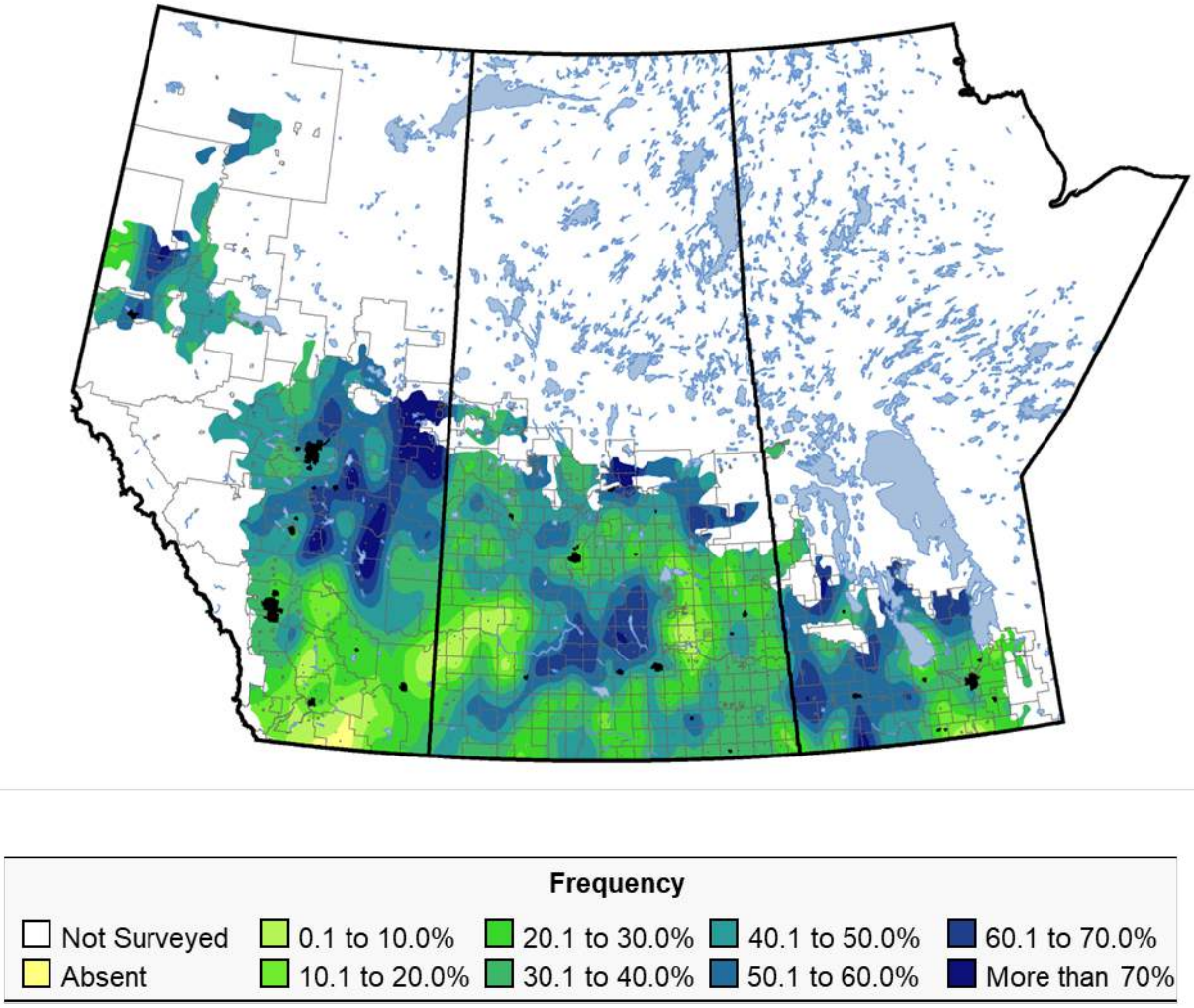

Figure B3. Distribution of wild buckwheat based 2019 to 2023 weed surveys.

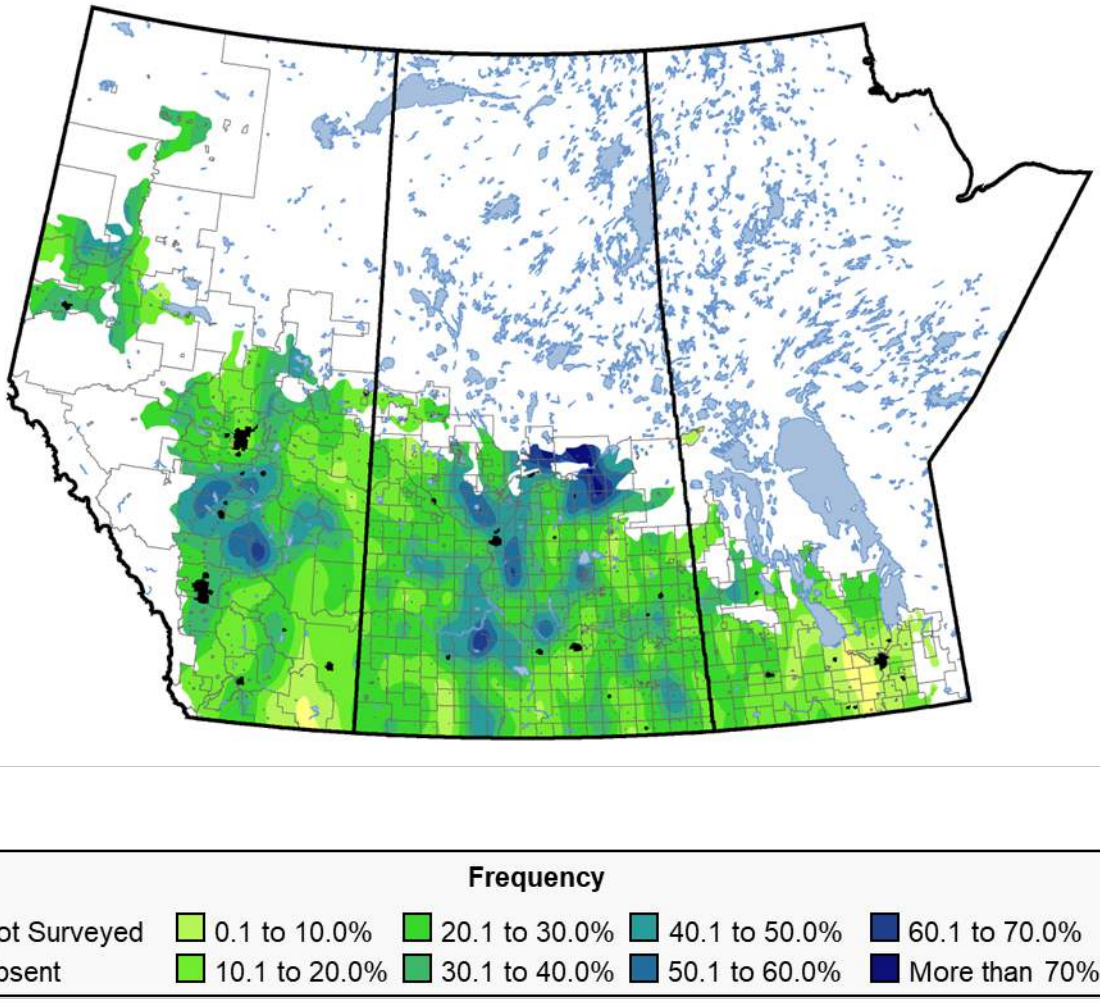

Figure B4. Distribution of wild oat based 2019 to 2023 weed surveys.

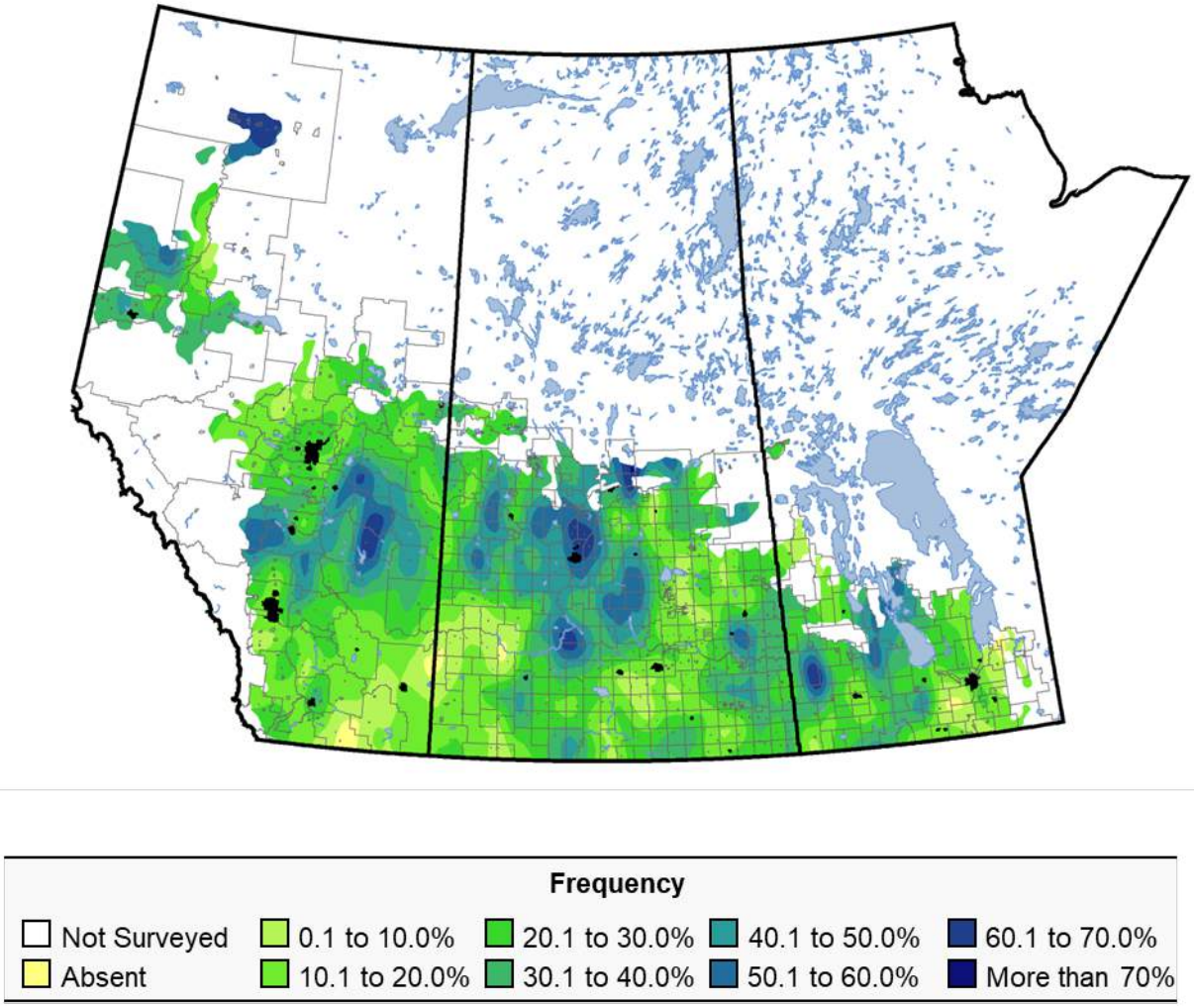

Figure B5. Distribution of lamb's-quarters based 2019 to 2023 weed surveys.

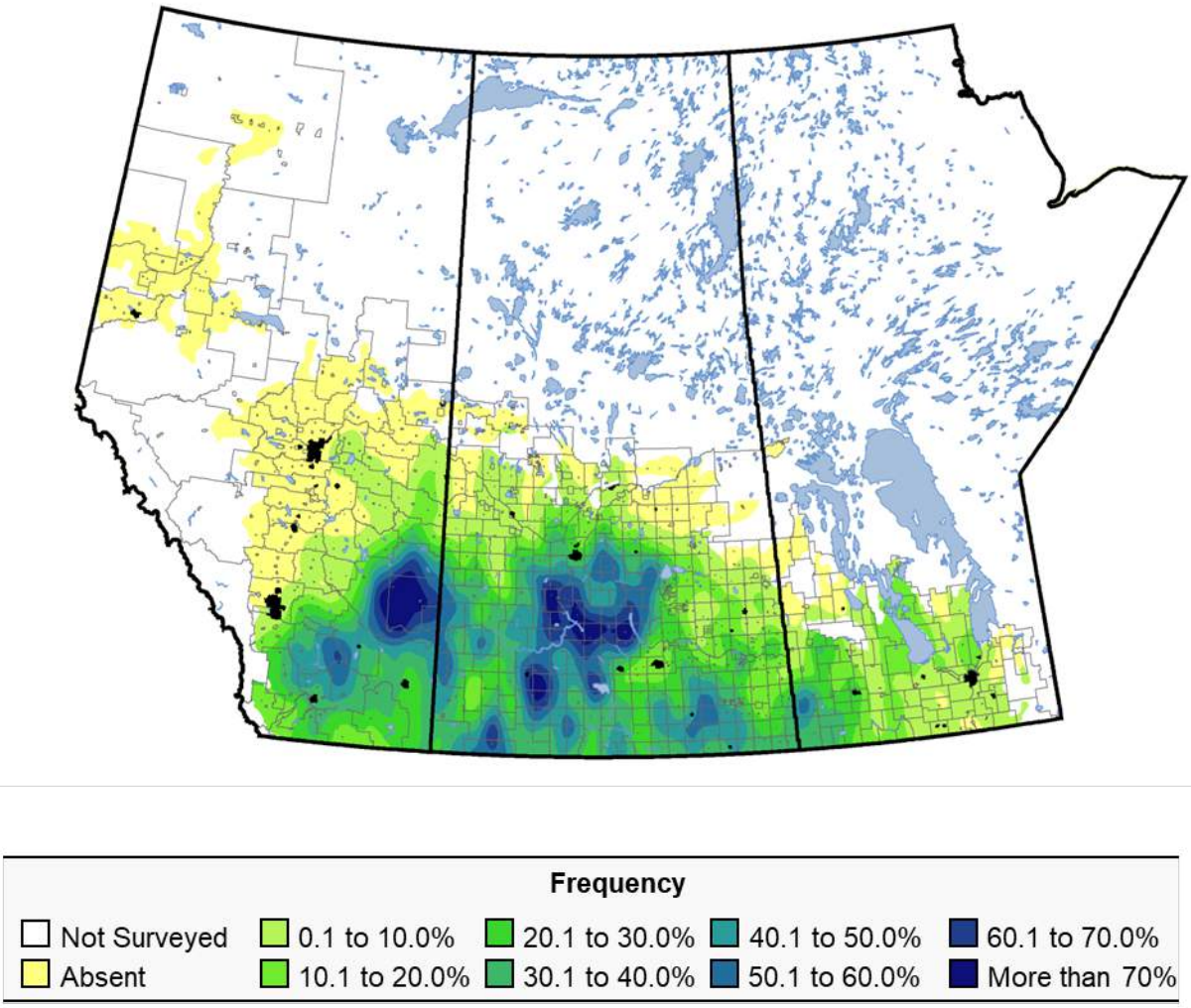

Figure B6. Distribution of kochia based 2019 to 2023 weed surveys.

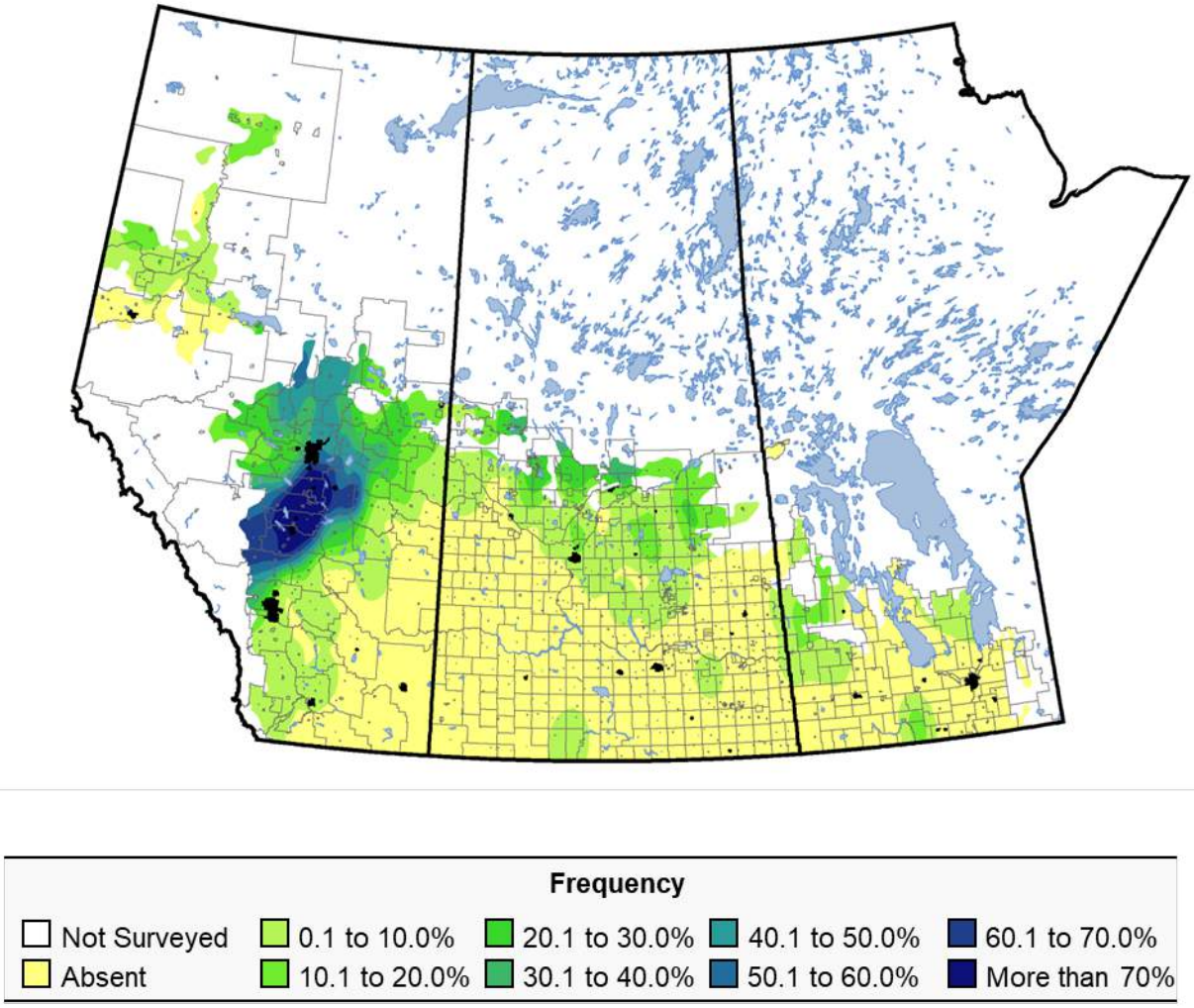

Figure B7. Distribution of chickweed based 2019 to 2023 weed surveys.

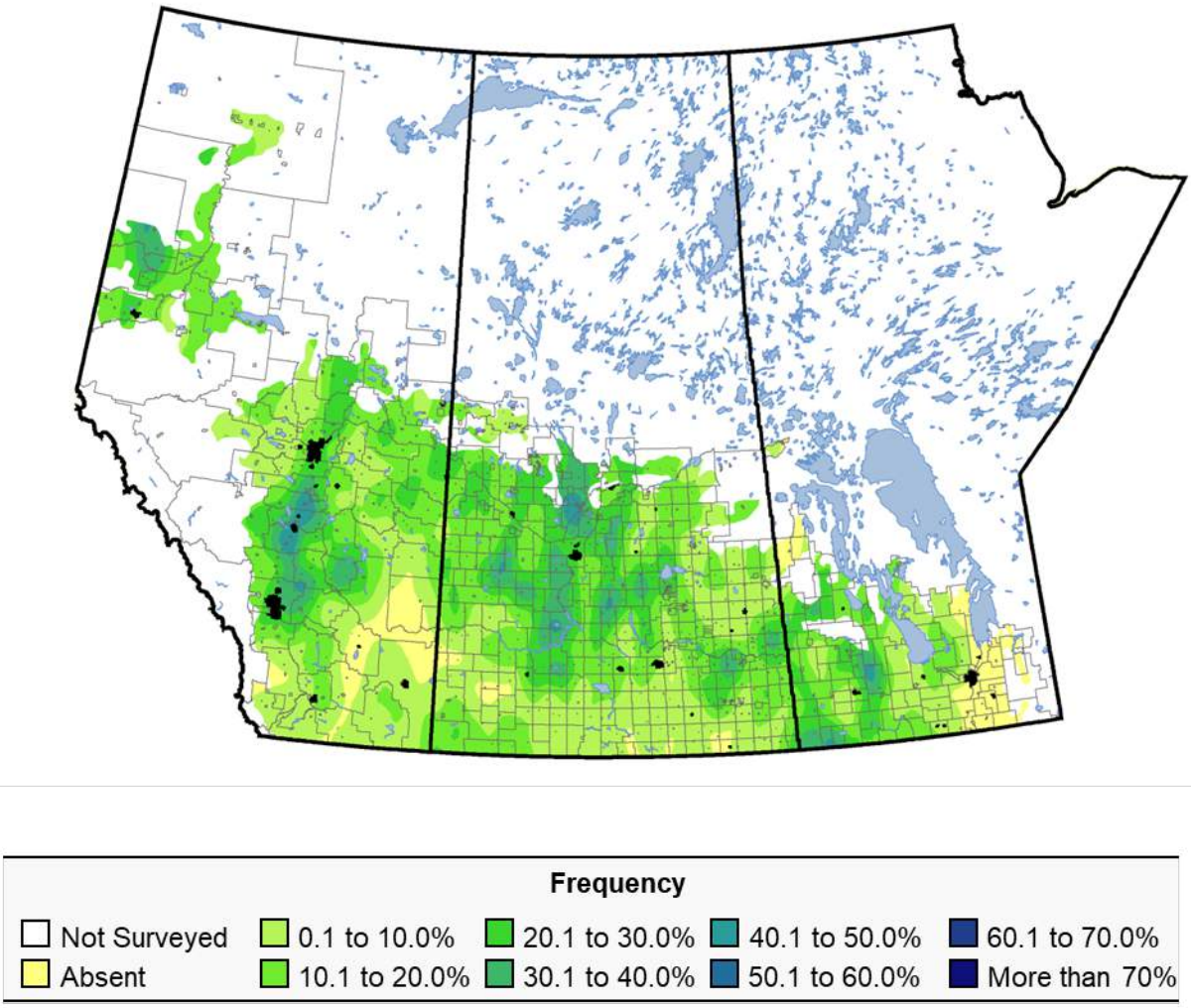

Figure B8. Distribution of volunteer wheat based 2019 to 2023 weed surveys.

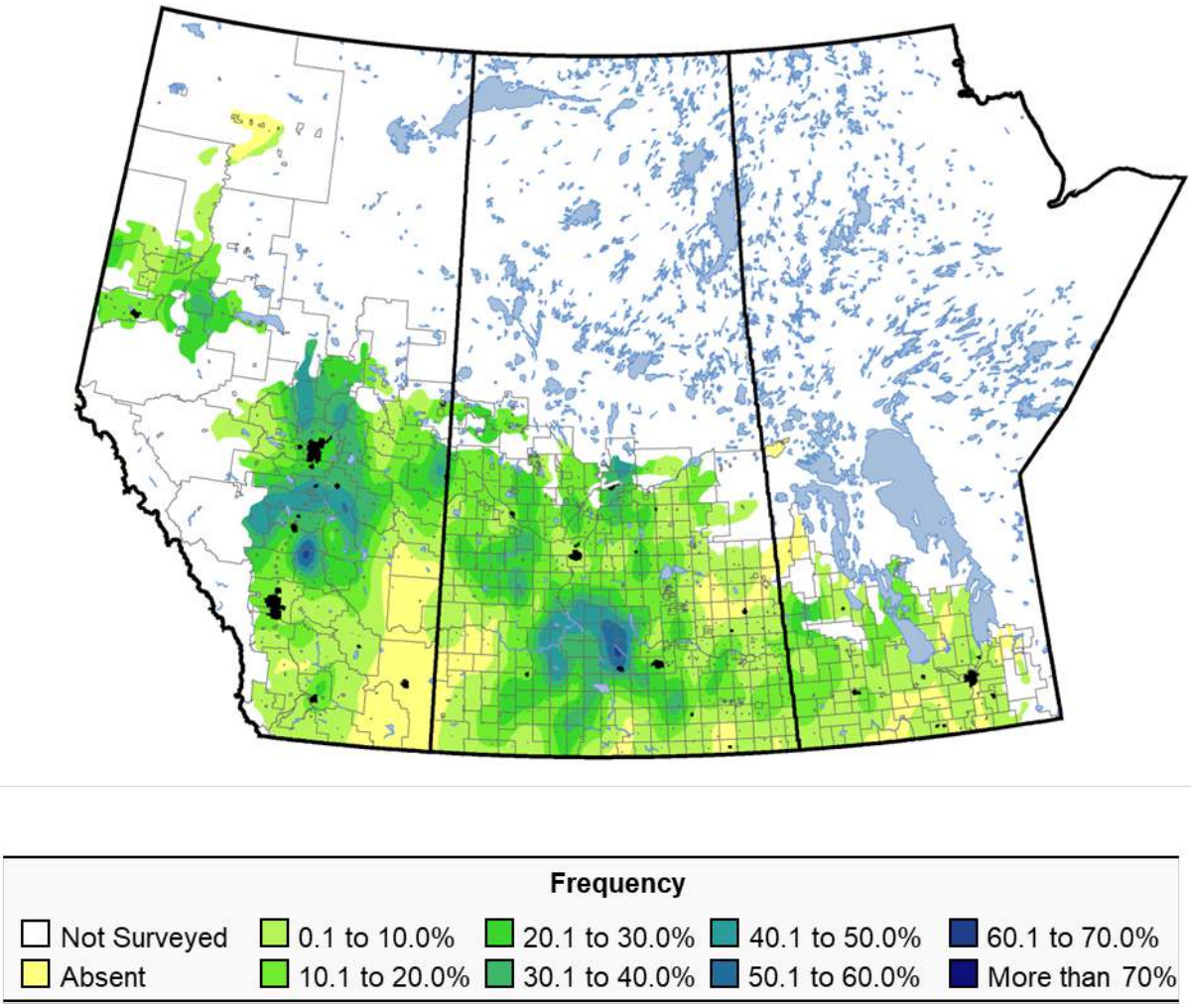

Figure B9. Distribution of spiny annual sow-thistle based 2019 to 2023 weed surveys.

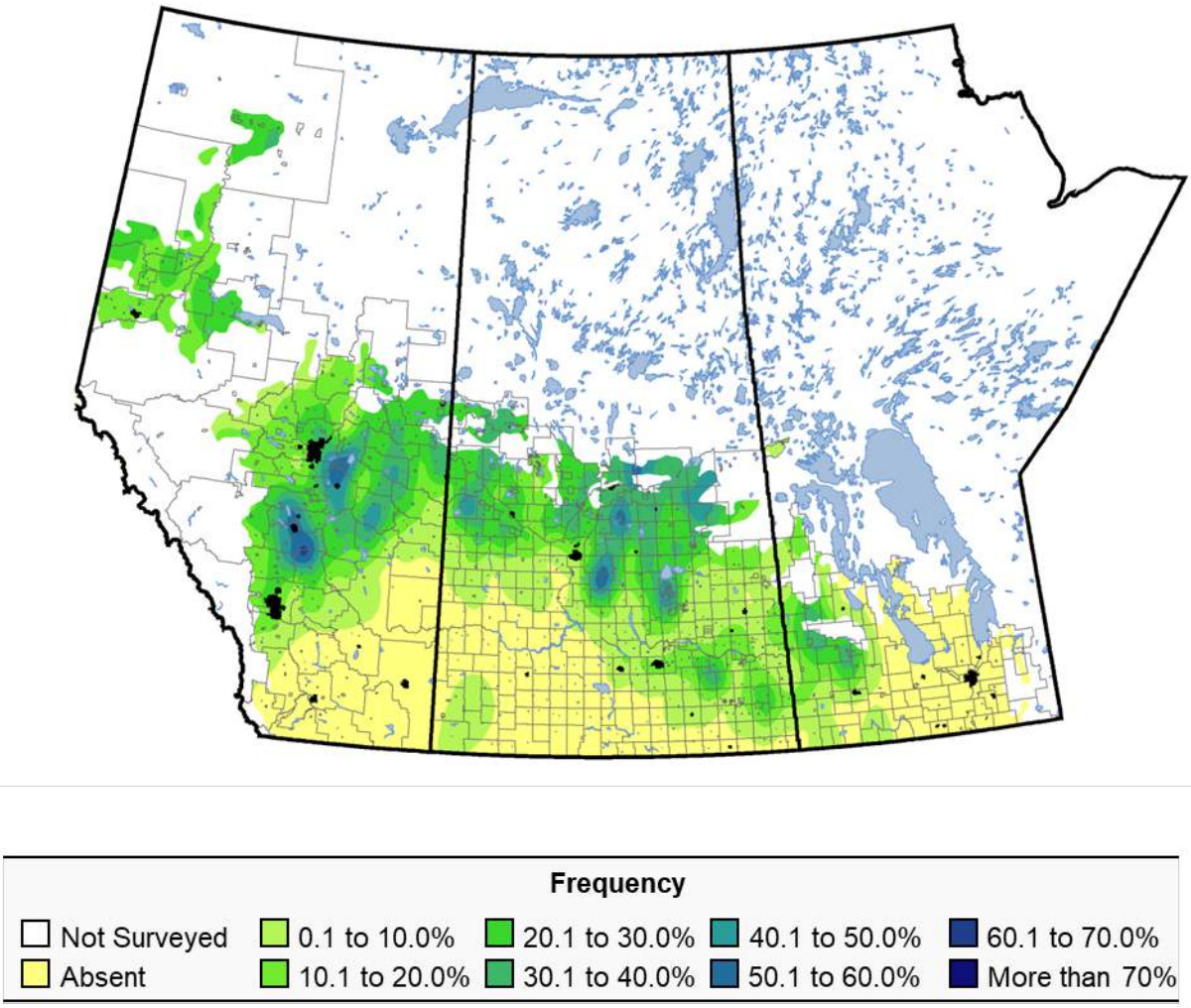

Figure B10. Distribution of false cleavers based 2019 to 2023 weed surveys.

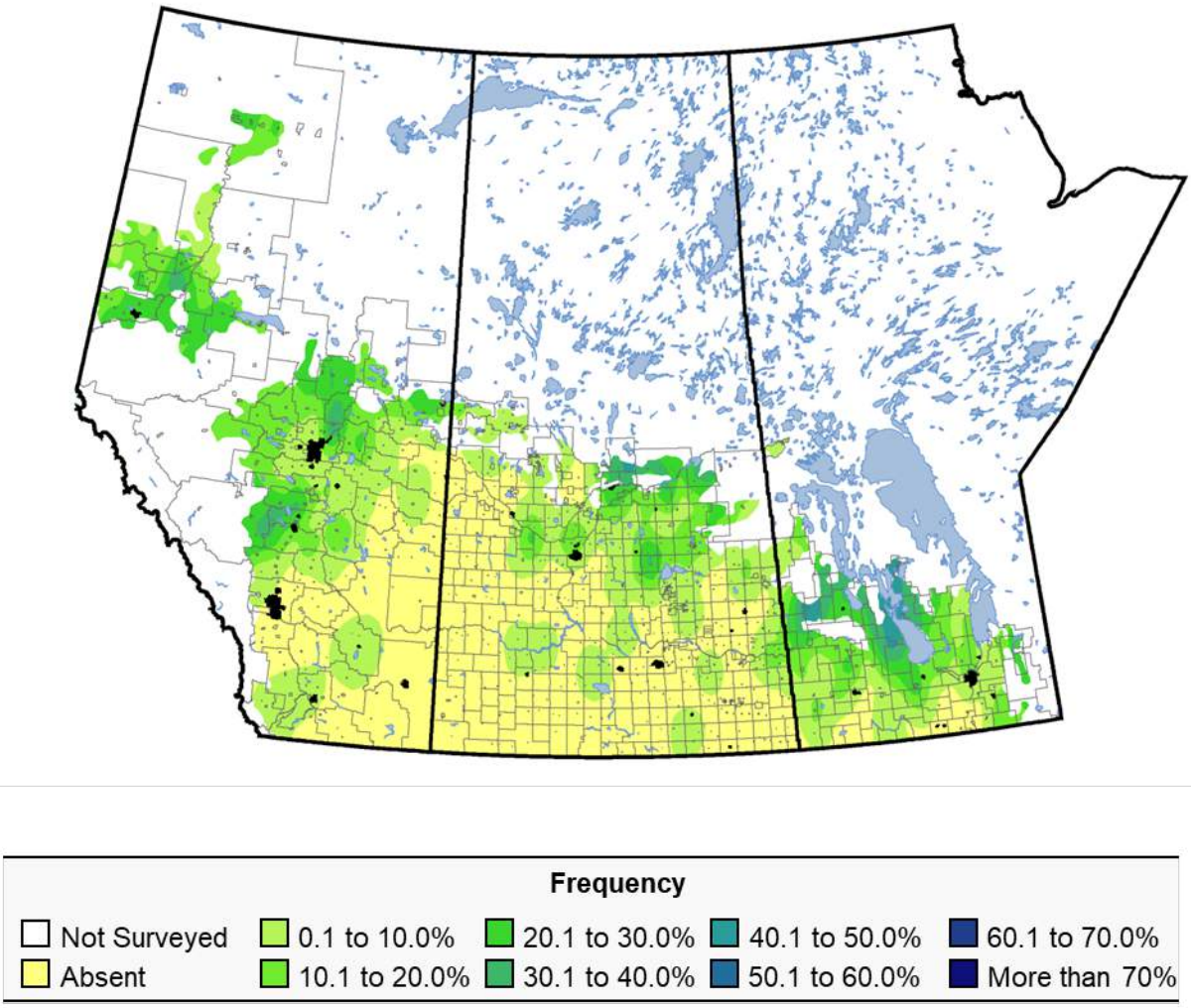

Figure B11. Distribution of broad-leaved plantain based 2019 to 2023 weed surveys.

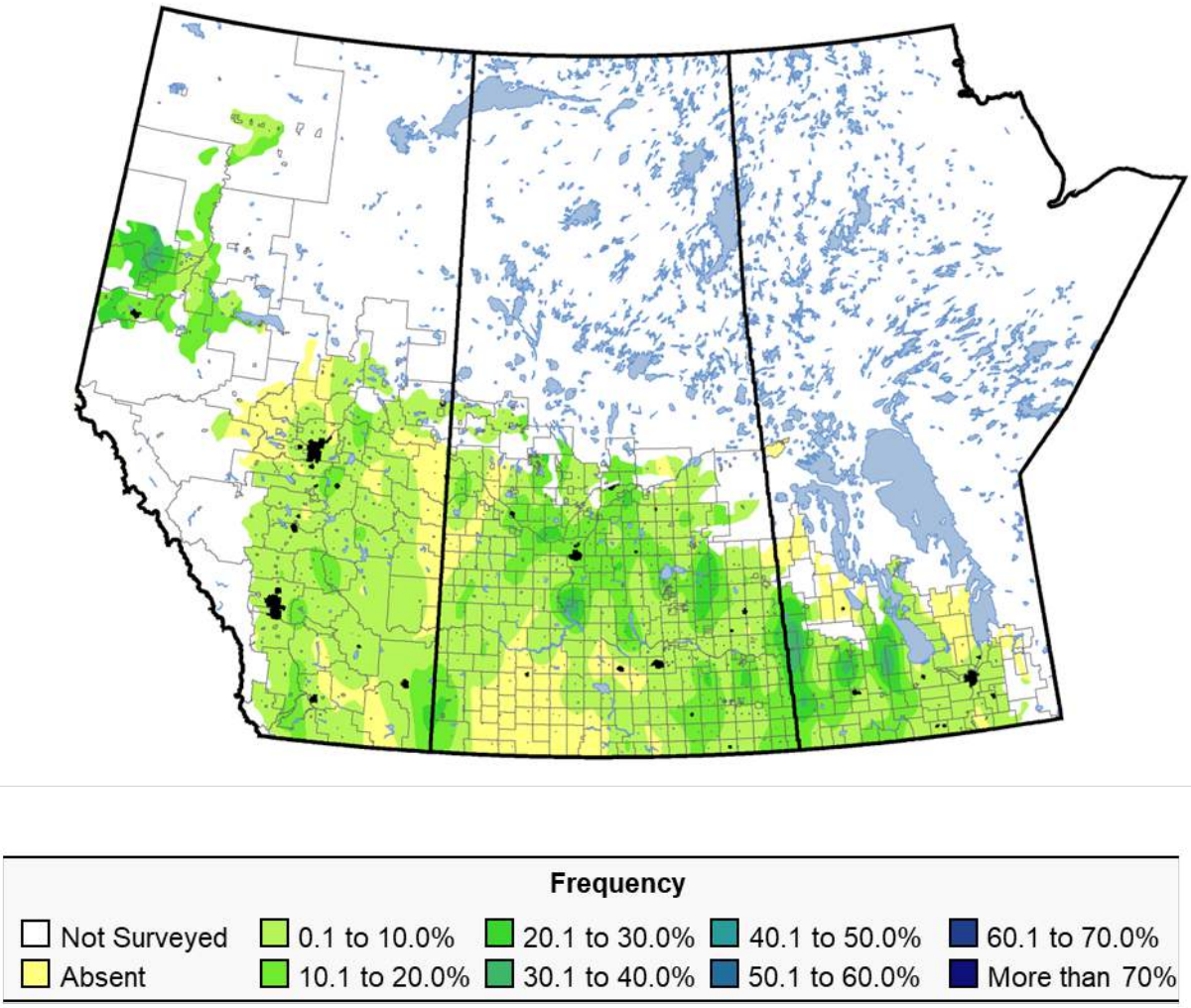

Figure B12. Distribution of foxtail barley based 2019 to 2023 weed surveys.

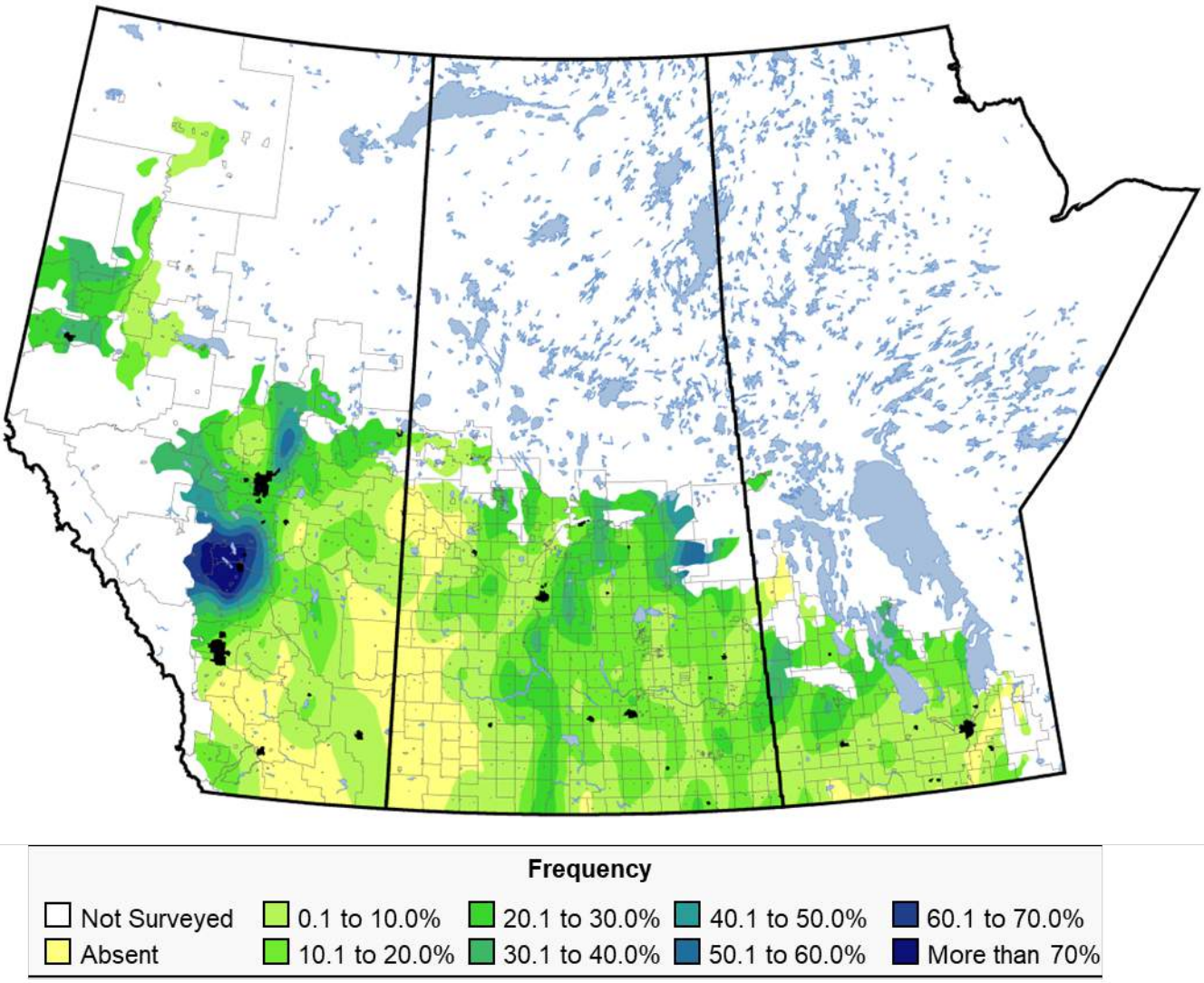

Figure B13. Distribution of dandelion based 2019 to 2023 weed surveys.

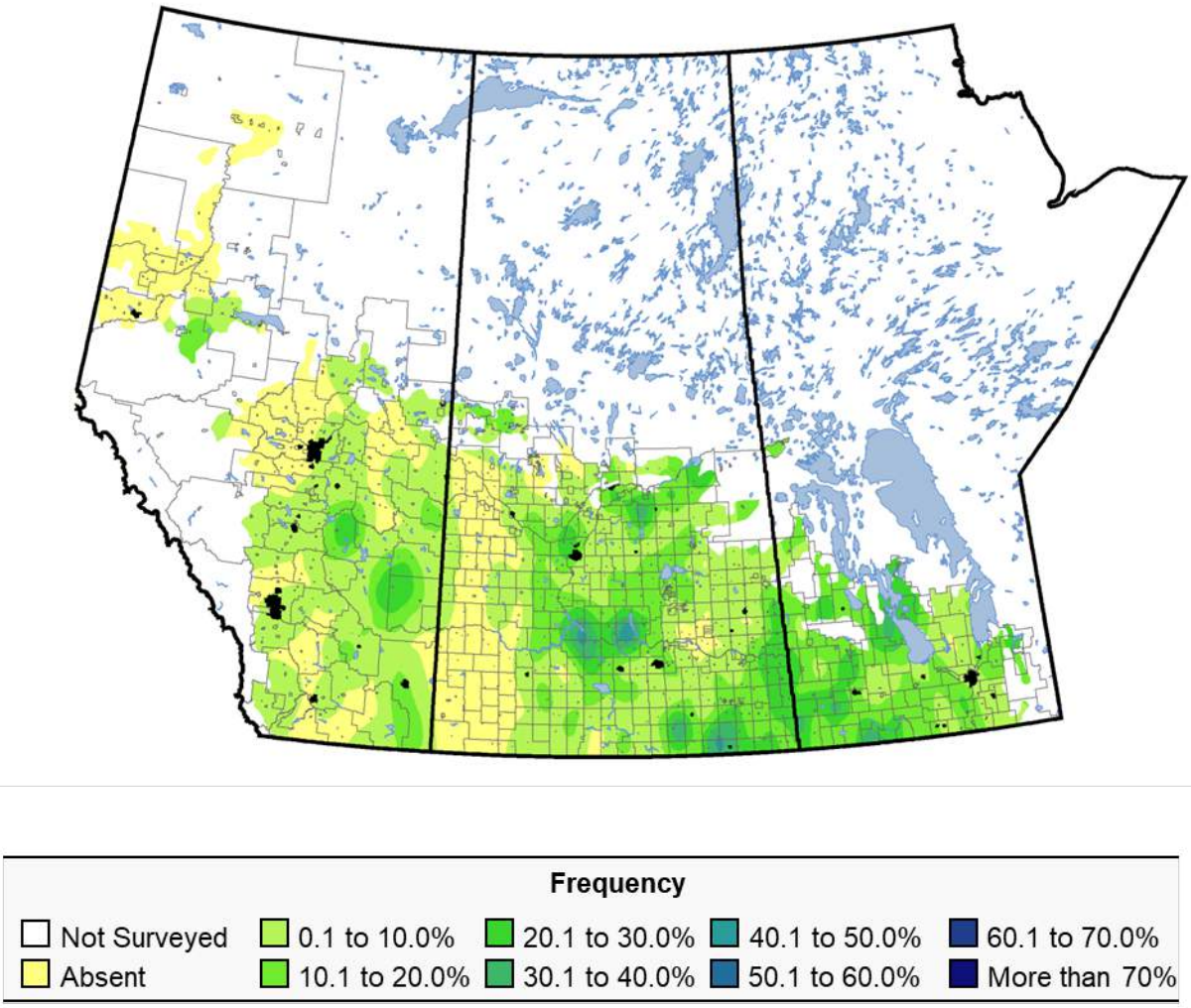

Figure B14. Distribution of barnyard grass species based 2019 to 2023 weed surveys.

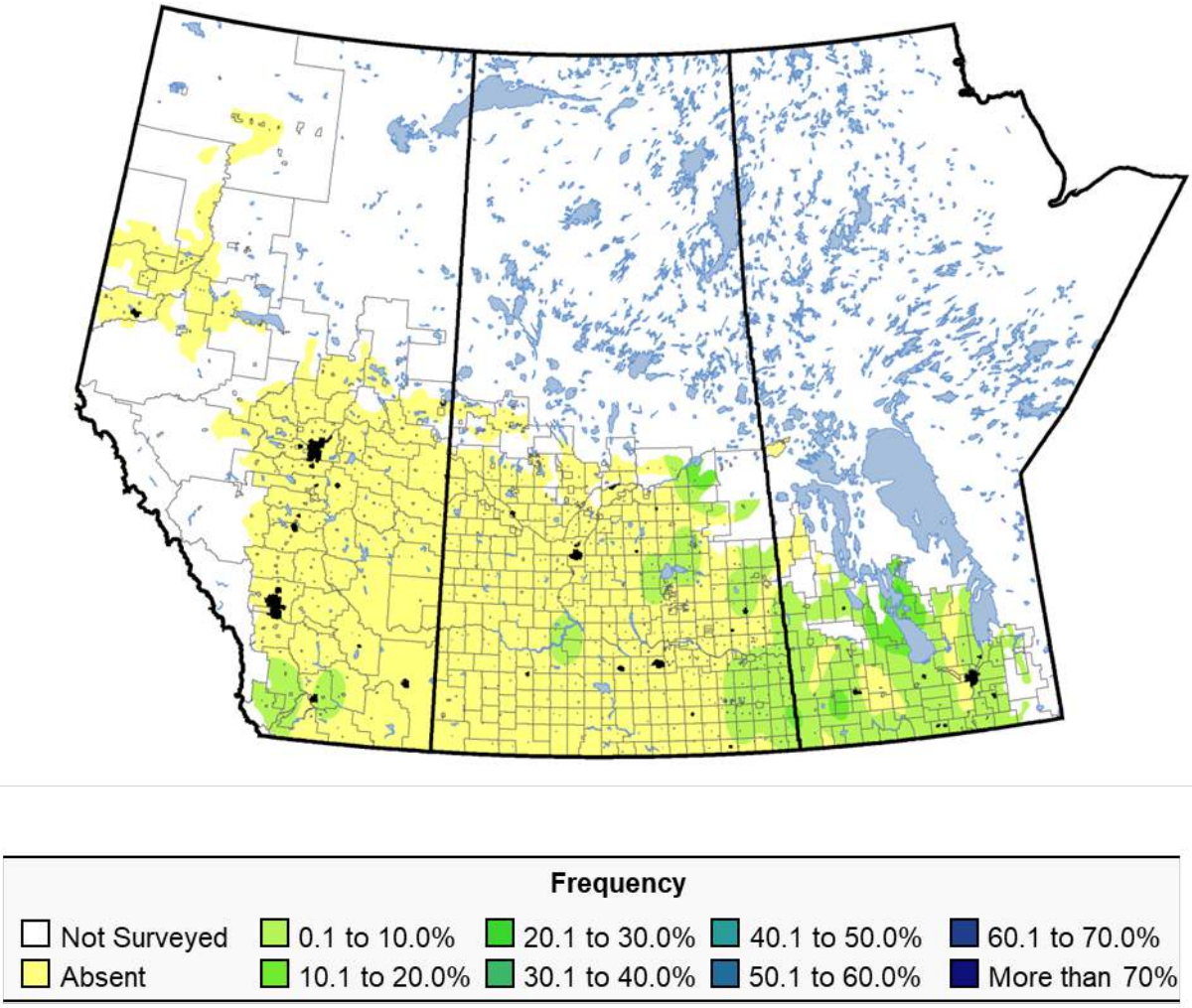

Figure B15. Distribution of barnyard grass based 2019 to 2023 weed surveys.

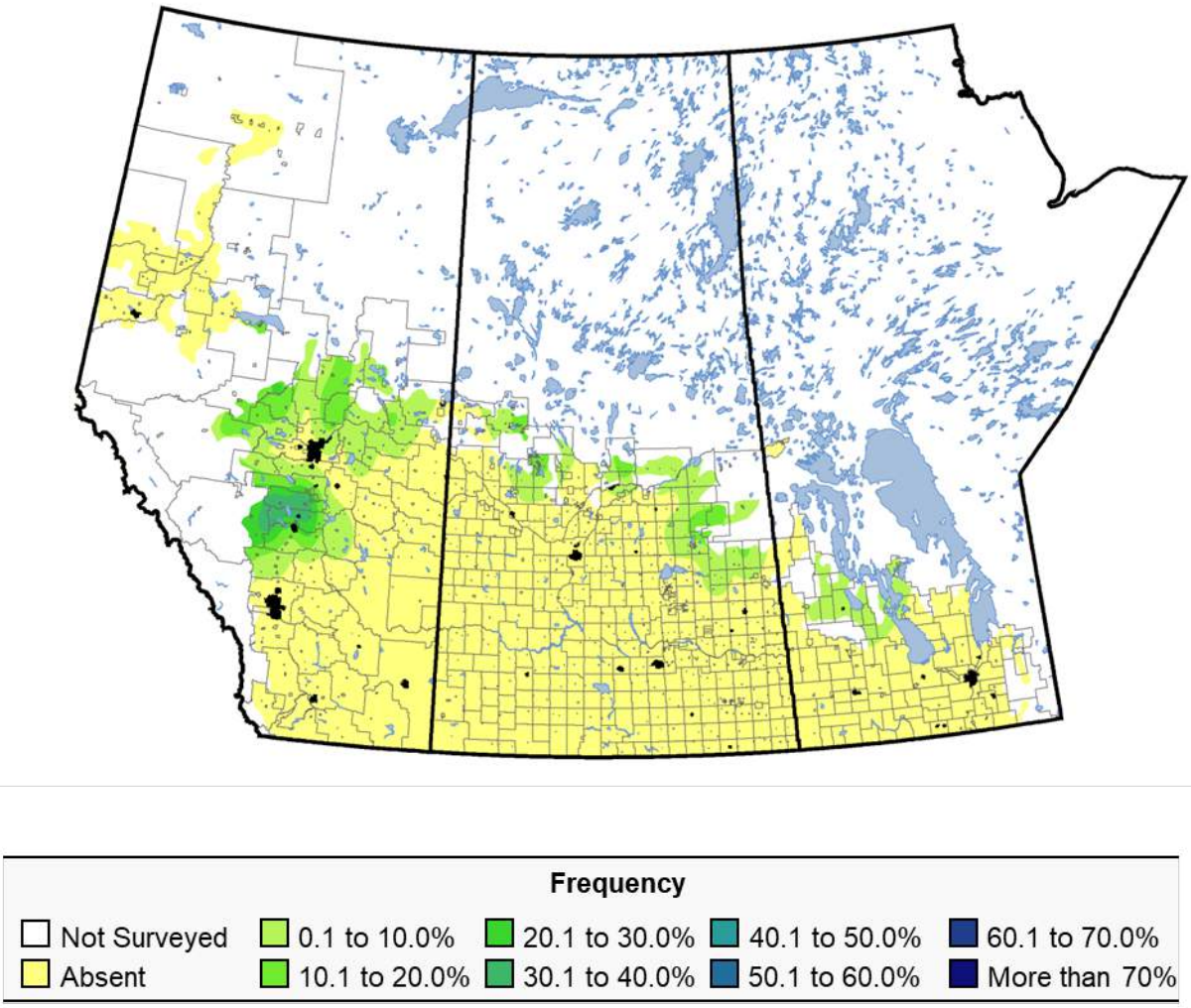

Figure B16. Distribution of annual blue grass based 2019 to 2023 weed surveys.

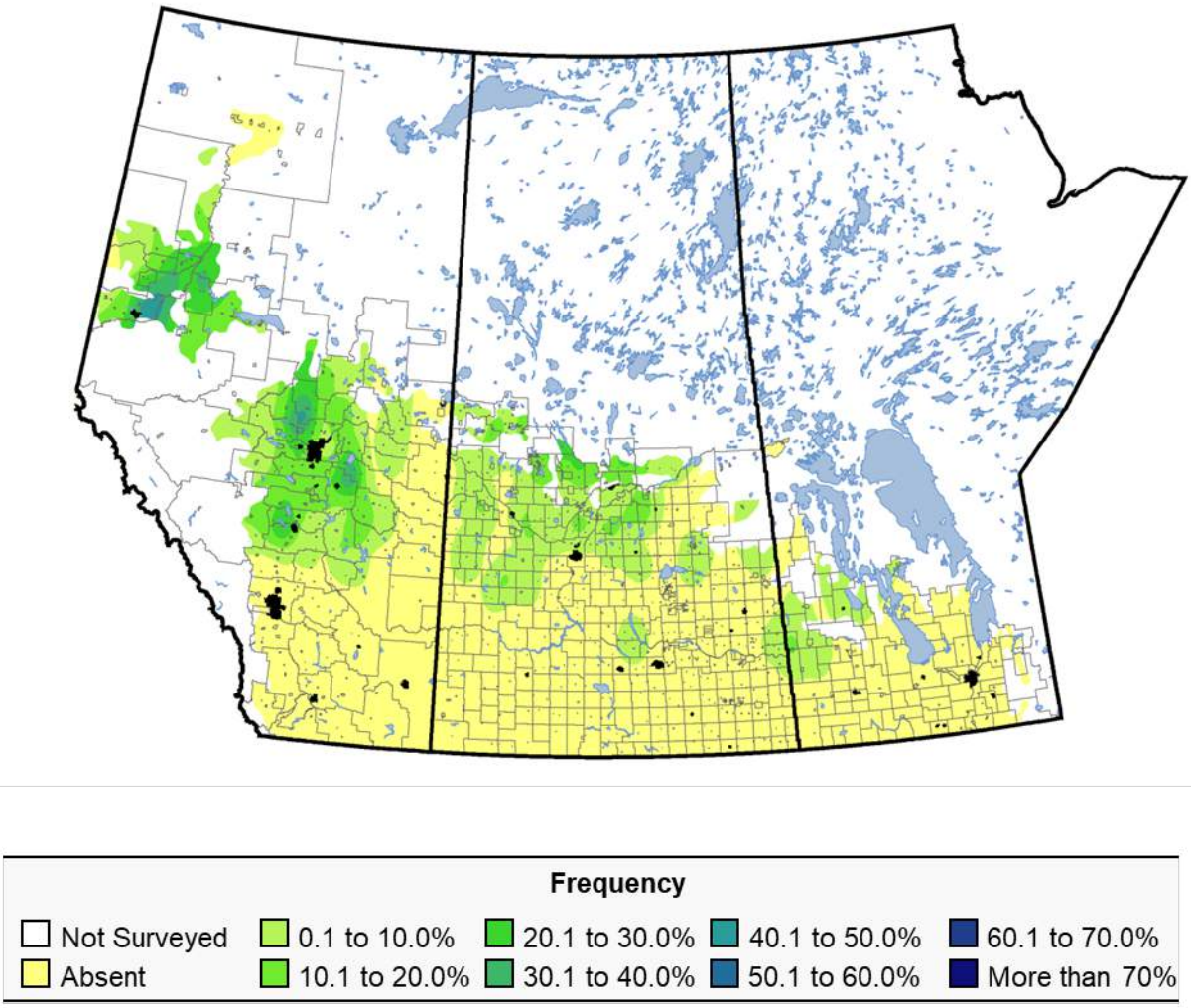

Figure B17. Distribution of low cudweed based 2019 to 2023 weed surveys.

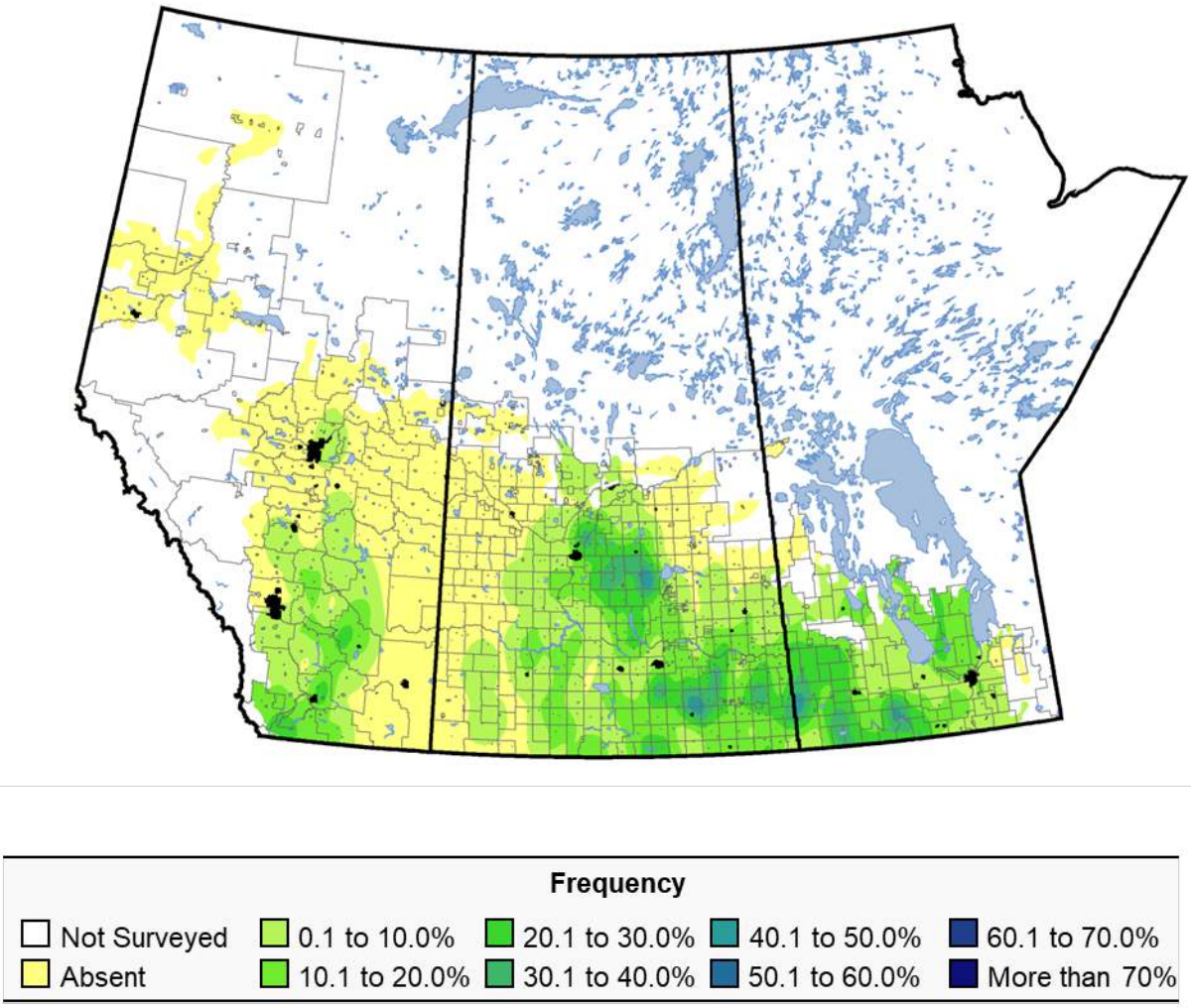

Figure B18. Distribution of round-leaved mallow based 2019 to 2023 weed surveys.

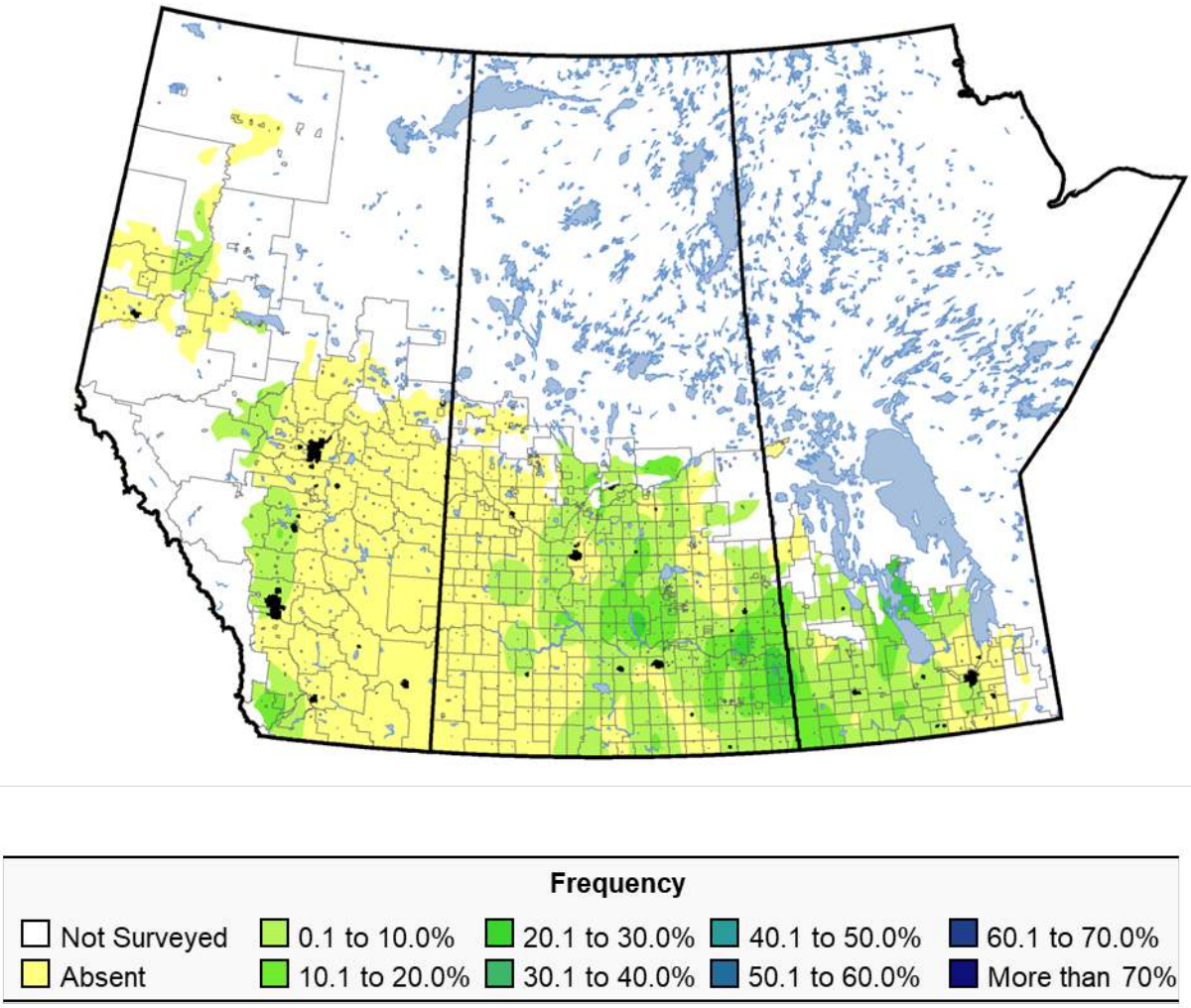

Figure B19. Distribution of black medick based 2019 to 2023 weed surveys.

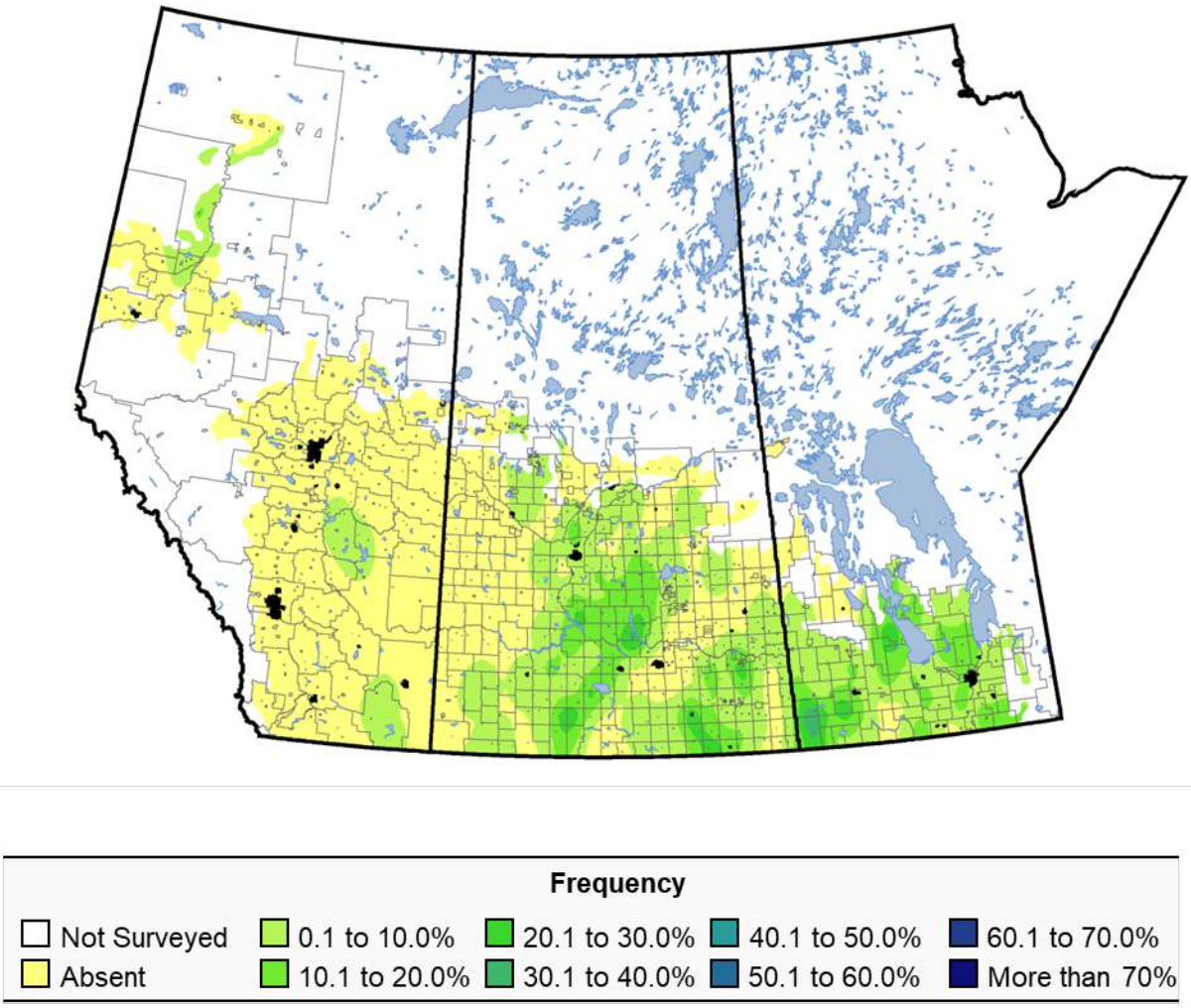

Figure B20. Distribution of biennial wormwood based 2019 to 2023 weed surveys.

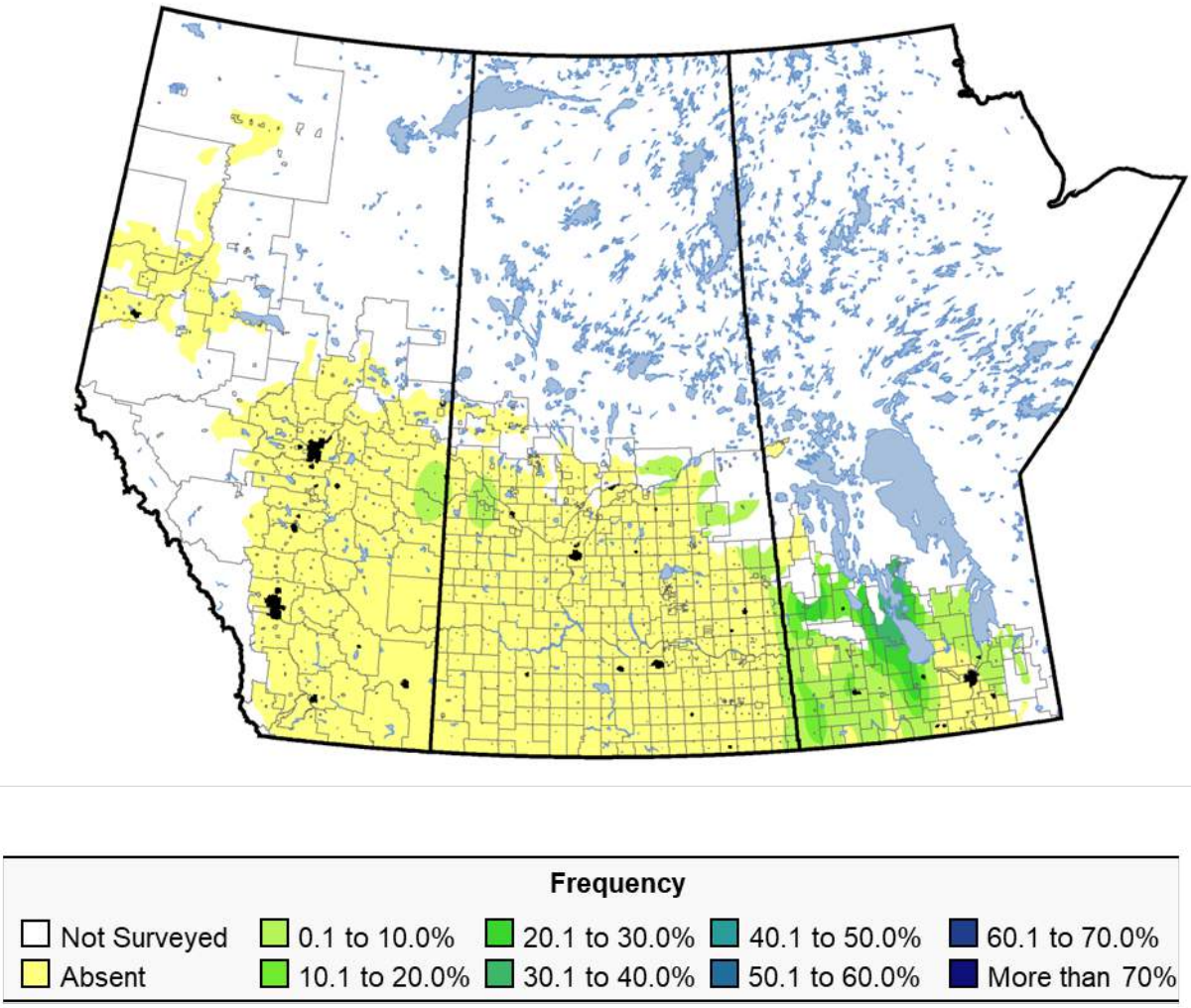

Figure B21. Distribution of golden dock based 2019 to 2023 weed surveys.

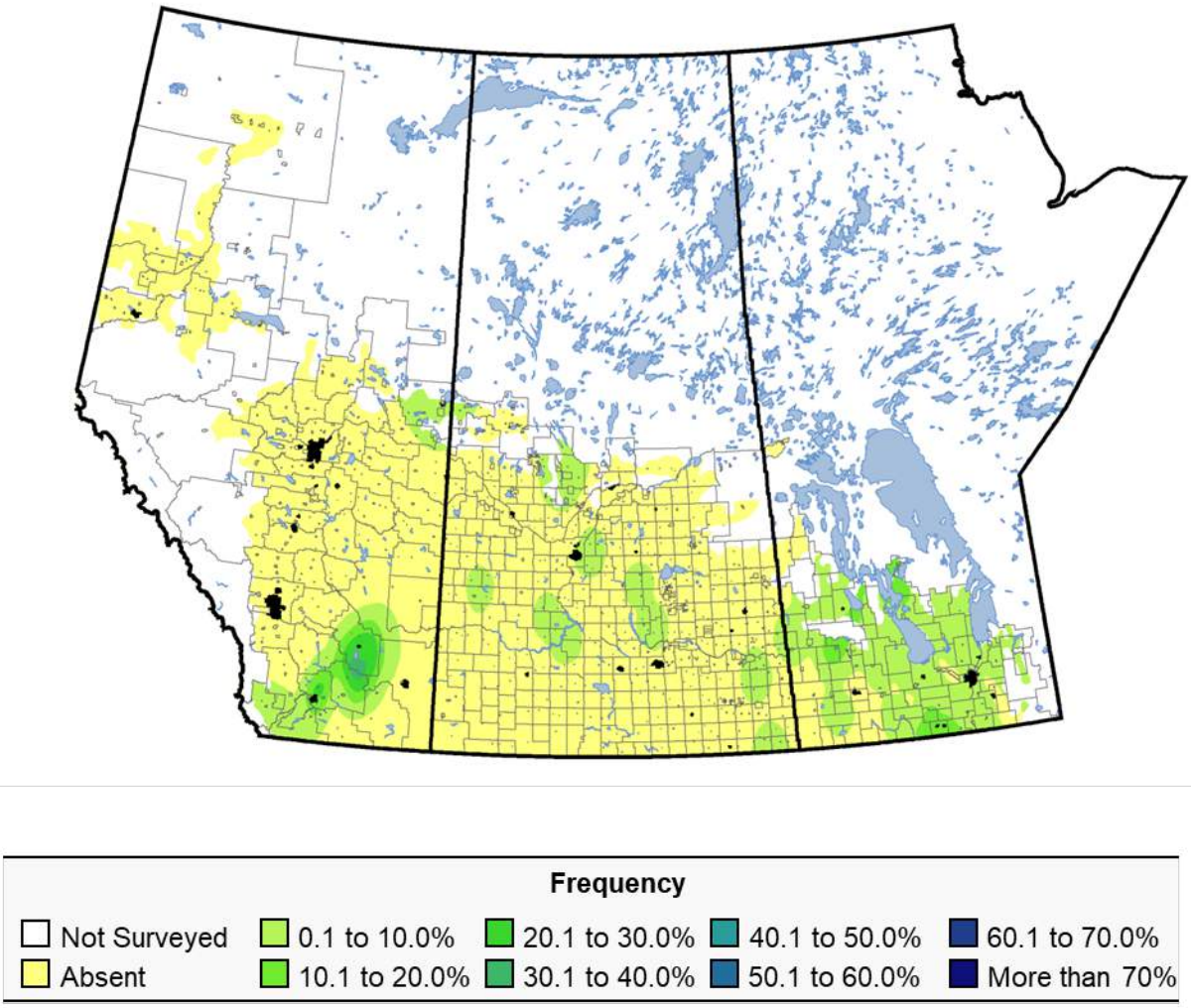

Figure B22. Distribution of green pigweed based 2019 to 2023 weed surveys.

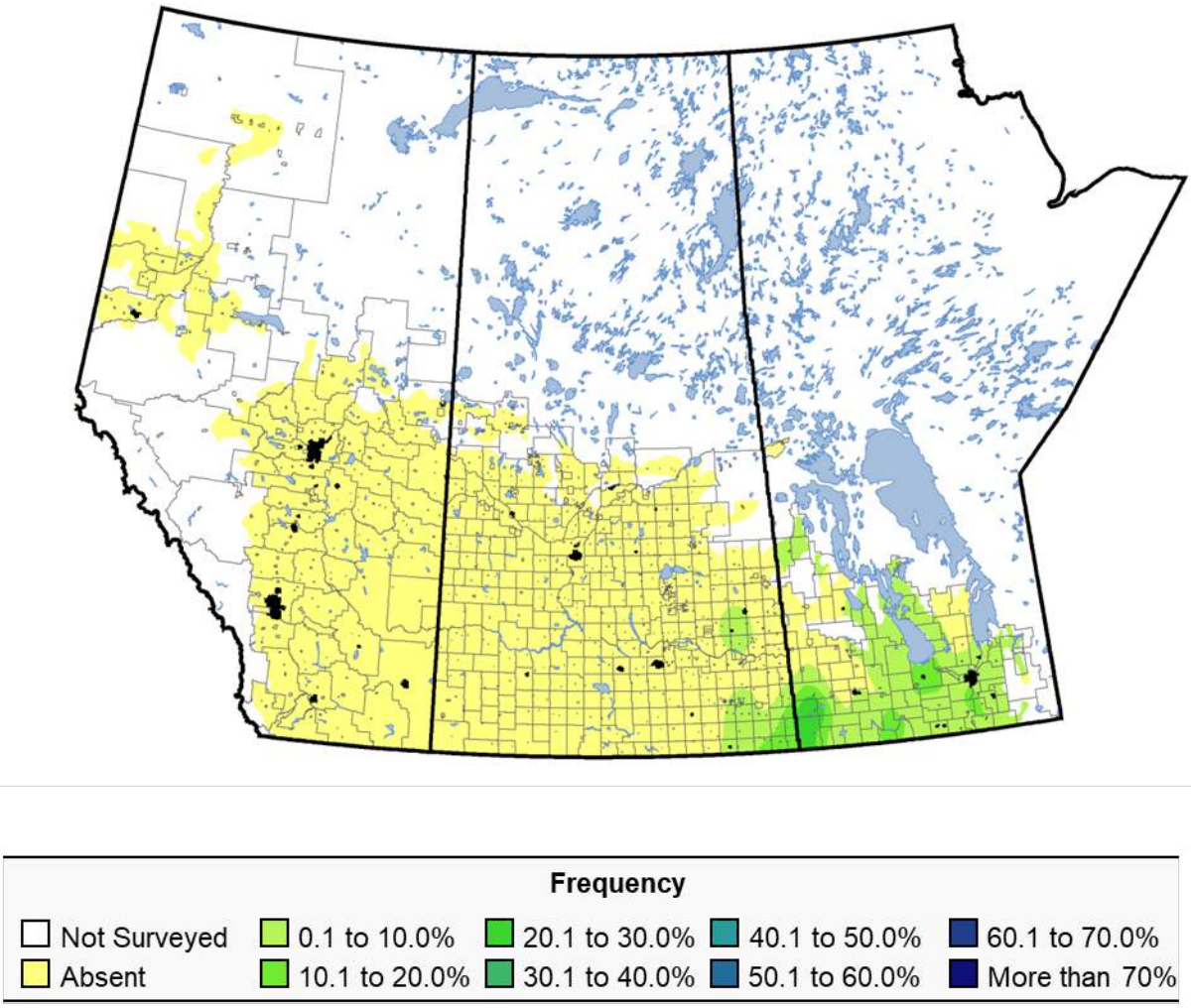

Figure B23. Distribution of yellow foxtail based 2019 to 2023 weed surveys.

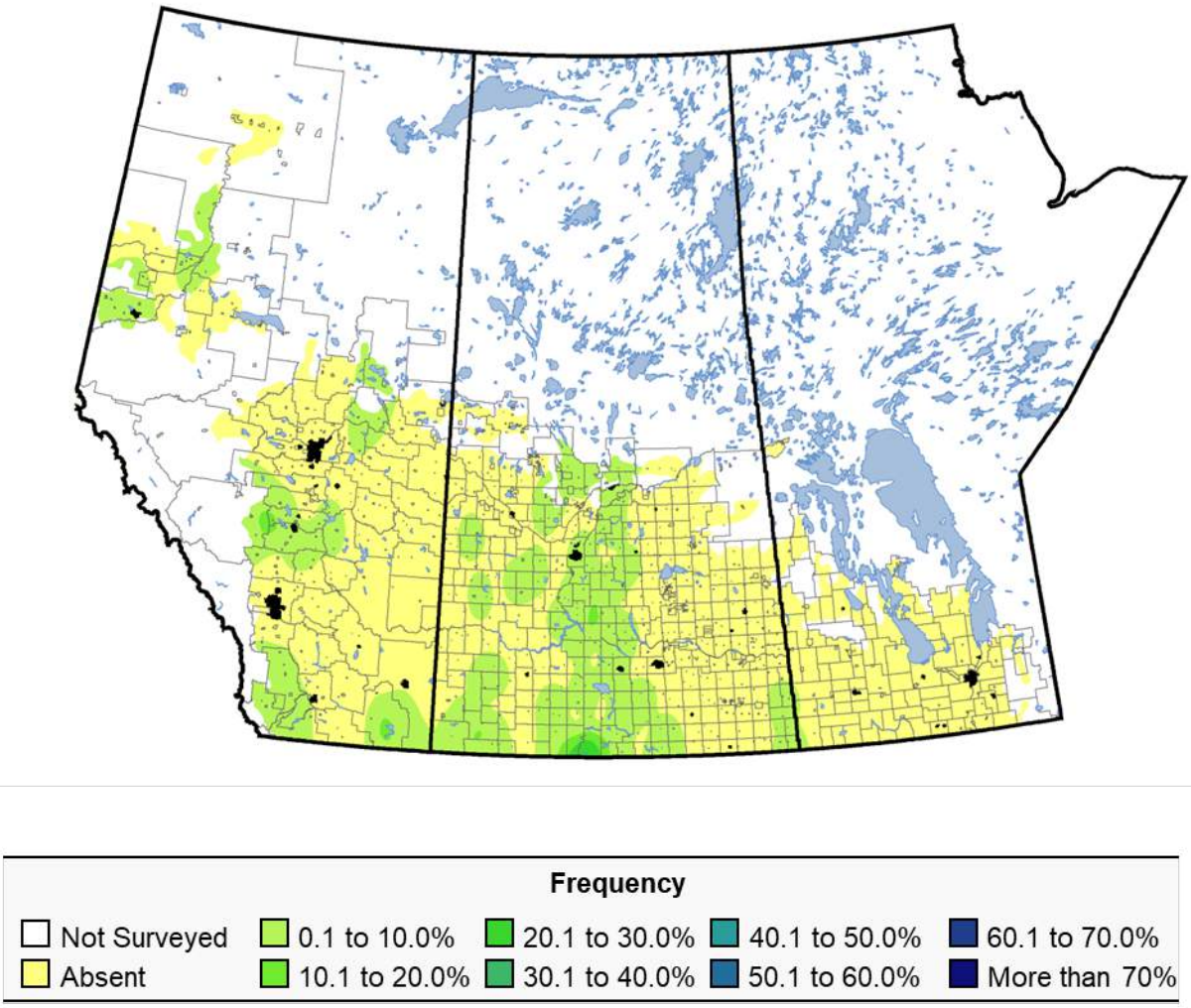

Figure B24. Distribution of annual brome species based 2019 to 2023 weed surveys.

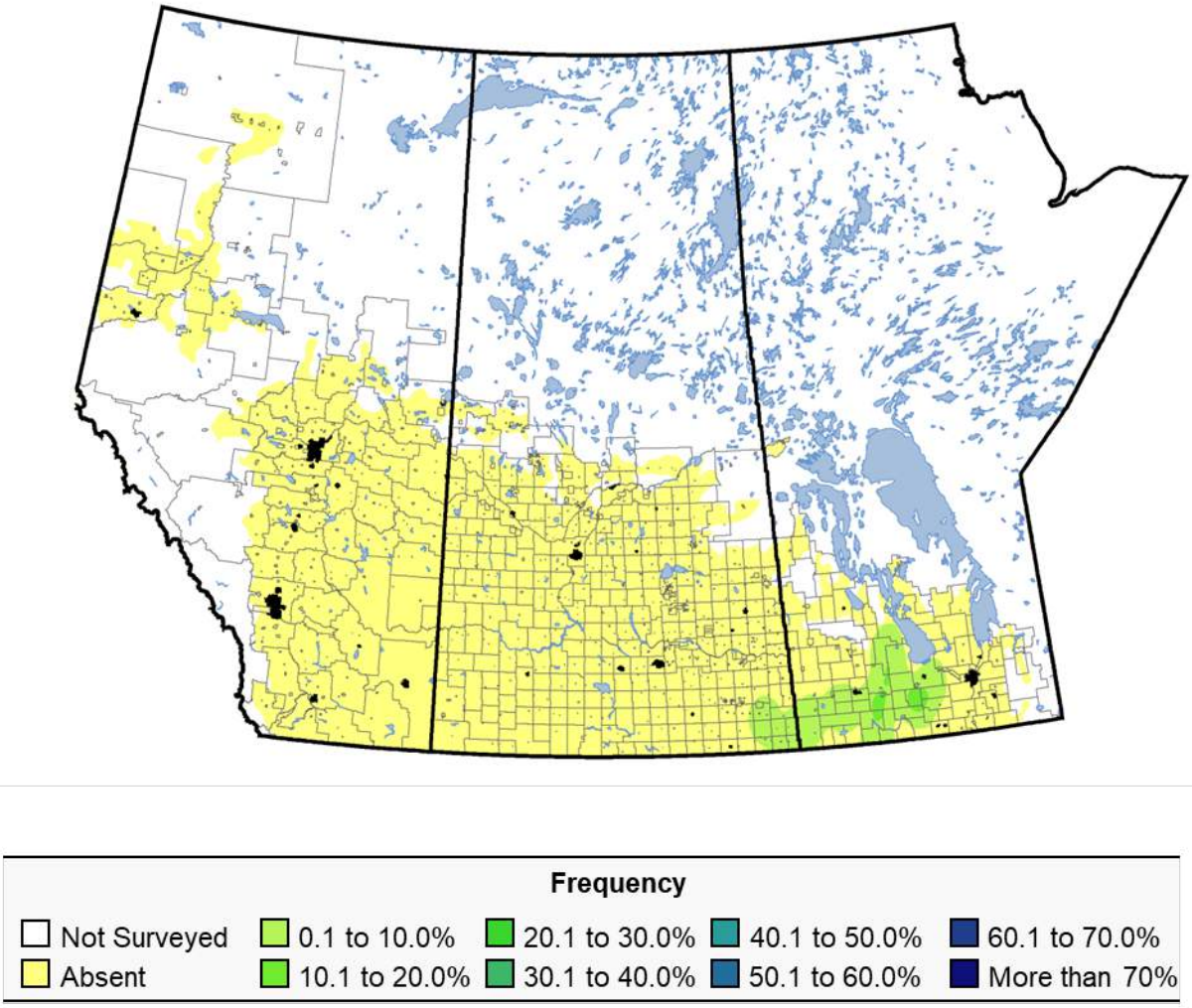

Figure B25. Distribution of stink grass based 2019 to 2023 weed surveys.

Appendix C

2019-23 Prairie-wide Weed Survey Summary Tables

Table C1. Common (Darbyshire et al. 2000) and scientific names (Brouillet et al. 2010+) of plants found in 2019-23 weed surveys

Common Name	Scientific Name
Absinth	*Artemisia absinthium* L.
Alfalfa	*Medicago sativa* L.
Alsike clover (reported with clover species)	*Trifolium hybridum* L.
American dragonhead	*Dracocephalum parviflorum* Nutt.
American stinging nettle	*Urtica dioica* subsp. *gracilis* (Aiton) Selander
American vetch (reported with vetch species)	*Vicia americana* Muhl. ex Willd. var. a*mericana*
Annual blue grass	*Poa annua* L.
Annual brome species (includes downy & Japanese brome)	*Bromus japonicus* Houtt. & *B. tectorum* L.
Annual sow-thistle	*Sonchus oleraceus* L.
Annual spurge species (includes ridge-seeded & thyme-leaved spurge)	*Euphorbia serpillifolia* Pers. & *E. glyptosperma* Engelm.
Argentine canola (reported with canola/rapeseed)	*Brassica napus* L.
Aspen poplar (reported with poplar species	*Populus tremuloides* Michx.
Aster species	*Aster* spp.
Atriplex species (includes halberd-leaved & spreading atriplex)	*Atriplex* spp.
Ball mustard	*Neslia paniculata* (L.) Desv.
Balsam poplar (reported with poplar species)	*Populus balsamifera* L.
Baltic rush (reported with rush species)	*Juncus balticus* Willd.
Barley	*Hordeum vulgare* L.
Barnyard grass (reported with barnyard grass species)	*Echinochloa crus-galli* (L.) P.Beauv.
Barnyard grass species (includes barnyard grass & western barnyard grass)	*Echinochloa crus-galli* (L.) P.Beauv. & *E. muricata var. microstachya* Wiegand
Berseem clover (reported with clover species)	*Trifolium alexandrinum* L.
Bicknell's geranium (includes Carolina geranium)	*Geranium bicknellii* Britton
Biennial cinquefoil (reported with rough cinquefoil)	*Potentilla biennis* Greene
Biennial wormwood	*Artemisia biennis* Willd.
Bifid-lip hemp-nettle (reported with hemp-nettle)	*Galeopsis bifida* Boenn.
Bird's-eye speedwell (includes field speedwell)	*Veronica persica* Poir.
Black medick	*Medicago lupulina* L.
Black nightshade (reported with nightshade species)	*Solanum nigrum* L.
Bladder campion	*Silene vulgaris* (Moench) Garcke
Blue grass species (includes Kentucky blue grass)	*Poa* spp.
Blue lettuce	*Mulgedium pulchellum* (Pursh) G. Don
Blue vervain	*Verbena hastata* L.
Bluebur (includes western bluebur)	*Lappula squarrosa* (Retz.) Dumort.
Broad-leaved plantain (includes narrow-leaved plantain)	*Plantago major* L.
Brook cinquefoil (reported with rough cinquefoil)	*Potentilla rivalis* Nutt.
Buttercup species (includes celery-leaved buttercup)	*Ranunculus* spp.
Canada anemone	*Anemonastrum canadense* (L.) Mosyakin
Canada fleabane	*Erigeron canadensis* L.
Canada goldenrod (reported with goldenrod species)	*Solidago canadensis* L. var. *canadenis*
Canada thistle	*Cirsium arvense* (L.) Scop.
Canary grass	*Phalaris canariensis* L.
Canola/rapeseed (includes Argentine & Polish canola)	*Brassica napus* L. & B. rapa L.
Caragana	*Caragana arborescens* Lam.
Carolina geranium (reported with Bicknell's geranium)	*Geranium carolinianum* L.
Cattail	*Typha latifolia* L.
Celery-leaved buttercup (reported with buttercup species)	*Ranunculus sceleratus* var. *multifidus* Nutt.
Chickweed	*Stellaria media* (L.) Vill.

(Table continued on next page)

Table C1. Common and scientific names of plants found in 2019-23 weed surveys *(continued)*

Common Name	Scientific Name
Chicory	*Cichorium intybus* L.
Cicer milk-vetch (reported with milk-vetch species)	*Astragalus cicer* L.
Cleavers* (reported with false cleavers)	*Galium aparine* L.
Clover species (includes alsike, red, white, Berseem & crimson clover)	*Trifolium* spp.
Cocklebur	*Xanthium strumarium* L.
Collomia	*Collomia linearis* Nutt.
Common burdock	*Arctium minus* (Hill) Bernh.
Common groundsel	*Senecio vulgaris* L.
Common mallow (reported with round-leaved mallow)	*Malva neglecta* Wallr.
Common pepper-grass	*Lepidium densiflorum* Schrad.
Common ragweed	*Ambrosia artemisiifolia* L.
Common yarrow	*Achillea millefolium* L.
Common yellow wood-sorrel	*Oxalis dillenii* Jacq.
Coriander	*Coriandrum sativum* L.
Corn	*Zea mays* L.
Corn gromwell	*Buglossoides arvensis* (L.) I.M.Johnst.
Corn spurry	*Spergula arvensis* L.
Cow cockle	*Gypsophila vaccaria* (L.) Sm.
Crested wheat grass	*Agropyron cristatum* (L.) Gaertn.
Crimson clover (reported with clover species)	*Trifolium incarnatum* L.
Curled dock (reported with dock species)	*Rumex crispus* L.
Dandelion (includes red-seeded dandelion)	*Taraxacum officinale* F.H.Wigg.
Dock species (includes curled, serrate-valved & water dock)	R*umex* spp.
Dog mustard	*Erucastrum gallicum* (Willd.) O.E.Schultz
Dog nettle	*Urtica urens* L.
Downy brome (reported with annual brome species)	*Bromus tectorum* L.
Dudley's rush (reported with rush species)	*Juncus dudleyi* Wieg.
Durum (reported with wheat)	*Triticum durum* Desf.
Dwarf snapdragon	*Chaenorhinum minus* (L.) Lange
Erect knotweed (reported with prostrate knotweed)	*Polygonum erectum* L.
Fababean	*Vicia faba* L.
False cleavers (includes cleavers & three-petalled bedstraw)	*Galium spurium* L.
False ragweed	*Cyclachaena xanthiifolia* (Nutt.) Fresen.
Fescue species (includes red & rough fescue)	*Festuca* spp.
Field bean	*Phaseolus vulgaris* L.
Field bindweed	*Convolvulus arvensis* L.
Field horsetail (includes marsh, woodland, water & meadow horsetail)	*Equisetum arvense* L.
Field mint	*Mentha arvensis* L.
Field pea	*Pisum sativum* L.
Field speedwell (reported with bird's-eye speedwell)	*Veronica agrestis* L.
Field violet	*Viola arvensis* Murray
Flax	*Linum usitatissimum* L.
Flixweed	*Descurainia sophia* (L.) Webb ex Prantl
Foxtail barley	*Hordeum jubatum* L.
Gaping goosefoot (reported with lamb's-quarters)	*Chenopodium hians* Standl.
Garden sorrel	*Rumex acetosa* L.
Giant ragweed	*Ambrosia trifida* L.
Goat's-beard (includes meadow goat's-beard)	*Tragopogon dubius* Scop.
Golden corydalis	*Corydalis aurea* Willd.
Golden dock	*Rumex fueginus* Phil.
Golden-bean	*Thermopsis rhombifolia* (Nutt. ex Pursh) Richardson

(Table continued on next page)

Table C1. Common and scientific names of plants found in 2019-23 weed surveys *(continued)*

Common Name	Scientific Name
Goldenrod species (includes Canada goldenrod)	*Solidago* spp.
Grass-leaved stitchwort (includes stitchwort species)	*Stellaria graminea* L.
Grass-leaved water-plantain	*Alisma gramineum* Lej.
Green ash	*Fraxinus pennsylvanica* Marshall
Green foxtail	*Setaria viridis* (L.) P.Beauv.
Green needle grass	*Nassella viridula* (Trin.) Barkworth
Green pigweed (reported with redroot pigweed)	*Amaranthus powellii* S.Watson
Hairy four-o'clock	*Mirabilis albida* (Walt.) Heim.
Hairy nightshade (reported with nightshade species)	*Solanum nitidibaccatum* Bitter
Hairy vetch (reported with vetch species)	*Vicia villosa* Roth
Halberd-leaved atriplex (reported with atriplex species)	*Atriplex prostrata* Boucher ex DC.
Hedge bindweed	*Calystegia sepium* (L.) R.Br.
Hemp-nettle (includes bifid-lip hemp-nettle)	*Galeopsis tetrahit* L.
Henbit	*Lamium amplexicaule* L.
Indian mustard	*Brassica juncea* (L.) Czern.
Italian rye grass (reported with perennial rye grass)	*Lolium multiflorum* Lam.
Japanese brome (reported with annual brome species)	*Bromus japonicus* Houtt.
Japanese millet	*Echinochloa esculenta* (A.Braun) H.Scholz
Kentucky blue grass (reported with blue grass species)	*Poa pratensis* L.
Kochia	*Bassia scoparia* (L.) A.J.Scott
Lady's-thumb (reported with pale smartweed)	*Persicaria maculosa* Gray
Lamb's-quarters (includes other Chenopodium species)	*Chenopodium album* L.
Late-flowering goosefoot (reported with lamb's-quarters)	*Chenopodium strictum* Roth
Leafy spurge	*Euphorbia esula* L.
Lentils	*Lens culinaris* Medik.
Low cudweed (includes western marsh cudweed)	*Gnaphalium uliginosum* L.
Manitoba maple	*Acer negundo* L.
Marsh horsetail (reported with field horsetail)	*Equisetum palustre* L.
Marsh yellow cress	*Rorippa palustris* (L.) Besser
Meadow brome	*Bromus riparius* Rehmann
Meadow foxtail	*Alopecurus pratensis* L.
Meadow goat's-beard (reported with goat's-beard)	*Tragopogon pratensis* L.
Meadow horsetail (reported with field horsetail)	*Equisetum pratense* Ehrh.
Meadow rue species	*Thalictrum* spp.
Milk-vetch species (includes Cicer milk-vetch)	*Astragalus* spp.
Milkweed species	*Asclepias* spp.
Narrow-leaved American vetch (reported with vetch species)	*Vicia americana* Muhl. ex Willd. var. *minor* Hook.
Narrow-leaved hawk's-beard	*Crepis tectorum* L.
Narrow-leaved plantain (reported with broad-leaved plantain)	*Plantago lanceolata* L.
Net-seeded lamb's-quarters (reported with lamb's-quarters)	*Chenopodium berlandieri* var. z*schackei* (Murr) Murr ex Graebn.
Night-flowering catchfly	*Silene noctiflora* L.
Nightshade species (includes black & hairy nightshade)	*Solanum* spp.
Northern bedstraw	*Galium boreale* L.
Northern willowherb	*Epilobium ciliatum* Raf.
Nuttall's alkaligrass	*Puccinellia nuttalliana (*Schult.) Hitchc.
Oak-leaved goosefoot	*Oxybasis glauca* (L.) S.Fuentes, Uotila & Borsch
Oats	*Avena sativa* L.
Pale smartweed (includes lady's-thumb)	*Persicaria lapathifolia* (L.) Delarbre
Pasture sage	*Artemisia frigida* Willd.
Pennsylvania pellitory	*Parietaria pensylvanica* Muhl. ex Willd
Perennial rye grass (includes Italian rye grass)	*Lolium perenne* L.
Perennial sow-thistle	*Sonchus arvensis* L.

(Table continued on next page)

Table C1. Common and scientific names of plants found in 2019-23 weed surveys *(continued)*

Common Name	Scientific Name
Persian darnel	*Lolium persicum* Boiss. & Hohen. ex Boiss.
Phacelia	*Phacelia tanacetifolia* Benth.
Pin cherry	*Prunus pensylvanica* L.f.
Pineappleweed	*Matricaria discoidea* DC.
Poison suckleya	*Suckleya suckleyana* (Torr.) Rydb.
Polish canola (reported with canola/rapeseed)	*Brassica rapa* L.
Poplar species (includes aspen & balsam poplar)	*Populus* spp.
Povertyweed	*Iva axillaris* Pursh
Prairie rose (reported with rose species)	*Rosa arkansana* Porter
Prairie sunflower (reported with sunflower)	*Helianthus petiolaris* Nutt.
Prickly lettuce	*Lactuca serriola* L.
Prickly rose (reported with rose species)	*Rosa acicularis* Lindl.
Proso millet	*Panicum miliaceum* L.
Prostrate knotweed (includes erect and striate knotweed)	*Polygonum aviculare* L.
Prostrate pigweed	*Amaranthus blitoides* S.Watson
Purslane	*Portulaca oleracea* L.
Purslane speedwell	*Veronica peregrina* L.
Pygmyflower	*Androsace septentrionalis* L.
Quack grass	*Elymus repens* (L.) Gould
Rayless aster	*Symphyotrichum ciliatum* (Ledeb.) G.L.Nesom
Red clover (reported with clover species)	*Trifolium pratense* L.
Red fescue (reported with fescue species)	*Festuca rubra* L.
Red goosefoot	*Oxybasis rubra* (L.) S.Fuentes, Uotila & Borsch
Redroot pigweed (includes green pigweed)	*Amaranthus retroflexus* L.
Red-seeded dandelion (reported with dandelion)	*Taraxacum erythrospermum* Andrz
Reed canary grass	*Phalaris arundinacea* L.
Ridge-seeded spurge (reported with annual spurge species)	*Euphorbia glyptosperma* Engelm.
Rose species (includes prairie & prickly rose)	*Rosa* spp.
Rough cinquefoil (includes brook and biennial cinquefoil)	*Potentilla norvegica* L.
Rough fescue (reported with fescue species)	*Festuca campestris* Rydb.
Rough hair grass	*Agrostis scabra* Willd.
Round-leaved mallow (includes common mallow)	*Malva pusilla* Sm.
Rush species (includes Baltic, Dudley's & Vasey's rush)	*Juncus* spp.
Russian pigweed	*Axyris amaranthoides* L.
Russian thistle (includes slender Russian thistle)	*Kali tragus* (L.) Scop.
Rye	*Secale cereale* L.
Scentless chamomile	*Tripleurospermum inodorum* (L.) Sch.Bip.
Scouring-rush (includes smooth & variegated scouring-rush)	*Equisetum hyemale* L.
Sedge species	*Carex* spp.
Serrate-valved dock (reported with dock species)	*Rumex stenophyllus* Ledeb.
Shepherd's-purse	*Capsella bursa-pastoris* (L.) Medik.
Siberian elm	*Ulmus pumila* L.
Silverweed	*Argentina anserina* (L.) Rydb. subsp. *anserina*
Skeletonweed	*Lygodesmia juncea* (Pursh) D.Don ex Hook.
Slender Russian thistle (reported with Russian thistle)	*Kali collinum* (Pall.) Akhani & Roalson
Slim-leaved goosefoot (reported with lamb's-quarters)	*Chenopodium leptopyllum* (Moq.) Nutt. ex S.Watson
Slim-leaved lamb's-quarters (reported with lamb's-quarters)	*Chenopodium pratericola* Rydb.
Slough grass	*Beckmannia syzigachne* (Steud.) Fernald
Small alyssum	*Alyssum alyssoides* (L.) L.
Small-leaved lamb's-quarters	*Chenopodium desiccatum* A.Nelson
Smooth brome	*Bromus inermis* Leyss.
Smooth scouring-rush (reported with scouring-rush)	*Equisetum laevigatum* A.Braun
Soybean	*Glycine max* (L.) Merr.

(Table continued on next page)

Table C1. Common and scientific names of plants found in 2019-23 weed surveys *(continued)*

Common Name	Scientific Name
Spear-leaved goosefoot	*Blitum nuttallianum* Schult.
Spike-rush species	*Eleocharis* spp.
Spiny annual sow-thistle	*Sonchus asper* (L.) Hill
Spreading alkaligrass	*Puccinellia distans* (Jacq.) Parl.
Spreading atriplex (reported with atriplex species)	*Atriplex patula* L.
Spreading dogbane	*Apocynum androsaemifolium* L.
Stink grass	*Eragrostis cilianensis* (All.) Vignolo ex Janch.
Stinkweed	*Thlaspi arvense* L.
Stitchwort species (reported with grass-leaved stitchwort)	*Stellaria* spp.
Stork's bill	*Erodium cicutarium* (L.) L'Hér. ex Aiton
Striate knotweed (reported with prostrate knotweed)	*Polygonum achoreum* S.F.Blake
Sunflower (includes prairie sunflower)	*Helianthus annuus* L.
Sweet-clover species (includes white & yellow sweet-clover)	*Melilotus officinalis* (L.) Lam. & M. albus Medik.
Tall hedge mustard	S*isymbrium loeselii* L.
Tansy	*Tanacetum vulgare* L.
Tartary buckwheat	*Fagopyrum tataricum* (L.) Gaertn.
Three-petalled bedstraw (reported with false cleavers)	*Galium trifidum* L.
Thyme-leaved sandwort	*Arenaria serpyllifolia* L.
Thyme-leaved spurge (reported with annual spurge species)	*Euphorbia serpillifolia* Pers.
Timothy	*Phleum pratense* L.
Toad rush	*Juncus bufonius* L.
Triticale	*Triticale hexaploide* Lart.
Tufted vetch (reported with vetch species)	*Vicia cracca* L.
Tumble mustard	*Sisymbrium altissimum* L.
Tumble pigweed	*Amaranthus albus* L.
Umbellate hawkweed	*Hieracium umbellatum* L.
Variegated scouring-rush (reported with scouring-rush)	*Equisetum variegatum* Schleich. ex F.Weber & D.Mohr
Vasey's rush (reported with rush species)	*Juncus vaseyi* Engelm.
Vetch species (includes American, narrow-leaved American, hairy & tufted vetch)	*Vicia* spp.
Water dock (reported with dock species)	*Rumex britannica* L.
Water horsetail (reported with field horsetail)	*Equisetum fluviatile* L.
Water mudwort	*Limosella aquatica* L.
Water smartweed	*Persicaria amphibia* var. st*ipulacea* (N.Coleman) H.Hara
Watson's goosefoot (reported with lamb's-quarters)	*Chenopodium watsonii* A.Nelson
Western barnyard grass (reported with barnyard grass spp.)	*Echinochloa muricata* var. *microstachya* Wiegand
Western bluebur (reported with bluebur)	*Lappula occidentalis* (S.Watson) Greene
Western marsh cudweed (reported with low cudweed)	*Gnaphalium palustre* Nutt.
Western sea-blite	*Suaeda calceoliformis* (Hook.) Moq.
Wheat (includes durum)	*Triticum aestivum* L.
White clover (reported with clover species)	*Trifolium repens* L.
White cockle	*Silene latifolia* Poir.
White mustard	*Sinapis alba* L.
White sweet-clover (reported with sweet-clover species)	*Melilotus albus* Medik.
Wild buckwheat	*Fallopia convolvulus* (L.) Á.Löve
Wild chamomile	*Matricaria chamomilla* L.
Wild licorice	*Glycyrrhiza lepidota* Pursh
Wild mustard	*Sinapis arvensis* L.
Wild oats	*Avena fatua* L.
Wild radish	*Raphanus raphanistrum* L.
Wild tomato	*Solanum triflorum* Nutt.

(Table continued on next page)

Table C1. Common and scientific names of plants found in 2019-23 weed surveys *(continued)*

Common Name	Scientific Name
Willow species	*Salix* spp.
Witch grass	*Panicum capillare* L.
Wood sage	*Salvia nemorosa* L.
Wood whitlow-grass	*Draba nemorosa* L.
Woodland horsetail (reported with field horsetail)	*Equisetum sylvaticum* L.
Wormseed mustard	*Erysimum cheiranthoides* L.
Yellow alyssum	*Alyssum turkestanicum* Regel & Schmalh.
Yellow foxtail	*Setaria pumila* (Poir.) Roem. & Schult.
Yellow sweet-clover (reported with sweet-clover species)	*Melilotus officinalis* (L.) Lam.
Yellow toadflax	*Linaria vulgaris* Mill.

Table C2. Top fifty weeds in 2019-23 (4098 fields)

Rank	Species	Frequency (%)	Field Uniformity		Field Density (#/m^2)			Relative Abundance
			All	Occurrence	All	Occurrence	High	
1	Green foxtail	23.8	10.1	42.2	8.7	36.4	3334.4	37.4
2	Canola/rapeseed	26.8	11.5	42.8	3.9	14.7	521.8	26.4
3	Wild oats	26.6	9.3	35.2	3.8	14.2	1145.6	24.0
4	Wild buckwheat	39.6	10.5	26.5	1.3	3.3	391.2	21.3
5	Lamb's-quarters	28.1	7.2	25.5	1.5	5.4	425.0	16.5
6	Kochia	20.8	5.4	26.0	1.5	7.1	276.0	13.2
7	Chickweed	7.6	3.3	43.4	2.5	32.5	842.8	11.2
8	Wheat	14.9	5.3	35.6	1.1	7.6	195.0	10.9
9	Spiny annual sow-thistle	14.7	4.2	28.7	1.1	7.4	450.4	9.8
10	Canada thistle	21.5	3.5	16.2	0.4	1.9	62.4	8.9
11	False cleavers	13.3	3.6	27.1	0.7	5.3	306.0	8.0
12	Dandelion	13.5	2.7	19.7	0.3	2.4	141.8	6.2
13	Barnyard grass species	8.7	2.1	24.5	0.9	10.3	228.0	6.1
14	Stinkweed	8.0	2.2	27.8	0.8	9.9	315.6	5.8
15	Redroot pigweed	10.0	2.2	21.9	0.5	4.7	198.8	5.4
16	Shepherd's-purse	9.0	1.9	21.5	0.4	4.2	172.8	4.7
17	Field horsetail	7.9	1.7	21.1	0.4	4.6	79.2	4.2
18	Wild mustard	4.3	1.6	37.0	0.6	13.3	402.0	3.9
19	Narrow-leaved hawk's-beard	7.2	1.5	21.5	0.3	3.9	106.4	3.7
20	Foxtail barley	7.7	1.3	16.6	0.3	3.9	297.6	3.6
21	Round-leaved mallow	8.1	1.4	17.8	0.2	2.5	65.8	3.6
22	Perennial sow-thistle	7.6	1.5	19.8	0.2	2.7	55.2	3.5
23	Russian thistle	4.8	1.2	24.7	0.4	8.0	360.8	3.1
24	Pale smartweed	7.2	1.2	16.2	0.2	2.6	61.4	3.1
25	Hemp-nettle	6.1	1.3	21.8	0.2	2.6	40.6	2.9
26	Broad-leaved plantain	6.2	1.1	17.3	0.2	2.9	161.8	2.8
27	Barley	3.7	1.1	30.3	0.4	9.4	262.4	2.7
28	Lentils	3.5	1.5	41.5	0.3	7.2	69.4	2.7
29	Annual spurge species	5.2	1.1	20.8	0.2	3.5	84.6	2.6
30	Black medick	3.4	0.8	22.8	0.3	7.5	208.4	2.1
31	Low cudweed	3.3	0.6	19.1	0.3	8.2	84.8	2.0
32	Annual blue grass	1.4	0.4	24.2	0.4	31.1	992.0	1.8
33	Night-flowering catchfly	3.3	0.7	21.4	0.2	5.7	112.4	1.8
34	Tumble pigweed	4.1	0.6	14.7	0.1	1.6	20.2	1.6
35	Stork's bill	2.9	0.6	21.9	0.1	4.8	88.6	1.5
36	Alfalfa	3.1	0.7	21.3	0.1	3.1	72.6	1.5
37	Biennial wormwood	3.7	0.5	13.2	< 0.1	1.3	36.6	1.4
38	Clover species	2.8	0.6	21.2	0.1	2.6	33.0	1.3
39	Flax	1.3	0.5	41.0	0.2	13.3	135.8	1.2
40	Annual brome species	1.2	0.4	31.7	0.2	17.3	195.8	1.1
41	Yellow foxtail	1.0	0.3	30.7	0.2	23.4	400.4	1.1
42	Prostrate knotweed	3.0	0.4	11.6	< 0.1	1.3	30.8	1.1
43	Oats	0.9	0.4	44.2	0.2	17.8	120.0	1.0
44	Oak-leaved goosefoot	1.9	0.4	19.5	0.1	4.1	86.0	1.0
45	Flixweed	2.3	0.4	15.4	< 0.1	1.6	26.4	0.9
46	Rough cinquefoil	2.0	0.3	13.6	< 0.1	2.4	77.4	0.8
47	Corn spurry	0.8	0.3	32.3	0.1	11.5	81.8	0.7
48	Vetch species	1.8	0.2	12.3	< 0.1	1.4	19.6	0.7
49	Purslane speedwell	1.4	0.2	14.6	0.1	3.9	56.8	0.7
50	Quack grass	1.0	0.2	18.5	0.1	7.9	111.2	0.6

Table C3. Top fifty weeds in 2019-23 spring wheat (1361 fields)

Rank	Species	Frequency (%)	Field Uniformity		Field Density (#/m^2)			Relative Abundance
			All	Occurrence	All	Occurrence	High	
1	Canola/rapeseed	38.0	18.8	49.4	7.0	18.5	521.8	42.6
2	Green foxtail	25.6	10.9	42.7	9.0	35.3	1125.2	37.5
3	Wild buckwheat	41.1	11.9	29.1	1.7	4.1	391.2	24.5
4	Wild oats	26.5	8.7	32.8	4.0	15.2	481.4	23.8
5	Kochia	22.8	6.1	26.9	1.4	6.2	96.6	14.3
6	Chickweed	7.5	3.2	41.9	3.3	44.4	842.8	12.6
7	Lamb's-quarters	18.9	4.7	24.8	1.1	5.9	248.8	11.4
8	Spiny annual sow-thistle	14.5	4.4	30.5	1.6	11.1	450.4	11.3
9	Canada thistle	22.0	3.3	15.0	0.3	1.5	18.0	9.1
10	False cleavers	11.2	3.5	31.0	0.7	6.4	125.2	7.5
11	Barnyard grass species	8.8	2.2	25.2	1.4	16.1	228.0	7.5
12	Foxtail barley	11.6	1.9	16.1	0.5	4.4	297.6	5.7
13	Stinkweed	6.3	1.9	30.2	0.9	14.4	315.6	5.4
14	Lentils	5.8	2.7	47.2	0.5	8.7	69.4	5.0
15	Dandelion	10.2	2.1	20.2	0.3	2.7	67.0	5.0
16	Russian thistle	6.0	1.7	28.3	0.6	10.3	122.8	4.5
17	Redroot pigweed	8.3	1.4	17.3	0.3	4.0	129.0	4.1
18	Wild mustard	3.3	1.3	39.9	0.8	24.3	402.0	3.9
19	Shepherd's-purse	6.0	1.4	22.8	0.4	6.8	172.8	3.7
20	Narrow-leaved hawk's-beard	6.6	1.4	22.0	0.3	4.0	45.2	3.5
21	Pale smartweed	6.2	1.3	20.5	0.2	3.6	53.6	3.2
22	Broad-leaved plantain	5.9	1.1	18.3	0.3	4.4	161.8	3.0
23	Perennial sow-thistle	6.4	1.2	18.4	0.2	2.7	53.4	3.0
24	Annual blue grass	1.1	0.3	30.0	1.0	95.3	992.0	3.0
25	Annual spurge species	5.3	1.1	21.1	0.2	4.7	84.6	2.9
26	Hemp-nettle	5.9	1.2	20.4	0.2	2.9	40.6	2.9
27	Round-leaved mallow	6.6	1.0	15.0	0.1	2.2	65.8	2.8
28	Field horsetail	5.1	0.8	16.6	0.2	3.5	40.2	2.4
29	Low cudweed	2.9	0.7	22.5	0.3	9.9	55.8	2.0
30	Wheat	2.5	0.9	35.8	0.2	9.3	66.4	2.0
31	Tumble pigweed	4.4	0.7	16.1	0.1	1.8	20.2	1.9
32	Night-flowering catchfly	3.5	0.7	19.0	0.1	2.5	42.0	1.6
33	Biennial wormwood	3.2	0.5	16.0	0.1	2.0	36.6	1.4
34	Annual brome species	1.1	0.3	32.6	0.2	18.1	96.0	1.0
35	Stork's bill	2.0	0.3	17.3	0.1	5.2	57.2	1.0
36	Alfalfa	1.9	0.4	21.4	0.1	3.8	41.0	1.0
37	Flax	1.3	0.4	34.8	0.1	8.9	47.6	1.0
38	Prostrate knotweed	2.4	0.3	12.9	< 0.1	2.1	24.0	1.0
39	Yellow foxtail	1.2	0.4	29.6	0.1	10.6	80.6	0.9
40	Black medick	1.7	0.4	20.4	< 0.1	2.6	20.0	0.8
41	Flixweed	1.7	0.3	19.9	< 0.1	1.8	9.6	0.8
42	Common groundsel	0.9	0.2	29.0	0.1	14.5	134.6	0.7
43	Field pea	1.6	0.3	16.0	< 0.1	1.6	15.4	0.7
44	Soybean	1.3	0.3	24.6	< 0.1	2.6	23.8	0.7
45	Oats	0.5	0.3	55.4	0.1	18.9	66.8	0.6
46	Purslane speedwell	1.6	0.2	10.6	< 0.1	1.3	4.6	0.6
47	Pineappleweed	1.1	0.2	21.7	< 0.1	3.1	19.6	0.6
48	Rough cinquefoil	1.1	0.2	14.3	0.1	4.8	56.8	0.5
49	Quack grass	1.0	0.2	14.8	< 0.1	4.0	41.0	0.5
50	Dock species	1.1	0.2	15.4	< 0.1	2.4	20.2	0.5

Table C4. Top fifty weeds in 2019-23 barley (512 fields)

Rank	Species	Frequency (%)	Field Uniformity		Field Density (#/m^2)			Relative Abundance
			All	Occurrence	All	Occurrence	High	
1	Canola/rapeseed	35.6	14.6	40.9	5.1	14.3	291.8	32.9
2	Wild oats	29.8	10.3	34.6	6.1	20.6	1145.6	30.5
3	Green foxtail	18.7	9.4	50.4	7.1	37.8	520.0	29.4
4	Chickweed	12.1	7.0	57.8	6.2	50.9	439.0	23.6
5	Wild buckwheat	34.0	8.8	25.9	1.1	3.1	37.4	17.9
6	Kochia	19.1	5.4	28.0	3.0	15.7	276.0	16.2
7	Lamb's-quarters	23.0	5.3	23.0	1.0	4.5	130.0	12.3
8	Canada thistle	21.7	3.7	17.2	0.5	2.4	62.4	9.5
9	Dandelion	17.3	3.8	22.1	0.7	3.9	141.8	8.9
10	Barnyard grass species	9.2	2.5	26.9	1.0	11.1	134.0	6.7
11	Spiny annual sow-thistle	10.7	2.9	27.1	0.7	6.6	205.8	6.7
12	False cleavers	11.2	2.8	25.0	0.5	4.6	67.8	6.2
13	Stinkweed	7.2	2.4	34.0	1.0	14.0	282.4	6.1
14	Wheat	9.5	2.7	28.7	0.6	6.7	86.8	6.0
15	Redroot pigweed	9.9	2.3	23.2	0.6	6.0	115.4	5.7
16	Shepherd's-purse	7.5	1.8	24.4	0.4	5.5	61.4	4.3
17	Foxtail barley	9.5	1.7	17.6	0.2	2.3	23.4	4.1
18	Hemp-nettle	8.5	1.8	21.1	0.2	2.4	14.4	4.0
19	Pale smartweed	9.2	1.5	16.0	0.2	2.1	20.0	3.8
20	Broad-leaved plantain	7.0	1.3	18.7	0.3	3.7	40.6	3.3
21	Perennial sow-thistle	6.4	1.3	20.5	0.2	3.1	34.4	3.1
22	Round-leaved mallow	7.1	1.3	17.6	0.1	2.0	13.4	3.1
23	Field horsetail	7.7	1.1	14.6	0.1	1.7	12.6	3.1
24	Wild mustard	3.5	1.2	33.9	0.4	11.8	115.6	2.8
25	Narrow-leaved hawk's-beard	6.2	1.1	18.2	0.1	2.3	20.4	2.7
26	Annual blue grass	3.9	0.8	19.4	0.3	6.4	46.2	2.2
27	Flax	1.1	0.8	72.1	0.5	41.3	135.8	2.1
28	Annual spurge species	2.7	0.9	32.8	0.2	7.5	44.2	1.9
29	Russian thistle	3.7	0.8	21.2	0.1	2.2	39.8	1.7
30	Clover species	4.2	0.7	15.5	< 0.1	0.9	3.4	1.6
31	Annual brome species	1.9	0.7	38.2	0.2	11.7	40.6	1.6
32	Black medick	2.4	0.7	30.6	0.2	6.5	33.2	1.6
33	Night-flowering catchfly	2.8	0.7	25.1	0.1	4.6	30.6	1.5
34	Low cudweed	3.1	0.5	16.5	0.2	5.3	15.6	1.5
35	Tumble pigweed	3.1	0.6	20.7	0.1	3.0	15.8	1.5
36	Lentils	2.9	0.7	23.5	0.1	2.1	8.0	1.4
37	Stork's bill	2.8	0.5	16.3	0.1	2.6	12.0	1.2
38	Purslane speedwell	1.4	0.4	27.8	0.2	14.1	33.6	1.1
39	Biennial wormwood	2.6	0.5	17.2	< 0.1	1.6	7.8	1.1
40	Oats	1.9	0.5	25.7	0.1	4.4	24.4	1.1
41	Corn spurry	1.1	0.5	44.1	0.2	15.1	76.6	1.0
42	Prostrate knotweed	2.9	0.3	11.7	< 0.1	0.8	4.2	1.0
43	Alfalfa	2.6	0.4	15.5	< 0.1	1.3	4.4	1.0
44	Marsh yellow cress	1.0	0.1	10.5	0.3	29.8	117.6	1.0
45	Barley	2.1	0.3	14.0	0.1	3.4	20.0	0.9
46	Dock species	2.1	0.3	14.8	0.1	2.5	11.6	0.9
47	Spear-leaved goosefoot	0.8	0.2	27.4	0.2	23.1	90.6	0.9
48	Prostrate pigweed	1.7	0.3	20.6	0.1	3.2	19.4	0.8
49	Flixweed	2.1	0.3	15.2	< 0.1	0.9	3.4	0.8
50	Persian darnel	0.8	0.4	47.4	0.1	9.3	16.4	0.7

Table C5. Top fifty weeds in 2019-23 oats (278 fields)

Rank	Species	Frequency (%)	Field Uniformity		Field Density (#/m^2)			Relative Abundance
			All	Occurrence	All	Occurrence	High	
1	Green foxtail	46.8	28.3	60.4	46.6	99.4	3334.4	84.8
2	Lamb's-quarters	30.7	14.3	46.6	4.6	15.0	126.0	20.0
3	Wild buckwheat	44.5	14.6	32.7	2.3	5.1	77.6	19.8
4	Wild oats	27.6	12.6	45.7	4.1	15.0	139.8	17.9
5	Canada thistle	30.5	7.5	24.7	1.2	3.9	42.8	11.6
6	Redroot pigweed	21.5	7.5	34.7	1.6	7.5	92.4	10.5
7	Dandelion	23.4	6.6	28.3	0.8	3.4	32.4	9.3
8	Canola/rapeseed	18.6	6.2	33.6	1.3	7.0	64.8	8.8
9	Stinkweed	11.5	4.8	41.8	1.5	12.7	98.4	6.9
10	Field horsetail	12.8	3.7	28.9	1.2	9.1	53.4	6.0
11	Kochia	13.7	4.0	29.3	0.7	5.2	22.0	5.8
12	Wild mustard	9.4	4.1	43.0	0.8	8.6	86.6	5.2
13	Alfalfa	12.6	2.4	18.7	0.3	2.3	18.2	4.1
14	Narrow-leaved hawk's-beard	8.8	2.4	27.0	0.6	6.5	49.0	3.7
15	Wheat	10.6	2.2	20.9	0.3	3.1	17.2	3.7
16	Hemp-nettle	7.6	3.0	38.8	0.4	5.6	13.8	3.7
17	Barnyard grass species	9.7	2.3	24.0	0.4	4.0	26.2	3.7
18	Chickweed	5.0	1.7	34.1	1.3	26.2	219.6	3.6
19	Perennial sow-thistle	9.3	2.4	25.4	0.3	3.0	9.6	3.5
20	Barley	10.3	1.7	16.4	0.4	3.9	76.8	3.4
21	Round-leaved mallow	7.2	2.1	29.0	0.3	4.6	21.6	3.0
22	Clover species	7.5	1.9	25.7	0.3	3.9	13.4	2.9
23	Pale smartweed	9.6	1.5	15.6	0.1	1.3	5.8	2.8
24	Corn spurry	3.7	1.9	50.5	0.8	21.0	81.8	2.8
25	Shepherd's-purse	8.2	1.7	20.2	0.2	2.9	29.6	2.8
26	Foxtail barley	7.2	1.4	19.2	0.4	6.2	109.8	2.7
27	Night-flowering catchfly	7.2	1.4	19.4	0.2	2.9	33.2	2.4
28	Russian thistle	5.8	1.4	24.2	0.4	6.7	73.6	2.4
29	Broad-leaved plantain	6.4	1.5	23.5	0.1	2.1	7.6	2.3
30	False cleavers	6.0	1.4	23.0	0.1	2.4	17.0	2.1
31	Stork's bill	4.4	1.1	25.6	0.4	7.9	88.6	1.9
32	Rough cinquefoil	5.1	1.0	19.9	0.3	5.1	77.4	1.9
33	Spiny annual sow-thistle	5.9	1.0	16.0	0.1	1.8	7.2	1.8
34	Oats	2.1	1.2	55.6	0.6	27.5	119.0	1.8
35	Sweet-clover species	2.6	1.3	49.9	0.4	16.6	40.0	1.8
36	Annual spurge species	4.8	0.9	18.7	0.1	2.7	19.8	1.6
37	Vetch species	5.3	0.8	15.4	0.1	1.3	5.0	1.5
38	Black medick	4.4	1.0	21.6	0.1	1.6	5.2	1.5
39	Field pea	3.4	0.9	26.4	0.1	3.8	23.8	1.3
40	Yellow foxtail	1.3	0.4	31.2	0.6	45.9	174.6	1.3
41	Prostrate knotweed	4.2	0.5	11.9	< 0.1	0.6	1.2	1.1
42	Bluebur	3.0	0.4	12.0	< 0.1	0.9	3.2	0.8
43	Biennial wormwood	3.1	0.3	9.7	< 0.1	1.0	5.2	0.8
44	Tartary buckwheat	0.4	0.4	100.0	0.4	91.8	91.8	0.8
45	White mustard	1.6	0.6	36.3	0.1	4.0	10.0	0.7
46	Flixweed	2.4	0.4	17.3	< 0.1	1.5	7.0	0.7
47	Flax	1.4	0.4	30.4	0.2	12.0	52.0	0.7
48	Fescue species	2.0	0.3	17.6	0.1	3.0	9.8	0.6
49	American dragonhead	2.3	0.2	10.3	< 0.1	1.8	8.8	0.6
50	Annual blue grass	1.2	0.4	31.2	0.1	9.7	18.0	0.6

Table C6. Top fifty weeds in 2019-23 corn (42 fields)

Rank	Species				Frequency (%)	Field Uniformity		Field Density (#/m^2)		
						All	Occurrence	All	Occurrence	High
1	Green foxtail	26.0	13.5	51.9	6.4	24.5	172.0		51.0	
2	Wild buckwheat	57.6	18.5	32.2	2.9	5.1	49.0		42.5	
3	Lamb's-quarters	63.9	18.4	28.8	2.3	3.6	30.4		39.9	
4	Redroot pigweed	41.8	9.7	23.2	0.8	1.9	17.2		20.3	
5	Round-leaved mallow	41.0	6.9	16.8	0.4	1.0	3.6		15.7	
6	Barnyard grass species	13.6	4.5	32.7	1.0	7.4	32.8		11.8	
7	Yellow foxtail	9.6	4.4	46.0	1.0	10.1	32.8		10.8	
8	Kochia	18.5	5.4	29.3	0.4	2.4	6.4		10.4	
9	Canola/rapeseed	17.7	4.6	26.0	0.3	1.6	6.4		8.7	
10	Dandelion	15.2	3.4	22.6	0.5	3.6	15.4		8.7	
11	Purslane	21.9	2.7	12.5	0.4	1.7	11.8		8.5	
12	Black medick	15.8	1.8	11.3	0.1	0.5	1.4		5.0	
13	Willow species	8.6	2.2	25.2	0.2	2.6	4.4		4.6	
14	Nightshade species	5.4	2.6	47.5	0.2	4.2	8.2		4.4	
15	Biennial wormwood	15.7	0.8	5.0	0.1	0.3	1.0		3.9	
16	Soybean	7.7	2.1	27.3	0.1	1.4	2.4		3.8	
17	Golden dock	6.0	1.7	27.6	0.2	2.7	5.8		3.4	
18	Sweet-clover species	11.2	0.8	7.4	0.1	0.6	1.0		3.1	
19	Shepherd's-purse	10.6	0.8	7.3	0.1	0.7	1.0		3.0	
20	Oak-leaved goosefoot	6.6	1.2	17.7	0.1	1.0	2.6		2.6	
21	American dragonhead	7.9	1.0	12.4	< 0.1	0.5	0.8		2.5	
22	Field horsetail	4.8	0.6	12.2	0.2	4.3	9.2		2.5	
23	Alfalfa	7.3	0.9	13.0	0.1	0.7	0.8		2.4	
24	Canada thistle	8.5	0.7	8.5	< 0.1	0.4	0.8		2.4	
25	Broad-leaved plantain	8.2	0.7	8.9	< 0.1	0.5	1.2		2.4	
26	Tumble pigweed	5.2	1.1	21.4	0.1	1.4	2.6		2.3	
27	Bicknell's geranium	5.1	1.0	19.6	0.1	1.0	1.4		2.1	
28	Stink grass	2.7	0.8	30.0	0.1	2.4	2.4		1.5	
29	Dwarf snapdragon	4.1	0.6	15.4	< 0.1	0.8	2.0		1.5	
30	Perennial sow-thistle	5.8	0.3	5.0	< 0.1	0.2	0.2		1.4	
31	Foxtail barley	4.8	0.4	7.8	< 0.1	0.3	0.4		1.3	
32	Wild mustard	5.3	0.3	5.0	< 0.1	0.2	0.2		1.3	
33	Wheat	2.8	0.6	20.0	< 0.1	1.6	1.6		1.2	
34	Absinth	3.0	0.3	10.0	< 0.1	0.4	0.4		0.9	
35	Night-flowering catchfly	3.0	0.3	10.0	< 0.1	0.4	0.4		0.9	
36	Bird's-eye speedwell	3.0	0.3	10.0	< 0.1	0.4	0.4		0.9	
37	Spiny annual sow-thistle	1.2	0.4	35.0	0.1	4.4	4.4		0.9	
38	Flixweed	3.3	0.2	5.0	< 0.1	0.4	0.4		0.8	
39	Wild oats	3.0	0.2	5.0	< 0.1	0.2	0.2		0.7	
40	Pale smartweed	3.0	0.1	5.0	< 0.1	0.2	0.2		0.7	
41	Field pea	2.7	0.1	5.0	< 0.1	0.4	0.4		0.7	
42	Prostrate pigweed	2.7	0.1	5.0	< 0.1	0.2	0.2		0.7	
43	Annual sow-thistle	2.7	0.1	5.0	< 0.1	0.2	0.2		0.7	
44	Vetch species	2.7	0.1	5.0	< 0.1	0.2	0.2		0.7	
45	Slough grass	2.1	0.2	10.0	< 0.1	0.4	0.4		0.6	
46	Rough cinquefoil	2.0	0.1	5.0	< 0.1	0.6	0.6		0.5	
47	Silverweed	2.1	0.1	5.0	< 0.1	0.4	0.4		0.5	
48	Marsh yellow cress	2.1	0.1	5.0	< 0.1	0.2	0.2		0.5	
49	Scouring-rush	2.1	0.1	5.0	< 0.1	0.2	0.2		0.5	
50	Bladder campion	2.0	0.1	5.0	< 0.1	0.2	0.2		0.5	

Table C7. Top fifty weeds in 2019-23 canola/rapeseed (1205 fields)

		Frequency	Field Uniformity		Field Density (#/m^2)			Relative
Rank	Species	(%)	All	Occurrence	All	Occurrence	High	Abundance
1	Wheat	28.1	11.5	41.0	2.6	9.2	195.0	27.1
2	Wild oats	23.9	8.8	37.0	2.7	11.1	128.0	24.1
3	Lamb's-quarters	40.7	9.6	23.6	1.6	3.9	411.2	23.8
4	Wild buckwheat	40.2	9.3	23.0	0.9	2.2	34.2	20.5
5	False cleavers	22.3	5.7	25.7	1.2	5.3	306.0	14.8
6	Green foxtail	17.6	5.3	30.1	1.4	8.1	169.0	14.5
7	Spiny annual sow-thistle	17.6	4.6	26.2	1.0	5.8	121.8	12.1
8	Chickweed	9.3	3.6	38.7	1.4	14.6	191.0	10.9
9	Kochia	16.0	3.8	23.4	0.8	5.2	184.4	10.2
10	Shepherd's-purse	15.2	3.2	21.0	0.5	3.0	52.4	8.0
11	Barley	6.4	2.7	41.6	1.0	14.9	262.4	7.8
12	Field horsetail	13.0	3.0	22.9	0.6	4.3	79.2	7.7
13	Canada thistle	17.8	2.4	13.8	0.2	1.2	11.6	6.8
14	Canola/rapeseed	10.8	2.9	27.3	0.4	4.0	104.4	6.7
15	Barnyard grass species	8.5	1.9	22.4	0.7	8.1	190.4	6.4
16	Dandelion	15.1	2.5	16.8	0.2	1.4	52.6	6.3
17	Redroot pigweed	9.8	2.0	20.0	0.3	3.5	79.6	5.2
18	Round-leaved mallow	9.4	1.7	18.0	0.2	2.6	28.2	4.5
19	Low cudweed	5.6	1.0	18.4	0.5	8.4	84.8	4.1
20	Pale smartweed	9.1	1.3	14.3	0.2	2.6	44.2	4.1
21	Perennial sow-thistle	7.8	1.4	18.4	0.2	2.4	55.2	3.7
22	Hemp-nettle	7.1	1.4	20.1	0.1	2.0	11.2	3.4
23	Broad-leaved plantain	8.0	1.2	14.7	0.1	1.7	26.6	3.3
24	Stinkweed	6.7	1.3	19.3	0.2	2.7	69.2	3.3
25	Night-flowering catchfly	3.5	0.9	24.7	0.4	11.8	112.4	3.3
26	Narrow-leaved hawk's-beard	5.8	1.1	19.2	0.2	3.1	45.0	3.0
27	Stork's bill	4.6	1.0	22.7	0.2	4.1	38.2	2.7
28	Lentils	3.1	1.2	38.6	0.2	5.6	59.6	2.5
29	Foxtail barley	4.5	0.8	17.3	0.2	4.0	75.4	2.4
30	Yellow foxtail	1.0	0.3	29.6	0.4	43.4	400.4	2.3
31	Annual spurge species	4.5	0.8	17.9	0.1	2.3	30.4	2.1
32	Oak-leaved goosefoot	4.4	0.8	17.5	0.1	2.3	28.6	2.1
33	Clover species	4.1	0.8	20.6	0.1	2.1	15.8	2.0
34	Annual brome species	0.9	0.4	39.0	0.3	35.4	195.8	1.9
35	Tumble pigweed	4.7	0.7	14.3	0.1	1.6	11.4	1.9
36	Black medick	3.6	0.6	15.8	0.1	4.0	106.2	1.9
37	Alfalfa	2.6	0.8	29.3	0.1	5.4	72.6	1.8
38	Oats	0.9	0.5	58.2	0.3	30.5	120.0	1.7
39	Annual blue grass	1.4	0.4	25.1	0.2	14.9	81.2	1.5
40	Flax	1.4	0.6	41.5	0.2	10.7	51.2	1.5
41	Coriander	0.1	0.1	57.6	0.3	218.5	389.6	1.5
42	Biennial wormwood	4.0	0.5	12.2	< 0.1	0.9	6.8	1.4
43	Prostrate knotweed	3.9	0.4	10.3	0.1	1.3	30.8	1.4
44	Rough cinquefoil	3.0	0.4	13.1	< 0.1	1.1	11.2	1.1
45	Golden dock	2.3	0.4	17.7	0.1	2.5	35.0	1.1
46	Purslane speedwell	2.1	0.3	15.2	0.1	3.9	56.8	1.1
47	Flixweed	2.3	0.4	15.7	< 0.1	1.9	11.4	1.0
48	Wild mustard	1.6	0.4	26.1	< 0.1	3.0	14.0	0.9
49	Pineappleweed	1.9	0.3	16.8	0.1	2.8	32.4	0.9
50	Russian thistle	1.4	0.3	22.0	< 0.1	3.3	23.8	0.8

Table C8. Top fifty weeds in 2019-23 flax (50 fields)

Rank	Species	Frequency (%)	Field Uniformity		Field Density (#/m^2)			Relative Abundance
			All	Occurrence	All	Occurrence	High	
1	Green foxtail	43.5	20.5	47.1	12.3	28.3	155.0	57.2
2	Wild oats	34.6	15.1	43.7	7.9	22.7	165.6	39.4
3	Wild buckwheat	42.0	8.5	20.2	0.5	1.3	6.0	15.8
4	Kochia	25.2	7.5	29.6	2.0	7.8	65.4	15.7
5	Canola/rapeseed	30.3	7.9	26.0	0.5	1.8	8.0	13.1
6	Wild mustard	11.9	4.3	35.9	2.7	22.5	122.4	12.8
7	Canada thistle	25.1	6.6	26.2	1.0	4.0	26.0	12.4
8	Round-leaved mallow	23.7	5.3	22.5	1.1	4.5	23.4	11.4
9	Spiny annual sow-thistle	13.2	6.3	47.6	1.2	8.9	28.8	10.4
10	Lamb's-quarters	21.3	6.0	28.0	0.7	3.2	14.0	10.3
11	Wheat	18.5	3.3	17.9	1.4	7.5	62.2	9.8
12	Redroot pigweed	21.9	5.3	24.1	0.4	2.0	8.6	9.3
13	Stinkweed	17.5	4.4	25.1	0.5	3.0	16.6	8.0
14	Annual spurge species	9.9	2.9	29.5	0.3	3.3	12.8	4.9
15	Dandelion	13.6	2.2	16.5	0.1	0.7	2.0	4.5
16	Lentils	3.7	2.0	55.0	0.8	20.6	39.0	4.3
17	False cleavers	6.8	2.7	39.7	0.4	5.4	14.2	4.3
18	Perennial sow-thistle	13.8	1.5	10.6	0.1	0.5	1.2	3.9
19	Shepherd's-purse	11.6	1.6	13.7	0.1	1.1	1.8	3.7
20	Narrow-leaved hawk's-beard	12.2	1.2	10.2	0.1	0.5	0.8	3.4
21	Pale smartweed	10.0	1.5	15.5	0.1	1.2	4.8	3.4
22	Vetch species	3.7	1.8	49.6	0.3	8.6	15.4	2.9
23	Barnyard grass species	8.7	1.3	15.0	0.1	1.0	1.4	2.9
24	Chickweed	1.9	1.1	55.0	0.5	26.0	26.0	2.5
25	Foxtail barley	7.5	1.1	15.0	0.1	0.7	1.0	2.4
26	Hemp-nettle	5.9	1.1	19.4	0.1	1.7	5.0	2.2
27	Black medick	5.7	1.1	19.0	0.1	1.5	3.4	2.1
28	Persian darnel	1.7	1.5	85.0	0.2	13.2	13.2	2.0
29	Alfalfa	3.8	1.3	35.0	0.1	2.0	2.2	1.9
30	Biennial wormwood	4.3	1.2	27.6	0.1	1.7	1.8	1.9
31	Dock species	5.9	0.4	6.6	< 0.1	0.7	1.2	1.5
32	Annual sow-thistle	2.0	0.9	45.0	0.1	7.0	7.0	1.5
33	Tumble pigweed	5.7	0.4	6.5	< 0.1	0.4	0.6	1.4
34	Prostrate pigweed	4.5	0.5	10.0	< 0.1	0.6	1.0	1.3
35	Russian thistle	3.8	0.5	14.3	< 0.1	0.8	1.4	1.2
36	Night-flowering catchfly	2.3	0.8	35.0	0.1	2.4	2.4	1.2
37	Cow cockle	4.1	0.4	9.3	< 0.1	0.7	1.2	1.2
38	Meadow brome	1.8	0.6	35.0	0.1	5.0	5.0	1.0
39	Barley	1.9	0.6	30.0	0.1	2.8	2.8	0.9
40	Field pea	3.3	0.3	9.8	< 0.1	0.5	0.6	0.9
41	Flixweed	3.5	0.2	5.0	< 0.1	0.3	0.4	0.8
42	Oak-leaved goosefoot	1.9	0.5	25.0	< 0.1	1.6	1.6	0.8
43	Water smartweed	1.9	0.4	20.0	< 0.1	2.2	2.2	0.8
44	Canada fleabane	2.3	0.2	10.0	< 0.1	0.6	0.6	0.6
45	Broad-leaved plantain	1.9	0.3	15.0	< 0.1	1.0	1.0	0.6
46	Prostrate knotweed	2.3	0.2	10.0	< 0.1	0.4	0.4	0.6
47	Povertyweed	1.9	0.2	10.0	< 0.1	1.0	1.0	0.6
48	Oats	2.0	0.2	10.0	< 0.1	0.4	0.4	0.6
49	American dragonhead	1.9	0.2	10.0	< 0.1	0.4	0.4	0.5
50	Common pepper-grass	2.3	0.1	5.0	< 0.1	0.2	0.2	0.5

Table C9. Top fifty weeds in 2019-23 soybean (72 fields)

Rank	Species	Frequency (%)	Field Uniformity		Field Density (#/m^2)			Relative Abundance
			All	Occurrence	All	Occurrence	High	
1	Canola/rapeseed	44.1	15.5	35.1	1.8	4.0	31.4	54.1
2	Wild buckwheat	43.5	9.7	22.2	0.8	1.9	18.6	35.9
3	Green foxtail	29.0	7.4	25.6	0.8	2.9	28.6	28.3
4	Wild oats	11.3	2.9	25.6	1.9	16.4	125.0	27.0
5	Spiny annual sow-thistle	6.1	2.6	42.2	1.0	15.7	51.4	15.6
6	Round-leaved mallow	16.9	2.5	15.0	0.4	2.4	10.0	13.1
7	Lamb's-quarters	15.5	2.5	16.0	0.2	1.0	2.2	9.9
8	Wheat	10.5	2.3	21.8	0.2	1.8	8.2	8.5
9	Perennial rye grass	1.7	1.5	90.0	0.5	30.8	30.8	8.0
10	Kochia	9.5	1.9	20.0	0.2	1.7	6.4	7.3
11	Barnyard grass species	13.4	1.4	10.6	0.1	0.7	2.4	7.1
12	Broad-leaved plantain	7.2	1.8	25.2	0.2	3.0	7.2	7.1
13	Redroot pigweed	9.2	2.1	22.9	0.1	1.2	3.4	7.0
14	Canada thistle	13.0	1.3	9.7	0.1	0.5	1.8	6.5
15	Perennial sow-thistle	4.3	1.6	36.5	0.3	6.1	19.4	6.3
16	Lentils	1.8	1.3	70.0	0.2	13.8	13.8	4.9
17	Biennial wormwood	8.0	0.9	11.8	0.1	0.9	3.0	4.6
18	Dandelion	7.7	0.9	12.0	< 0.1	0.6	1.6	4.2
19	Foxtail barley	3.8	1.0	25.2	0.1	2.4	6.8	3.5
20	Willow species	3.4	1.1	31.9	0.1	2.3	3.8	3.4
21	Black medick	7.3	0.5	7.4	< 0.1	0.4	1.2	3.3
22	Sweet-clover species	3.4	0.8	22.7	0.1	1.6	2.4	2.7
23	Leafy spurge	1.2	0.3	25.0	0.1	10.2	10.2	2.0
24	Pale smartweed	3.1	0.5	15.1	< 0.1	0.8	1.2	1.9
25	Annual spurge species	2.5	0.4	15.6	< 0.1	1.8	2.8	1.8
26	Field horsetail	4.0	0.2	5.0	< 0.1	0.6	1.4	1.7
27	Stork's bill	1.5	0.5	35.0	< 0.1	2.2	2.2	1.6
28	Night-flowering catchfly	2.5	0.3	12.7	< 0.1	0.6	1.2	1.4
29	American dragonhead	3.4	0.2	5.0	< 0.1	0.2	0.2	1.4
30	Narrow-leaved hawk's-beard	1.8	0.3	15.0	< 0.1	2.0	2.0	1.3
31	False cleavers	2.8	0.2	7.7	< 0.1	0.3	0.4	1.2
32	Purslane	1.6	0.2	15.0	< 0.1	2.0	2.0	1.1
33	White cockle	1.8	0.3	15.0	< 0.1	0.6	0.6	1.1
34	Buttercup species	1.8	0.3	15.0	< 0.1	0.6	0.6	1.1
35	Wild mustard	2.6	0.1	5.0	< 0.1	0.2	0.2	1.0
36	Tumble pigweed	2.4	0.1	5.0	< 0.1	0.4	0.6	1.0
37	Purslane speedwell	1.7	0.3	15.0	< 0.1	0.6	0.6	1.0
38	Northern willowherb	1.6	0.2	15.0	< 0.1	0.8	0.8	0.9
39	Stink grass	1.5	0.2	15.0	< 0.1	0.6	0.6	0.9
40	Quack grass	1.1	0.2	20.0	< 0.1	1.8	1.8	0.9
41	Stinkweed	1.3	0.3	20.0	< 0.1	0.8	0.8	0.9
42	American stinging nettle	1.2	0.2	20.0	< 0.1	0.8	0.8	0.8
43	Marsh yellow cress	1.8	0.1	5.0	< 0.1	0.2	0.2	0.7
44	Prostrate knotweed	1.8	0.1	5.0	< 0.1	0.2	0.2	0.7
45	Annual brome species	1.3	0.1	10.0	< 0.1	0.6	0.6	0.7
46	Soybean	1.5	0.1	5.0	< 0.1	0.4	0.4	0.6
47	Prostrate pigweed	1.6	0.1	5.0	< 0.1	0.2	0.2	0.6
48	Pennsylvania pellitory	1.2	0.1	10.0	< 0.1	0.8	0.8	0.6
49	Red goosefoot	1.2	0.1	10.0	< 0.1	0.4	0.4	0.6
50	Vetch species	1.4	0.1	5.0	< 0.1	0.2	0.2	0.6

Table C10. Top fifty weeds in 2019-23 field peas (226 fields)

Rank	Species	Frequency (%)	Field Uniformity		Field Density (#/m^2)			Relative Abundance
			All	Occurrence	All	Occurrence	High	
1	Canola/rapeseed	35.1	17.6	50.3	6.3	18.0	176.0	37.0
2	Green foxtail	23.2	7.9	34.1	9.2	39.7	868.8	34.5
3	Wild oats	36.2	12.8	35.4	3.8	10.4	137.4	27.1
4	Kochia	29.3	9.9	33.6	3.1	10.4	100.2	21.5
5	Lamb's-quarters	30.2	7.4	24.5	2.7	8.9	425.0	18.8
6	Wild buckwheat	39.6	9.8	24.7	1.0	2.6	105.4	18.4
7	Wheat	20.0	6.3	31.6	1.3	6.7	89.4	12.4
8	Canada thistle	25.1	4.8	19.0	0.6	2.4	21.8	10.5
9	Spiny annual sow-thistle	13.1	5.4	41.0	0.8	6.1	17.2	8.9
10	Narrow-leaved hawk's-beard	14.3	3.8	26.3	0.8	5.8	106.4	8.0
11	Barnyard grass species	10.2	3.7	35.7	0.6	5.8	29.4	6.5
12	False cleavers	10.9	3.4	31.5	0.5	4.5	22.8	6.2
13	Stinkweed	11.3	2.2	19.7	0.8	7.3	160.2	6.1
14	Perennial sow-thistle	14.0	2.7	19.3	0.4	2.9	25.8	6.1
15	Wild mustard	5.7	2.5	43.5	1.1	19.6	121.8	6.0
16	Black medick	6.9	2.5	35.6	0.7	10.5	40.4	5.2
17	Russian thistle	10.1	2.3	23.1	0.5	4.8	36.8	5.2
18	Shepherd's-purse	7.3	2.0	27.5	0.5	6.2	31.8	4.2
19	Redroot pigweed	5.1	1.2	23.6	0.8	16.4	198.8	4.1
20	Dandelion	10.5	1.7	16.2	0.2	1.9	13.0	4.0
21	Field horsetail	5.0	1.5	29.8	0.6	12.7	62.2	3.8
22	Barley	6.3	1.4	22.2	0.3	4.2	30.8	3.1
23	Annual spurge species	5.8	1.3	22.3	0.1	2.3	13.4	2.6
24	Round-leaved mallow	5.8	1.2	20.7	0.1	2.3	6.2	2.5
25	Foxtail barley	5.5	0.7	12.6	0.1	2.1	42.8	2.0
26	Tumble pigweed	5.7	0.8	13.7	< 0.1	0.8	3.0	1.9
27	Chickweed	3.0	1.2	39.3	0.1	4.9	12.0	1.9
28	Hemp-nettle	4.2	0.8	19.6	0.1	1.7	5.6	1.7
29	Pale smartweed	5.5	0.4	7.0	< 0.1	0.6	2.6	1.5
30	Clover species	2.6	0.8	30.3	0.1	4.4	12.2	1.5
31	Biennial wormwood	4.7	0.4	9.7	< 0.1	0.8	2.6	1.4
32	Quack grass	0.4	0.3	85.0	0.4	111.2	111.2	1.4
33	Bicknell's geranium	2.0	0.8	40.5	0.1	6.6	14.6	1.4
34	Broad-leaved plantain	2.8	0.5	17.3	< 0.1	1.6	15.8	1.1
35	Flixweed	3.6	0.2	6.7	< 0.1	0.7	3.0	1.0
36	Low cudweed	2.2	0.4	16.4	0.1	2.7	9.4	0.9
37	Scouring-rush	1.4	0.4	30.1	0.1	6.9	12.0	0.9
38	Sweet-clover species	2.2	0.4	19.7	< 0.1	1.2	1.8	0.9
39	Prostrate knotweed	3.2	0.2	5.0	< 0.1	0.2	0.4	0.8
40	Annual sow-thistle	1.3	0.4	28.0	0.1	7.7	26.4	0.8
41	Alfalfa	2.2	0.3	15.1	< 0.1	1.0	3.0	0.8
42	Annual brome species	2.0	0.3	16.7	< 0.1	1.1	1.8	0.7
43	Pineappleweed	1.1	0.3	23.5	0.1	9.0	21.4	0.7
44	Night-flowering catchfly	1.8	0.3	15.0	< 0.1	2.7	22.6	0.7
45	Lentils	2.0	0.3	13.2	< 0.1	1.0	2.6	0.7
46	Annual blue grass	0.9	0.2	27.9	0.1	12.0	20.8	0.6
47	Prickly lettuce	1.4	0.3	24.8	< 0.1	2.2	5.4	0.6
48	Meadow brome	1.7	0.2	12.2	< 0.1	1.0	1.6	0.5
49	Wild tomato	1.1	0.2	22.0	< 0.1	3.2	7.0	0.5
50	Dock species	1.5	0.2	11.6	< 0.1	0.7	1.2	0.5

Table C11. Top fifty weeds in 2019-23 lentils (260 fields)

Rank	Species	Frequency (%)	Field Uniformity		Field Density (#/m^2)			Relative Abundance
			All	Occurrence	All	Occurrence	High	
1	Canola/rapeseed	26.4	9.3	35.3	5.1	19.3	340.6	32.0
2	Green foxtail	22.5	8.4	37.4	5.1	22.8	181.0	30.4
3	Wild oats	30.8	8.8	28.4	2.8	9.0	142.6	24.8
4	Kochia	40.8	8.7	21.4	2.1	5.1	90.6	24.6
5	Wheat	31.5	9.1	28.9	1.3	4.0	46.4	20.2
6	Wild buckwheat	31.7	7.3	22.9	0.9	2.8	39.2	17.2
7	Spiny annual sow-thistle	26.1	7.3	28.0	1.2	4.5	46.6	16.9
8	Stinkweed	16.6	5.3	32.2	2.3	13.9	183.2	16.6
9	Wild mustard	16.4	6.4	38.8	1.4	8.7	82.2	14.6
10	Lamb's-quarters	22.3	4.9	21.9	0.6	2.7	27.0	11.8
11	Canada thistle	25.6	3.7	14.2	0.5	1.8	14.8	10.9
12	Black medick	6.0	2.4	40.4	2.1	34.8	208.4	10.7
13	Russian thistle	13.7	2.7	19.6	1.4	9.9	360.8	10.3
14	Narrow-leaved hawk's-beard	12.8	2.5	19.5	0.5	3.7	48.4	6.9
15	Annual spurge species	10.2	1.8	17.3	0.2	1.9	15.6	4.7
16	Perennial sow-thistle	7.0	1.8	26.1	0.2	2.8	18.4	4.0
17	Dandelion	8.6	1.1	12.5	0.1	0.8	3.6	3.2
18	Barnyard grass species	5.4	1.0	18.0	0.2	3.0	16.2	2.7
19	Flixweed	5.3	0.8	14.9	0.1	2.3	26.4	2.4
20	Prickly lettuce	4.8	0.7	14.3	0.2	3.5	37.4	2.3
21	Round-leaved mallow	4.9	0.7	13.7	0.1	2.5	20.2	2.2
22	Annual sow-thistle	3.6	0.9	24.7	0.1	3.6	17.2	2.1
23	Cow cockle	2.7	0.6	20.6	0.3	9.7	75.8	2.0
24	Goat's-beard	6.0	0.5	7.5	< 0.1	0.4	1.6	1.9
25	Flax	1.7	0.8	45.2	0.2	11.1	40.8	1.8
26	Foxtail barley	3.4	0.5	14.7	0.1	4.4	43.0	1.8
27	Redroot pigweed	4.0	0.5	12.5	0.1	2.4	22.4	1.7
28	Sunflower	3.9	0.4	11.4	< 0.1	1.3	11.2	1.5
29	Alfalfa	3.2	0.6	17.2	< 0.1	1.3	7.4	1.4
30	False cleavers	3.0	0.5	16.2	0.1	2.2	7.0	1.4
31	Vetch species	3.4	0.4	11.8	< 0.1	1.3	4.2	1.3
32	Prostrate knotweed	2.4	0.6	23.3	< 0.1	2.0	7.6	1.2
33	Biennial wormwood	3.2	0.3	9.4	< 0.1	0.8	3.4	1.1
34	Shepherd's-purse	2.7	0.3	10.7	< 0.1	0.8	1.8	1.0
35	Lentils	0.4	0.4	90.0	0.1	38.0	38.0	0.9
36	Tumble pigweed	2.4	0.2	8.6	< 0.1	0.4	1.0	0.8
37	Barley	1.4	0.3	21.3	< 0.1	2.0	4.6	0.7
38	Sweet-clover species	2.1	0.1	6.9	< 0.1	0.6	2.0	0.7
39	White mustard	1.5	0.2	15.2	< 0.1	1.3	4.0	0.6
40	Spear-leaved goosefoot	0.7	0.3	42.8	0.1	8.5	18.8	0.6
41	Quack grass	0.8	0.2	27.6	< 0.1	4.6	7.0	0.5
42	Scouring-rush	1.3	0.1	10.4	< 0.1	0.9	2.4	0.5
43	Cocklebur	0.8	0.1	17.1	< 0.1	5.4	11.0	0.5
44	Soybean	0.4	0.3	65.0	< 0.1	7.2	7.2	0.5
45	Field pea	1.3	0.1	6.9	< 0.1	0.5	1.0	0.4
46	Small-leaved lamb's-quarters	0.5	0.1	25.0	< 0.1	6.6	6.6	0.4
47	Clover species	0.8	0.1	17.8	< 0.1	0.8	1.2	0.3
48	Tumble mustard	0.9	0.1	9.2	< 0.1	1.3	2.8	0.3
49	Annual brome species	0.6	0.1	22.7	< 0.1	1.3	1.8	0.3
50	Persian darnel	0.8	0.1	9.7	< 0.1	0.5	0.8	0.3

Extension Activities

Ammeter, A. 2023. Know your enemy: Manitoba weed surveys provide update on new and established threats. Fence Post. Spring-Summer 2023. Pages 18-19.

Beckie, H. J., Shirriff, S. W., Leeson, J. Y., Hall, L. M., Harker, K. N., Dokken-Bouchard, F., & Brenzil, C. A. (2020). Herbicide-resistant weeds in the Canadian prairies: 2012 to 2017. Weed Technology, 34(3), 461–474. doi:10.1017/wet.2019.128

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Brown-Livingston, K., J.Y. Leeson and S. Hladun. 2022. Residual Weed Population Shifts in Manitoba – 1978 to 2022. Poster presented at the Manitoba Agronomists' Conference, December 14-15. Winnipeg, MB. Abstract at https://umanitoba.ca/agricultural-food-sciences/school-agriculture/school-manitoba-agronomists-conference (Attendance > 100)

Chastko, T. Benaragama, D. Leeson, J.Y., Willenborg, C. J. 2024. The impact of herbicide-resistant canola systems on the weed community dynamics in the Canadian Prairies. Canadian Journal of Plant Science. 104 (5):514-528.https://doi.org/10.1139/cjps-2023-0158.

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Leeson, J.Y. 2018. Weed Management Practices in Annual Cropping Systems in the Prairie Provinces. Abstract in proceedings of the Canadian Weed Science Society Annual Meeting, November 19-22, Niagara Falls, ON. (Attendance ~ 200)

Leeson, J.Y. 2019. Prairie Provincial Weed Surveys: Canola – Weeds, Crop Stand, Management. Oral presentation at Canola Council Agronomy Specialists Meeting. January 18. (Attendance 12)

Leeson, J.Y., L. Hall, C. Neeser, B. Tidemann and K. N. Harker. 2020. Alberta's Current Weed Survey Results. Agronomy Update 2020. January 7-8. Red Deer, AB.

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Leeson, J.Y., and S. Hladun. 2022. Residual Weed Population Shifts in Saskatchewan – 1976 to 2021. Poster presented at the joint Weed Science Society of America and Canadian Weed Science Society Annual Meeting, February 22-24. Abstract available on-line:https://wssa.net/meeting/meeting-abstracts/(Attendance ~ 440)

Leeson, J.Y., S. Hladun, C.M. Geddes, CM, C. Neeser, and B. Tidemann. 2023. Residual weed population shifts in Alberta – 1973 to 2023. Poster presented at the Canadian Weed Science Society Annual Meeting, November 20-23. Winnipeg, MB. (Attendance ~ 200)

Leeson, J.Y., Geddes, C.M. and Brown-Livingston, K. 2024. Manitoba Weed Survey. Manitoba Crop Alliance All Delegates Meeting. Brandon, MB. 2024/02/01-02. Invited. (Oral Presentation). 45 in attendance.

McCallum, B. D., C. M. Geddes, S. Chatterton, G. Peng, O. Carisse, T. K. Turkington, O. Olfert, J. Leeson, S. Sharpe, E. Stephens, V. Hervet, R. Aboukhaddour, M. Vankosky. 2021. We stand on guard for thee: A brief history of pest surveillance on the Canadian Prairies. Crop Protection. Volume 149. https://doi.org/10.1016/j.cropro.2021.105748.

Prairie Weed Monitoring Network. 2024. www.prairieweeds.com

Schmidt, L.. 2024. Status of Weed Surveillance Efforts in Manitoba. Pulse Beats. https://www.manitobapulse.ca/2024/04/pulse-beat-99-spring-2024/

Tidemann BD (2020) What's up with Alberta's Weeds? Invited presentation at FarmTech 2020. Edmonton, Alberta. January, 2020. Estimated audience of 300 people.

Tidemann BD (2023) Getting into the weeds. Invited presentation at the Sask Forage Seed Development Commission Annual Meeting. White Fox, SK. December 2023. Estimated audience of 75 people.

Tidemann BD (2023) What's up with weeds? Invited presentation at Central Alberta Co-op producer update. Innisfail, AB. February 2023. Estimated audience of 100 people.

Tidemann BD (2023) Grassy weeds in the Prairies: The pests, the problems, the plans. FMC Pre-School webinar, invited presentation [virtual]. February 2023. Estimated audience of 500 live, online recording posted so possibly higher.

Tidemann BD, Sharpe SM, Geddes CM, Leeson J (2024) Kochia finds a new frontier. Invited presentation at Agrivisions. Lloydminster, SK. February 2024. Estimated audience of 100.

Tidemann BD, Sharpe SM, Geddes CM, Leeson J (2024) Kochia: An old enemy in new places. Invited presentation at Central Alberta Agronomy Round-up. Stettler, AB. February 2024. Estimated audience of 75.

Whetter, J. 2019. Agronomy Insights: Top 10 weeds in canola. Page 36 in Canola Digest: March Edition. Available: https://canoladigest.ca/download/23/previous-issues/.../canola-digest-march-2019.pdf (Average Circulation 40,000)

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WGRF. 2019. Provincial Weed Surveys: Knowledge is power when it comes to weed management. Pages 20-21 in Western Grains Research Review Magazine Available: https://westerngrains.com/wp-content/uploads/2018/01/Final-WGRF_Magazine_2019-Web-version.pdf

Final Extension Report

Executive Summary

Weed surveys of annual crops have been regularly conducted in the Prairie Provinces since the 1970's. In the 1990's, a herbicide resistance component was added to the provincial surveys. The objectives of the project were to complete the sixth set of weed surveys in the Prairie Provinces and summarize previous weed survey information to help identify changes in weed populations.

From 2019 to 2023, weeds were surveyed in 4098 fields of annual crops in the Prairie Provinces. Saskatchewan was surveyed in 2019 and 2021, Manitoba in 2022 and Alberta in 2023. Crops surveyed included: spring wheat, barley, durum, oat, canola, flax, mustard, soybean, lentil, pea, chickpea, corn, pinto bean and sunflower. Weed data are summarized using a relative abundance index based on frequency, field uniformity and density. Similar methodology has been used since the beginning of the survey program, enabling the identification of shifts in weed communities.

While the number one ranked weed, green foxtail, has not changed since the onset of the survey program, several weeds were identified as increasing. In particular, there was an increase in the relative abundance of volunteer canola in all three provinces, ranking second overall in the current round of surveys. Other volunteer crops that have increased in abundance over time include: wheat, barley, and lentil. The increased presence of volunteer crops as weeds reflects both the increased acreage of these crops and diversification of crop rotations. Kochia also ranked higher than any previous survey in all provinces, likely due both to favourable weather and the spread of herbicide-resistant biotypes. Other weeds increasing include spiny annual sow-thistle, false cleavers, foxtail barley, broad-leaved plantain, barnyard grass species and dandelion. Some emerging regional species identified in this survey include golden dock, green pigweed and yellow foxtail in Manitoba, black medick in Saskatchewan and annual blue grass in Alberta. Other weeds of concern include round-leaved mallow, biennial wormwood, annual brome species and stink grass.

Weeds identified as increasing in abundance can be targeted for attention by various agencies involved in weed science. The trends identified by the weed surveys are important to the research, industry, and extension communities for developing weed management recommendations for producers that are essential components of sustainable farming systems. Regular weed surveys are necessary to detect changes in weed populations. Further monitoring is necessary to determine if the high relative abundance of some species was related to weather in the survey year, or if these species are increasing in abundance due to other factors. Future surveys could also determine the impact of emerging herbicide resistant weeds, and any mitigation practices that are adopted.

Survey Design

A weed abundance survey was completed in the Prairie Provinces including 4098 fields of annual crops from 2019 to 2023. Saskatchewan was surveyed in 2019 and 2021, Manitoba in 2022 and Alberta in 2023. The survey included the most common annual crops in each province (canola, spring wheat, durum, soybean, pea, lentil, oat, barley, mustard, flax, and corn). In Manitoba, pinto beans, sunflower

and field peas were also included in the survey. The fields were distributed amongst ecodistricts (areas with similar in landform, relief, surficial material, soil, vegetation and land use based on the seeded area of the selected crops. Sites were randomly selected from all quarter sections (65 ha) that have greater than 16 cultivated hectares. Owners were then identified and contacted to seek permission to survey their land. Weeds that had not been controlled in the fields were counted in mid-July through to September. At this time, the weeds in the field are, in part, a result of the agronomic management decisions made by the farm operator at various times during the crop year. Counts at this time of the year show the size and extent of troublesome weed populations. Within each field, weeds are counted in 0.25-metre square quadrats (50 cm by 50 cm) at 20 locations in a set pattern, avoiding any edge effects. The weed data was also summarized in a similar fashion to previous surveys to allow direct comparisons. Weeds were ranked using a relative abundance index based on frequency (percent of surveyed fields with the weed), field uniformity (percent of quadrats with the weed within a field) and density.

Results

Herbicide Resistance 2014-2017

The third round of pre-harvest herbicide resistance (HR) surveys conducted in Saskatchewan in 2014/2015, Manitoba in 2016, and Alberta in 2017, included 798 randomly selected cropped fields across 28 million ha. Of the fields where wild oat was collected, 69% had an HR biotype: 62% acetyl-CoA carboxylase inhibitor (group 1)-HR, 34% acetolactate synthase inhibitor (group 2)-HR, and 27% group 1+2-HR (vs. 44, 12, and 8%, respectively, in the previous second-round surveys from 2007 to 2009). The increase in group 2 resistance is the result increased selection pressure due to the reliance on this mode of action to manage group 1 resistance. The rise of group 2 resistance in green foxtail (11% of sampled fields) and yellow foxtail (17% of Manitoba fields), which was not detected in the previous survey round, parallels the results for wild oat resistance. There are no POST options to control group 1+2-HR wild oat in wheat or barley. Various group 2-HR populations of broadleaf weeds were confirmed, with cleavers, chickweed and stinkweed being most abundant. These surveys bring greater awareness of HR weeds at local and regional levels, and highlight the increasing urgency to preserve herbicide susceptibility in our key economic weed species.

Herbicide resistance surveys were also conducted on a subset of the fields included in the general survey from 2019 to 2023 in a separate project. Further increases in the prevalence of herbicide resistant weeds were documented in Saskatchewan and Manitoba with results from Alberta pending final testing. All the herbicide resistance data from the 1990's to present were collated to aid in the understanding of the development of herbicide resistance in the Prairie Provinces. This information will be available to the public on the Prairie Weed Monitoring Network website.

Top weeds in Prairies Provinces 2019-2023

When the data was combined across the Prairie Provinces, green foxtail was identified as the most abundant weed as in each of the previous surveys. Green foxtail was the most abundant weed in oat, corn and flax crops and ranked second in wheat, field pea and lentil crops. Volunteer canola ranked second overall and was the most abundant weed in wheat, barley, soybean, field pea and lentil crops.

Across all annual crops, wild oats and wild buckwheat ranked third and fourth, slightly lower than previous surveys, displaced by volunteer canola. Lamb's-quarters ranked fifth, a position it has held in five of the six surveys. The consistent presence of green foxtail, wild oat, wild buckwheat and lamb's-quarter in the top five most abundant weeds in the past fifty years reflects the widespread distribution and resilience of these species.

There were some differences in the top weeds in each year of the survey, attributable to province and weather in the survey year. In Saskatchewan in 2021, kochia was in the top 5 weed species due to the dry conditions. In Manitoba, redroot pigweed is more common, ranking fifth. In Alberta, chickweed was the most abundant weed, due to wet conditions in 2023 the boreal regions.

Weeds Increasing In Abundance

Volunteer canola has increased in relative abundance in all three provinces. Other volunteer crops that have increased in abundance over time include: wheat, barley, lentil, alfalfa, field pea, oat, and soybean. The increased presence of volunteer crops as weeds reflects both the increased acreage of these crops and diversification of crop rotations.

Kochia was the sixth most abundant weed in the Prairie provinces from 2019-2023, ranking higher than any previous survey, likely due both to favourable weather and the spread of herbicide-resistant biotypes. Over the survey years there has been some fluctuation in the abundance rank of kochia due in part to its adaption for drier conditions; however, overall it has rapidly been increasing in abundance; and becoming a problem in all of the Prairie Provinces. While it is generally more troublesome in the drier grassland areas of the Prairies, it's range has been expanding north. The rapid evolution of herbicide resistance in this species highlights the need to develop alternative weed management solutions.

Spiny annual sow-thistle, false cleavers, foxtail barley, broad-leaved plantain, barnyard grass species and dandelion have all increased since the 1970's; however, their relative abundance rank in the 2019-2023 survey was similar or lower than in the 2014-17 surveys. Herbicide resistant biotypes have been found in the Prairie provinces for four of these species (spiny annual sow-thistle, false cleavers, foxtail barley, and barnyard grass species). Additional surveys are required to determine if these species will continue to increase under favourable weather conditions.

Several less widespread weed species have also increased in frequency across the prairie provinces since the early 2000's. These species are of concern as they may be expected to continue to expand their range. Annual blue grass is currently primarily found in northern Alberta and Saskatchewan, excluding the Peace River region. Low cudweed is associated with wetter regions of Saskatchewan and Alberta and could be expected to spread if weather is favourable. Both round-leaved mallow and black medick are common in Manitoba, eastern Saskatchewan and western Alberta. Biennial wormwood, golden dock, green pigweed and yellow foxtail are more common in the eastern portion of the prairies.

Other locally abundant species of note that have increased in frequency across the prairie provinces since the early 2000's include annual brome species and stink grass. The increase of downy brome, Japanese brome and stink grass is especially concerning due to the detection of herbicide resistant biotypes.

Relevance to farmers and future research

Weeds identified as increasing in abundance can be targeted for attention by various agencies involved in weed science. The trends identified by the weed surveys are important to the research, industry, and extension communities for developing weed management recommendations for producers that are essential components of sustainable farming systems.

Regular weed surveys are necessary to detect changes in weed populations. Further monitoring is necessary to determine if the high relative abundance of some species was related to weather in the survey year, or if these species are increasing in abundance due to other factors. Future surveys could also determine the impact of emerging herbicide resistant weeds, and any mitigation practices that are adopted.

The Prairie Weed Monitoring Network website is currently being developed to increase accessibility to weed survey data. The website will include data from each of the Prairie Weed Surveys starting in the 1970's.