PREVENT CANCER NOW

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Integrated Pest Management and Pesticides on Ontario Golf Courses

Full Report

November 2020

Photo credit: Andrew Nisker

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Introduction

"Canadians are passionate about a game that has a major economic, employment, health, tourism, environmental and charitable impact …," states Golf Canada.[1] The green vistas of golf courses in Canada's suburbs and rural landscapes appear bucolic, but are generally maintained using pesticides to manage diseases, weeds and insects. Intensity of pesticide use on golf courses in many developed nations is greater than in agriculture, ranging from approximately double in Ireland [2] to four-fold in Canada and nine-fold in the U.S.[3]

Ontario golf course owners and managers do something that is rare, if not unique, in North America. Every year, they are required to report pesticide use, and to make this information public online as well as on site. This arrangement originated under the *Cosmetic Pesticides Ban Act* (2008) (CPBA)[4] and Regulation 63/09 [5] that restricted pesticide use for "cosmetic" purposes (uses that do not result in public health benefit). Golf courses were permitted to use more toxic products, contingent upon training and implementation of Integrated Pest Management (IPM) and regular reporting to demonstrate how they are reducing pesticide use.

A decade following the passage of the CPBA and Regulation 63/09, *Prevent Cancer Now* anticipated that the Ontario golf industry would have reduced pesticide use, and learned lessons that could be shared to benefit golf course owners and golfers across North America.

In response to repeated queries regarding use of the data on the IPM website and lessons learned to advance healthy turf care, *Prevent Cancer Now* was told by the Ontario Ministry of Environment and Climate Change (OMECC) (now Ontario Ministry of Environment, Conservation and Parks [OMECP]) and the IPM Council of Canada, that the files received from the golf courses are simply posted online. To date, the IPM data had not been used for research. Thus, with experts doing planning and analyses, and volunteer citizen scientists extracting data, *Prevent Cancer Now* set out to assess whether IPM has reduced pesticide use on Ontario golf courses.

A brief history of "cosmetic" pesticides restrictions and the golf/IPM alliance

Concerns over unintended environmental and human health effects of pesticides came into widespread public consciousness with Rachel Carson's compelling description of effects of the insecticide DDT, in *Silent Spring* (1962).[6] In 1996, John Wargo published *Our children's toxic legacy: how science and law fail to protect us from pesticides.*[7,8] Wargo contrasted the complexities and vulnerability of foetal and child development with the simplistic single-chemical hazard + exposure = risk approaches of pesticide regulation. He described how knowledge gaps – both the unknown and the unknowable – are exploited to impede regulation.

In 2001, the Supreme Court of Canada ruled in favour of the town of Hudson, Quebec, over Spraytech / Société d'arrosage, that municipalities may restrict pesticide use for the general welfare of constituents (i.e., in good faith, at the request of the citizenry).[9] Hudson's local government and citizenry had been inspired by the persistent, detailed deputations of local physician, Dr. June Irwin who presented case reports and argued that pesticides used in the town were harming her patients.

In Ontario, the findings of Dr. Irwin and others were substantiated with scientific reviews by Toronto Public Health[10] and the Ontario College of Family Physicians[11,12] detailing human health impacts of pesticides, including an analysis that further restrictions beyond federal regulation are necessary to protect public health.[13] Potential harms, particularly permanent effects from early life exposures, are of particular importance when there is no countervailing public health benefit in contrast with hazards (i.e., pesticide use is for "cosmetic" purposes). Exposures to pesticides used for landscaping were confirmed, as they contaminated waterways in Toronto and Ottawa.[14,15]

Following the Supreme Court ruling, public concern culminated in the rapid development of a patchwork of local pesticide bylaws. A need to protect public health was addressed by the provincial government in Ontario when the CPBA and Regulation 63/09 [5] established that only least-toxic products and strategies are permitted to attain cosmetic goals in urban landscaping.

During this time, IPM had been widely promoted by lawn care and golf organizations as a reliable, science-based means to reduce pesticide use.[16] The Ontario Chapters of the National Golf Course Owners Association Canada played key roles as founders of the IPM Council of Canada in 2004,[17] with assurances that, "[t]he [IPM] Council believes that science has proven IPM ensures environmental sustainability and the reduction of all inputs including water, fertilizer and pesticides."[18] Along with Ridgetown College at the University of Guelph, the IPM Council of Canada helps to organize training, certification, audits, housing of reports on a website, and more.[19]

Leading up to passage of the CPBA, public pressure for consistent restrictions of pesticide use on lawns and golf courses led representatives of Ontario and national golf course organizations to present at public meetings, and to lobby municipal and provincial politicians and bureaucrats. Their advocacy focused on arguments that pesticides are essential for golf courses, framed with a strong belief in and commitment to reduction of pesticide use with IPM. In a compromise between health advocates and the golf industry, Regulation 63/09 [5] required golf courses and "IPM agents" to pay fees, maintain ongoing education and certification in IPM, post annual pesticides use reports on the IPM Council of Canada website, and arrange annual meetings to present these findings to the public.[5,18] In 2020, *Pesticides Act* amendments ended requirements for annual meetings, and permitted cemeteries to use toxic pesticides in the context of IPM training and reporting.

Objectives

The rich dataset being collected under Regulation 63/09[5] provides data that could be leveraged for research to advance IPM best practices, and to achieve substantial reductions in pesticide use. When asked repeatedly from 2016 to 2019 about the progress made by golf courses in reduction of pesticide use and adoption of least-toxic methods, the Ontario MECP informed *Prevent Cancer Now* that the Ministry was not tracking the IPM Council of Canada initiative, and that the matter rested with the Council. The IPM Council of Canada acknowledged but did not reply to emails, and listed no telephone number. *Prevent Cancer Now* sought to use data posted on the Council website to determine:

1. if golf courses had indeed reduced pesticide use under Regulation 63/09; and
2. under what circumstances any progress may have been achieved.

Methods

Data Acquisition

Since 2010, Ontario golf courses have been required to report usage of Class 9 pesticides (products that are banned for cosmetic uses and that require licencing of applicators) under Regulation 63/09.[5] Total quantities of each active ingredient are reported, as total kilograms applied over the previous year. The courses also must state the reason for pesticide use, the quantity used the preceding year and the reasons for the change in use over the past season.[5]

Golf courses were selected from a list ranking the top Ontario golf courses,[20] and for diverse locations. Pesticide data was originally accessed through an index of IPM-registered Ontario golf courses on the IPM Council website (www.IPMCouncilCanada.org), where all of the IPM registered courses were listed transparently online. Following electronic outreach seeking volunteers for this project, that was recognized and responded to by pro-pesticides advocates, the website was altered such that data is now available only through a search function at https://public.IPMCouncilCanada.org. Reports are in the form of pdfs and jpegs, sometimes as scans or images of handwritten forms. This means that data extraction from the online system is time-intensive – albeit relatively straightforward – representing an opportunity for volunteer citizen science.

An online form was created for data extraction, and pesticide use data was extracted for the years 2010 to 2017. Golf courses were disregarded when excessive missing and/or corrupted files meant that analysis would be intractable. Sixteen golf courses were included in the final analysis. After compiling the data, several rounds of quality control were executed, checking for erroneous transcription (i.e., human error in data extraction) as well as cleaning the data (i.e., correcting spelling errors and removing reports of class 11 pesticides [safer products such as mineral oil, that are not required to be reported]) When a commercial product that contained multiple ingredients had been erroneously reported, the quantities of the individual active ingredients were calculated and entered into the database.

Pesticide labels are legal documents with which applicators must comply; one is created for each pesticide product registered in Canada under the *Pest Control Products Act*. Labels for pesticide products were downloaded from the pesticide label search form on the Health Canada website.[21] These searches were accomplished by searching active ingredient name as well as “golf” or “turf” as accessory terms. Information extracted from labels included pesticide type (insecticide, herbicide or fungicide), group (according to the mode of action), toxicity concerns for various groups, and the application rate, or range of rates, for turf.

Data Normalization

Various pesticide products are of widely different potency, meaning that direct comparison of the quantities applied is meaningless. Pesticide use is reported as kilograms of active ingredients, so before summing up and comparing use of numerous pesticides the quantities applied were normalized according to potency. To make fair comparisons, we divided the kilograms by the average application rate for turf (kilograms per hectare or kg/ha) according to official labels on the Pest Management Regulatory Agency (Health Canada) website.[21]

[equivalent hectares] = [kilograms of pesticide active ingredient] ÷ [average application rate (kg/ha)]

Equivalent hectares (ha-eq) is the average area for a single application. This approach has been described by the Organisation for Economic Cooperation and Development (OECD) pesticide data guidance, recommending reporting "Application Area" to account for repeated applications of a given product,[22] but to our knowledge this is the first research summing normalized quantities to sum and compare applications of numerous pesticides, that have widely different potencies.

Some labels list a range of recommended rates; for instance, fungicide recommended rates could vary by up to 7-fold depending on species of fungus being treated on turf and the frequency of treatment. We used the range of application rates to identify a minimum, maximum and mean rate for each chemical, and used the mean rate and the quantity applied to determine the ha-eq.

Information availability on the IPM Council of Canada website

During initial investigations it was noted that some golf courses were not reporting to the IPM Council. Quantification was hampered when the website was revised, eliminating the previous list of all reporting golf courses and presenting only a search bar. In 2020, the IPM Council of Canada website was investigated to determine the golf courses reporting, as well as the completeness in terms of the existence of appropriately labelled files containing pesticide reports and maps.

Analyses

Using the master data set (16 golf courses over an 8-year period), we queried class 9 pesticide use on Ontario golf courses, addressing:

1. Trends of pesticide use (normalized as ha-eq using the average permitted application rate) in terms of:
    a. Annual use of fungicides, herbicides, insecticides and total pesticides;
    b. Use of pesticides by Audubon-certified versus non-Audubon-certified courses; and
    c. Testing a potential hallmark of IPM, that pesticides are used only when needed and not prophylactically (i.e., routinely, to prevent a possible infestation that is not confirmed). In the absence of IPM, pesticide use was expected to be more consistent but higher than when pesticides are applied only in response to an observed pest.

Results

Sufficient data for analyses was extracted for 16 of the top 50 golf courses, from across Ontario.[20] All selected golf courses have 18 holes, and rank highly on a national level. Numerous courses were ultimately not included because files were missing or corrupted.

Among the 16 representative golf courses, over the eight-year study period, a total of 44 unique active ingredients were reported. These included 26 fungicides, 10 herbicides and 8 insecticides, outlined in Tables 1, 2 and 3, respectively. Application rates ranged from 75 to 17,875 g/ha for fungicides; 12 to 4320 g/ha for herbicides; and 24 to 9320 g/ha for insecticides. The application rate, or mean application rate was used for summary data and analyses.

Two highly toxic fungicides that were no longer registered for use in Canada were reported in 2010. Benomyl, banned as of 2003, and chloroneb banned as of 2009 were included in analysis of ha-eq using application rates from historical labels.

Reports of less hazardous class 11 pesticides, including corn gluten meal, acetic acid and mineral oil that are not required to be reported under the IPM program were excluded from analyses.

Table 1. Fungicide active ingredients used on golf courses, 2010 - 2017

Active Ingredient Name	Mode of Action	Application Rate (g/ha)
Benomyl*	Unknown	1500-6250
Chloroneb*	Unknown	8125-17875
Chlorothalonil	Group M	2393-17490
Thiophanate-Methyl	Group 1	1750-12250
Iprodione	Group 2	1500-9000
Metconazole	Group 3	420-560
Myclobutanil	Group 3	720
Propiconazole	Group 3	372-1473
Tebuconazole	Group 3	720-1536
Triticonazole	Group 3	320-640
Metalaxyl-M & S-Isomer	Group 4	384-768
Benzovindiflupyr	Group 7	75
Boscalid	Group 7	224-392
Fluopyram	Group 7	175-250
Isofetamid	Group 7	508-636
Penthiopyrad	Group 7	450-750
Azoxystrobin	Group 11	300-1200
Fluoxastrobin	Group 11	278-552
Mandestrobin	Group 11	234-428
Trifloxystrobin	Group 11	155-305
Pyraclostrobin	Group 11	170-560
Fludioxonil	Group 12	375-750
Quintozene	Group 14	5400-7400
Cyazofamid	Group 21	493-918

Active Ingredient Name	Mode of Action	Application Rate (g/ha)
Propamocarb hydrochloride	Group 28	4621
Fosetyl-al	Group 33	16000

*Application rates were determined from historical labels. The last date for legal use of any product containing benomyl was Dec 31, 2003,[23] and chloroneb was Dec 31, 2008.[24]

Table 2. Herbicide active ingredients used on sample golf courses, 2010 – 2017.

Active Ingredient Name	Mode of Action	Application Rate (g/ha)
Fenoxaprop-p-ethyl	Group 1	92
Bispyribac (sodium)	Group 2	12-71
Dithiopyr	Group 3	434-558
2,4-D	Group 4	1072
Mecoprop-P	Group 4	825-1275
Dicamba	Group 4	600
Glyphosate	Group 9	902-4320
Carfentrazone-Ethyl	Group 14	110
Paraquat	Group 22	700
Trinexapac-Ethyl	Plant Growth Regulator Type II, Class A	45.2-361

Table 3. Insecticide active ingredients used on sample golf courses, 2010 – 2017.

Active Ingredient Name	Mode of Action	Application Rate (g/ha)
Carbaryl	Group 1A (Organophosphate)	9320
Chlorpyrifos	Group 1B (Organophosphate)	898-1123
Chlorantraniliprole	Group 28	29-225
Deltamethrin	Group 3 (Pyrethroid)	60
Lambda-Cyhalothrin	Group 3 (Pyrethroid)	37
Imidacloprid	Group 4A (Neonicotinoid)	281
Clothianidin	Group 4A (Neonicotinoid)	275
Spinosad	Group 5	24-48

Total Pesticide Use

Total pesticide use, normalized as ha-eq for each of 16 golf courses, from 2010 to 2017, is depicted in Figure 1. Total pesticide use ranged from 80 ha-eq to over 500 ha-eq. Some golf courses consistently used lower quantities of pesticides than the norm, while some courses used highly variable quantities from year to year.

Of the 16 golf courses, seven were certified by Audubon International under the classic category.[25] (Note: Audubon International is not a program of the venerable Audubon Society.[26]) The classic category applies to facilities that were not originally designed with Audubon

International objectives in mind, but committed to a range of measures, including minimizing pesticide use.[25]

Notably, courses H (red line) and O (light green line) are among the consistently lowest pesticide users, and both are certified by Audubon International. They are located in different ecozones, with one located in the Greater Toronto Area, and the other in a more remote location.

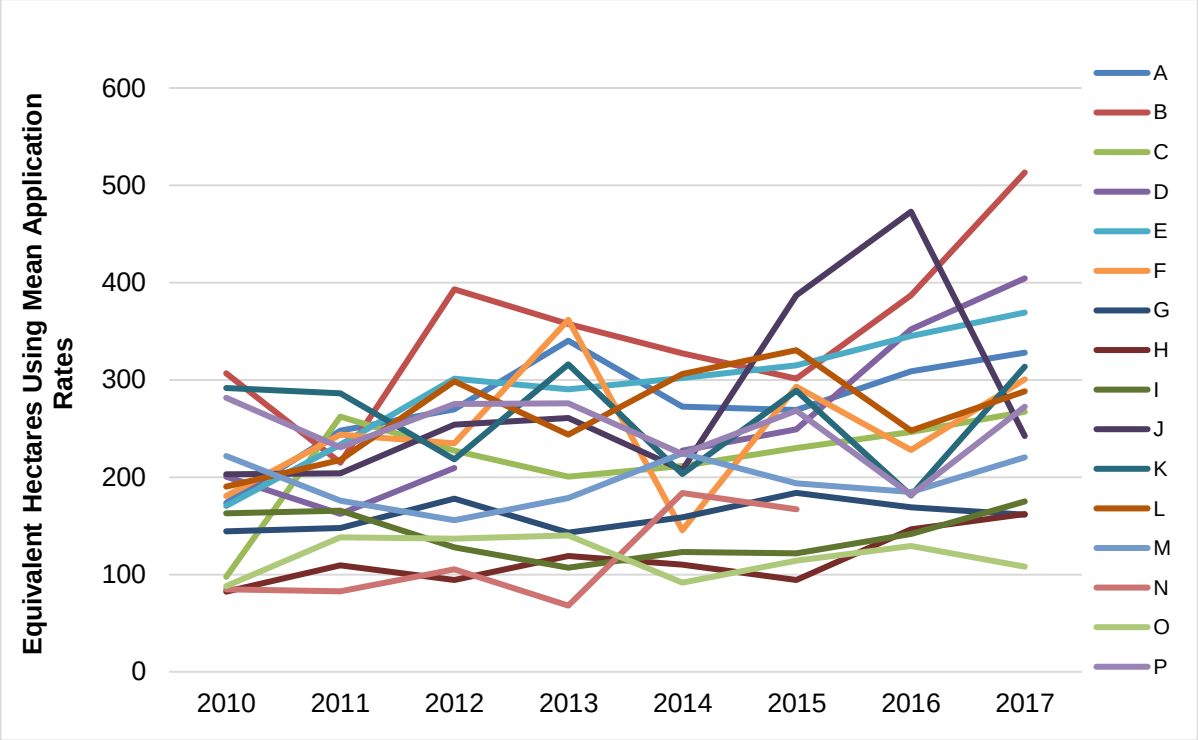


Figure 1. Total pesticide use as equivalent hectares (ha-eq) by each of 16 golf courses (7 Audubon certified; 9 not Audubon-certified), from 2010 to 2017.
Courses A, B, C, E, H, K and O were Audubon-certified.
Courses D, F, G, I, J, L, M, N and P were not Audubon-certified.
The data presented here includes outliers that were re-checked against the online IPM reports.

Annual pesticide use is also visualized in Figure 2, with the median depicted by the line, pesticide use of 75% of courses in boxes, and range of pesticide use among all courses as thin bars. There is no suggestion of a decrease in total pesticide use over time in this sample.

Total pesticide use (ha-eq) varied five-fold among this sample of golf courses. Pesticide use varied by more than a factor of 5 among golf courses, and was equivalent to more than the area of a typical golf course (60-100 ha) getting one application per year. Since the applications are concentrated on greens, and greens are typically about 5% of the total area, greens are receiving the equivalent of from 5 to more than 20 applications per year.

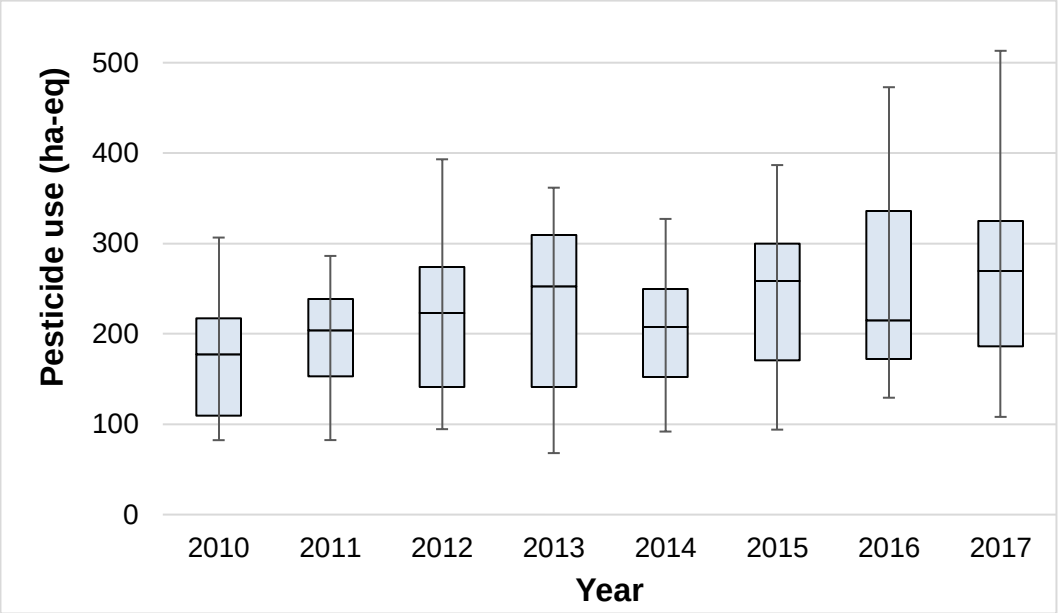


Figure 2: Total pesticide use normalized to equivalent hectares (ha-eq), calculated using the mean recommended application rate, for 16 Ontario golf courses. Bars represent minimum and maximum values, boxes represent the 1st to 3rd quartile, and the centre line is the median value.

Use of Fungicides, Herbicides and Insecticides

Golf courses include specialty turf, with the greens being particularly susceptible to fungal diseases. The largest fraction of pesticide use is fungicides, followed by herbicides and insecticides (Figure 3).

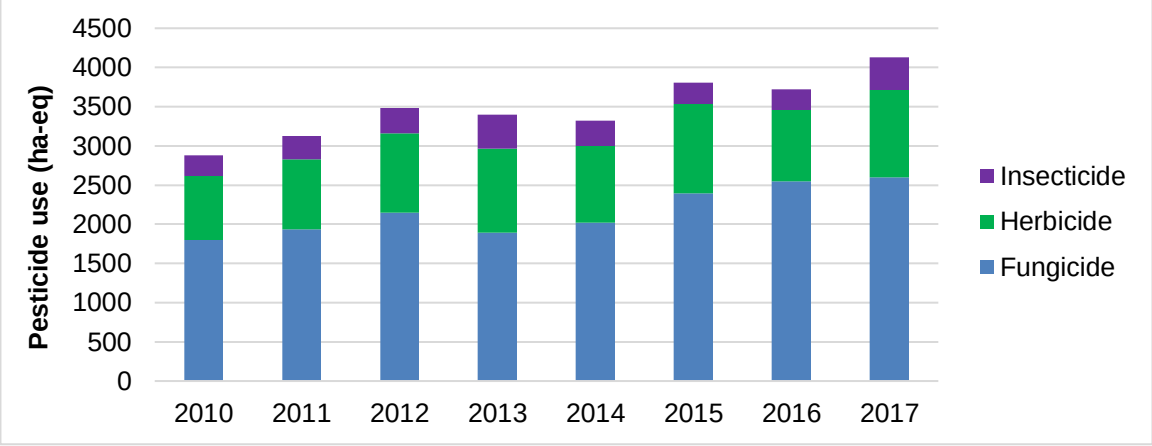
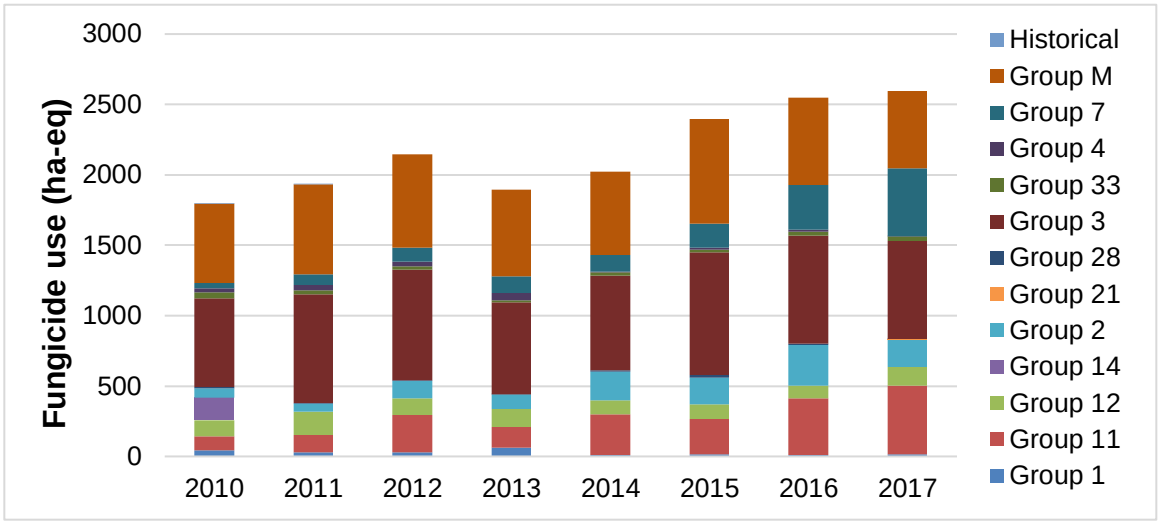


Figure 3. Total use of fungicides, herbicides and insecticides by 16 golf courses, equivalent hectares (ha-eq)

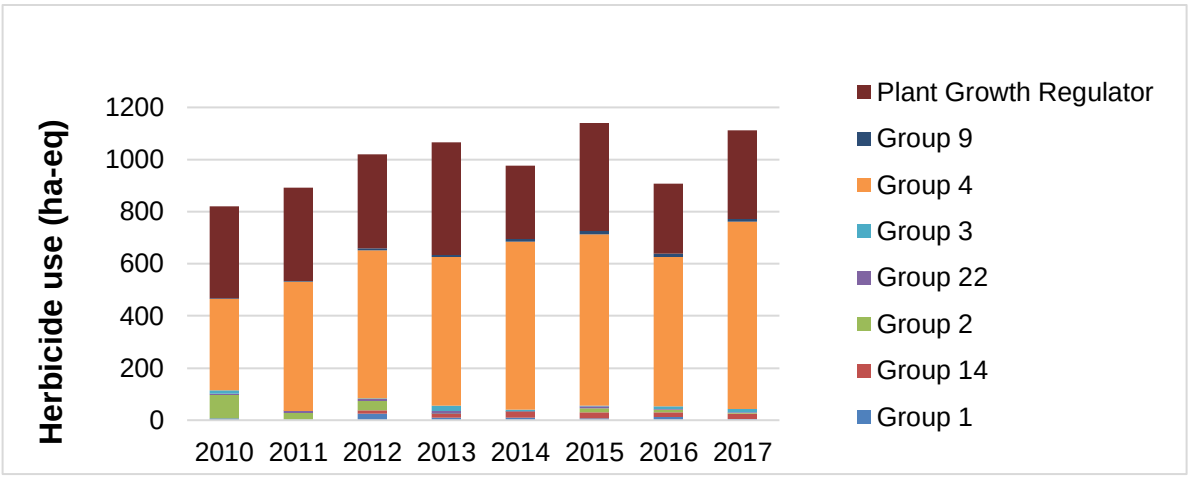
Pesticide Modes of Action

It is recommended that if pesticides are being used, that products with different modes of action should be used in rotation in order to forestall pest resistance. Fungicides, herbicides and insecticides with the same mode of action are grouped in panels A, B and C, in Figure 4, with clear preferences for a small number of modes of action (modes are listed in Tables 1 to 3).

A



B



C

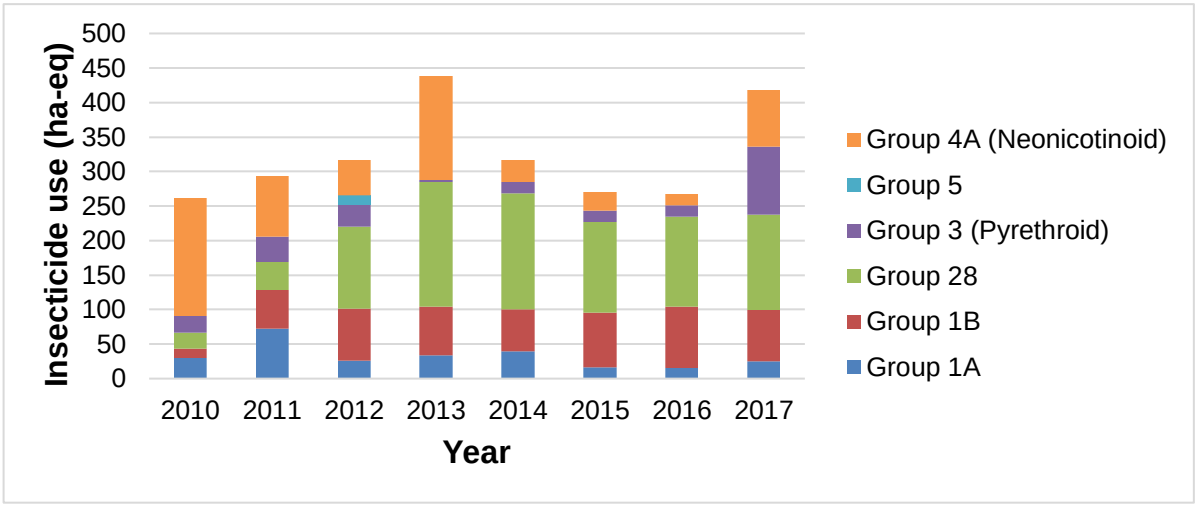


Figure 4. Total use of specific pesticide active ingredients by 16 Ontario golf courses (ha-eq): fungicides (A), herbicides (B) and insecticides (C)

Trends in pesticide use over time, for all courses combined

Further to visual inspection of the bar charts above, trend analyses of pesticide use on the entire sample of golf courses (see Appendix 1) suggest that pesticide use did not decrease during IPM implementation. Table 4 summarizes increased use over time of fungicides (high certainty) and herbicides (80 percent probability) across all golf courses combined, while use was unchanged among the sample of Audubon International certified courses. Insecticide use on certified courses increased over time (97 percent probability).

Table 4. Comparison of pesticide use trends for all golf courses, and for Audubon International certified courses

		Probability that a decreasing trend exists
Fungicides		
	All golf courses	0.00
	Audubon-certified	0.46
Herbicides		
	All golf courses	0.20
	Audubon-certified	0.75
Insecticides		
	All golf courses	0.40
	Audubon-certified	0.03

Trends in pesticide use according to variability of use – evidence of IPM

Hypothetically, if IPM was being implemented then pesticide application would be applied only as a last resort. The intent is that non-chemical cultural means, or non-toxic chemicals (e.g. vegetable oil) are used to address pests, and tolerance for pests is increased before using pesticides. In this case, pesticide use could be more highly variable over the years, yet lower over the long term.

The existence of this hallmark of IPM was examined for fungicides, herbicides and insecticides, by plotting total use against variability.* As summarized in Table 5, the only situation that suggested a positive trend was on Audubon International certified courses, where herbicide use tended to be lower as the variability of pesticide application increased. The converse was suggested for fungicide use – use tended to increase with increasing variability of application. Fungal diseases on the highly vulnerable bent grass used on greens progress more quickly than unwanted plants or insects, and this data suggests that prophylactic application of fungicides is preferred.

In summary, Audubon International certified golf courses exhibited this hallmark of IPM principles for herbicide use, with 93 percent certainty. Application of IPM principles was not apparent for use of any pesticides on non-certified courses.

* In technical terms, this is the standard deviation divided by average application rate. Graphs for all courses, and comparisons of Audubon International certified versus non-certified courses, are compiled in Figures A-1 and A-2 (see Appendix 1).

Table 5. Trend (regression) analysis of variability versus normalized total pesticide application rates, for Audubon International certified compared with non-certified golf courses

	Audubon International Certified	*p* (probability that variance did not decrease with increasing pesticide use)
Fungicide	No	
	Yes	0.91
Herbicide	No	
	Yes	**0.069**
Insecticide	No	
	Yes	0.60
Total Pesticide	No	
	Yes	0.37

Data availability and quality on the IPM Council of Canada website

The 2020 investigation of the contents of the IPM Council of Canada golf course search tool revealed that data was available for course ID numbers 8 to 727, of which 17 were broken links. Thus, 703 courses were represented on the site. Of these, 373 courses had at least one file named as reporting pesticides and one reporting maps for every year, and 276 golf courses had submitted no uncorrupted files. In the end, 215 courses – less than one third – had reported both pesticide use and a golf course map, uncorrupted, for all years.

Health effects of pesticides used on Ontario's golf courses

Chemicals applied to Ontario golf courses include 40 unique active ingredients (Tables 1 to 3), as well as adjuvants added to improve ease of application, spreading of pesticides and penetration into leaves and the soil.

The Pesticide Action Network in Europe (PAN International) compiles indicators of concern from a number of international lists identifying highly hazardous pesticides[27] based on the following criteria:

- High acute toxicity
    - World Health Organization (WHO) classification as "extremely" or "highly" hazardous (in rats), or
    - Globally Harmonized System (GHS) classification "fatal if inhaled"
- Long term toxic effects
    - Known, probable or likely human carcinogen according to the WHO International Agency for Research on Cancer (IARC) or US Environmental Protection Agency (US EPA)
    - GHS classification as a mutagen
    - GHS classification as toxic to reproduction

    - Endocrine disruptor European Union category 1, or category 2 plus suspected carcinogen
- High environmental concern
    - Meet criteria for two of three concerns: “very persistent” (per Stockholm Convention); and/or “very bioaccumulative” (per Stockholm Convention); and/or “very toxic to ecosystems” (e.g., in *Daphnia spp.*)
    - Hazard to ecosystem services (e.g., “highly toxic to bees” per US EPA) or
    - Severe or irreversible adverse effects, as listed in Rotterdam Convention Annex III or meeting the Convention’s criteria.

Thirteen active ingredients reported in use on Ontario golf clubs are on the Highly Hazardous list, including:

- Three fungicides benomyl (now banned in Canada), chlorothalonil and iprodione;
- Four herbicides glyphosate, 2,4-DB (that breaks down into 2,4-D) and paraquat; and
- All insecticides identified in this study: Carbaryl, Chlorpyrifos, Chlorantraniliprole, Deltamethrin, Lambda-Cyhalothrin, Imidacloprid, Clothianidin, and Spinosad.

There are concerns beyond these 13 active ingredients. PAN International notes numerous shortcomings in this hazard identification, such as uncertainties extrapolating animal hazards to humans, lack of inclusion of inhalational toxicity, endocrine disruption not being included in WHO classifications, and lack of information on formulants (adjuvants).[27] Every pesticide active ingredient is assessed in isolation, while pesticides may be used in combinations for greater efficacy against pests (and pose greater potential toxicity to non-target species). As well, commercial products include adjuvants to enhance spreading and penetration, and in some cases to slow metabolism – all intended to magnify toxicity. A *Prevent Cancer Now* summary of shortcomings of the pesticide assessment process is appended (Appendix 2).

Golf courses are the largest source of pesticides in urban environments, and are commonly adjacent to bodies of water and wetlands where pesticide runoff may have important ecological consequences. In addition to exposures as a result of playing or working on golf courses, it is also important to consider exposures in surrounding neighbourhoods and residences, including groundwater. As well, ongoing pesticide applications, including persistent chemicals used as historical pesticides, may contaminate the land and have implications for redevelopment.

Conclusions

This study represents the first analyses of potency-normalized pesticide use by 16 Ontario golf courses (2010 to 2017). *Prevent Cancer Now* found that pesticide use did not decrease following passage of the *Cosmetics Pesticides Ban Act*. Indeed, in this sample of courses, pesticide use increased over the years following initiation of IPM training and pesticide use reporting.

Reporting by Ontario golf courses began in 2010. *Prevent Cancer Now* embarked upon this pilot investigation of IPM reporting under Regulation 63/09 [5] with the hope that IPM was indeed achieving the promises heard during consultations regarding pesticides use for cosmetic purposes and that lessons learned could bring further reductions in pesticide use among golf courses in the province and further afield.

Annual pesticide use ranged from less than 100 ha-eq to over 500 ha-eq across this sample of golf courses. A small number of courses consistently used substantially smaller quantities of pesticides, demonstrating that opportunities exist to advance the field by recognizing and emulating successes. The hectare equivalent was more than the area of a typical golf course (60-100 ha). Since the applications are concentrated on greens, and greens are typically about 5% of the total area, greens may be receiving the equivalent of 20 or many more applications per year.

Audubon International certified courses exhibited a potential hallmark of IPM in use of herbicides, in that lower overall herbicide use was associated with greater variability over the study period. Otherwise, there was no indication that IPM-based decision-making was being implemented; i.e., that pesticide use followed routine scouting and after exhaustion of alternatives.

The results of this study indicate that the opportunity to reduce pesticide use on Ontario golf courses is falling short. Online reporting could be automated to improve the convenience and accuracy of reporting, and to produce useful databases for analyses and research. At present, data collection is inefficient and incomplete, and data extraction is onerous.

Key Findings

Despite IPM promises and reporting, this sample of Ontario golf courses did not reduce pesticide use

- Total use of pesticides did not decrease from 2010 to 2017.
- Reported total use of pesticides at each golf course during a single year, including fungicides, herbicides and insecticides, ranged from 80 to more than 500 ha-eq.

Lower pesticide use is possible – some courses fared better than others, across Ontario

- The small number of courses (five in our sample) that consistently used lower quantities of pesticides are located in multiple ecozones, including the Greater Toronto Area as well as remote locales.

Not all Ontario golf courses were complying with IPM reporting, and no one is keeping track

- In searches for known Ontario golf courses, it was found that some are not represented on the IPM Council of Canada website. In 2019 the IPM website had active folders for about 700 courses, while Scoregolf.com reports that there are more than 800 courses in Ontario.
- Many of the reporting golf courses had missing or corrupted files, mostly in initial years.
- Less than one third of Ontario golf courses reported complete data.
- The Ontario Ministry of Environment and Climate Change (now Ontario Ministry of Environment, Conservation and Parks) indicated that the IPM Council should police reporting under Regulation 63/09. The IPM Council indicated that as a small, cash-strapped volunteer organization representing all Ontario golf courses, it lacks capacity (and arguably jurisdiction).
- Initially, illegal use of old pesticides that were no longer registered was reported. This was not observed in recent years.

Golf courses that are Audubon International certified might apply IPM to herbicide use

- On certified golf courses herbicide use was more variable, and it was also lower. This suggests that herbicide use might be in response to weeds rather than routine. This hallmark of IPM was not evident for the entire sample of courses, or for fungicides, insecticides or total pesticides.
- Use of pesticides that are least-toxic options (e.g., corn gluten meal herbicide or vegetable oil insecticide) was sometimes reported, although reporting of these is not required.

Pesticides pose hazards to players, workers, neighbours and ecosystems

- Three fungicides, three herbicides and all insecticides used on Ontario golf courses have been identified as “highly hazardous” by international authorities (e.g., World Health Organization, European Union and US EPA).
- Pesticide ingredients used on Ontario golf courses are convincingly associated with cancers, child developmental problems (including neurodevelopment and birth defects), respiratory problems such as asthma, immune dysfunction, and cardiovascular and neurological diseases. Some active ingredients interfere with hormone systems (i.e., are endocrine disruptors).

An opportunity for research and improvement is being squandered

- The rich dataset being collected under Regulation 63/09 is on-the-ground experience that could and should be leveraged for research to advance best practices and pesticide reduction.
- The reporting method using document files is inefficient and requires onerous data extraction to make use of the information. Online reporting in a form would be more convenient for the IPM Council and golf course staff, and would permit automatic validation of reporting (e.g., flagging of inappropriate pesticides, or reporting of commercial products rather than active ingredients). The current method thwarts rather than facilitates research, identification of successful practices, and ongoing improvement.

Recommendations

IPM Council, Golf Course Owners and Superintendents

- Recognize and learn from courses that successfully use lower quantities of pesticides.
- Recognize that pesticides pose not only financial costs, but also health risks to neighbours, staff, players and ecosystems, and contamination risks for surface and ground water.

- Leverage growing public awareness of the need for safer practices, fostering biodiversity and use of climate-friendly practices, with IPM reporting evidence, to improve market share.

Citizens

- If you live in Ontario, use the online golf course pesticide reporting resource, http://public.ipmcouncilcanada.org/index.aspx, to examine pesticide use on golf courses in your community and/or where you golf. Golf courses are substantial sources of pesticides that are no longer permitted on residential lawns and gardens, and other urban landscapes.
- Ask your local golf course about pesticides, and how they are reducing use. Annual meetings were abolished when the *Pesticides Act* and Regulation 63/09 [28] were amended in 2019-2020.
- In Ontario, ask local lawn bowling facilities, cemeteries, sports fields hosting national or international competitions and other locations maintaining specialized turf for reports on pesticide use. These must be prepared, and provided to the public under Regulation 63/09.[28]
- Educate yourself, the public and politicians. Seek regulation that permits only least-toxic pesticides on lawns, gardens, facilities and landscapes in your municipality and province.
- Citizens everywhere can improve ecological land care, naturalization and reforestation.

Ontario Ministry of Environment, Conservation and Parks (OMECP)

- Work with Ridgetown College (Ontario centre for IPM education) and the IPM Council to streamline reporting, institute direct data submission, improve quality and accountability in order to advance research, identify best practices, and improve turf maintenance for human and ecological health.
- Enforce IPM accreditation, reporting and evidence of pesticides reductions for golf courses.
- Investigate and prosecute use of illegal pesticides. Award golf courses with the lowest use of pesticides for turf.

Industry and academia

- Learn from organic turf care experts and conduct research to transition to non-toxic maintenance programs, for management of natural turf playing surfaces such as for golf.
- The IPM Council of Canada, Ridgetown College and the OMECP should modernize the system for golf courses to submit data. This will support research and advancement of successful, preferable practices. A rich, accessible data set could facilitate, for example, incorporation of weather data to improve prediction of potential pest problems and to provide signals and lead-time for prevention and less toxic solutions. There are doubtless many important research questions to be addressed.

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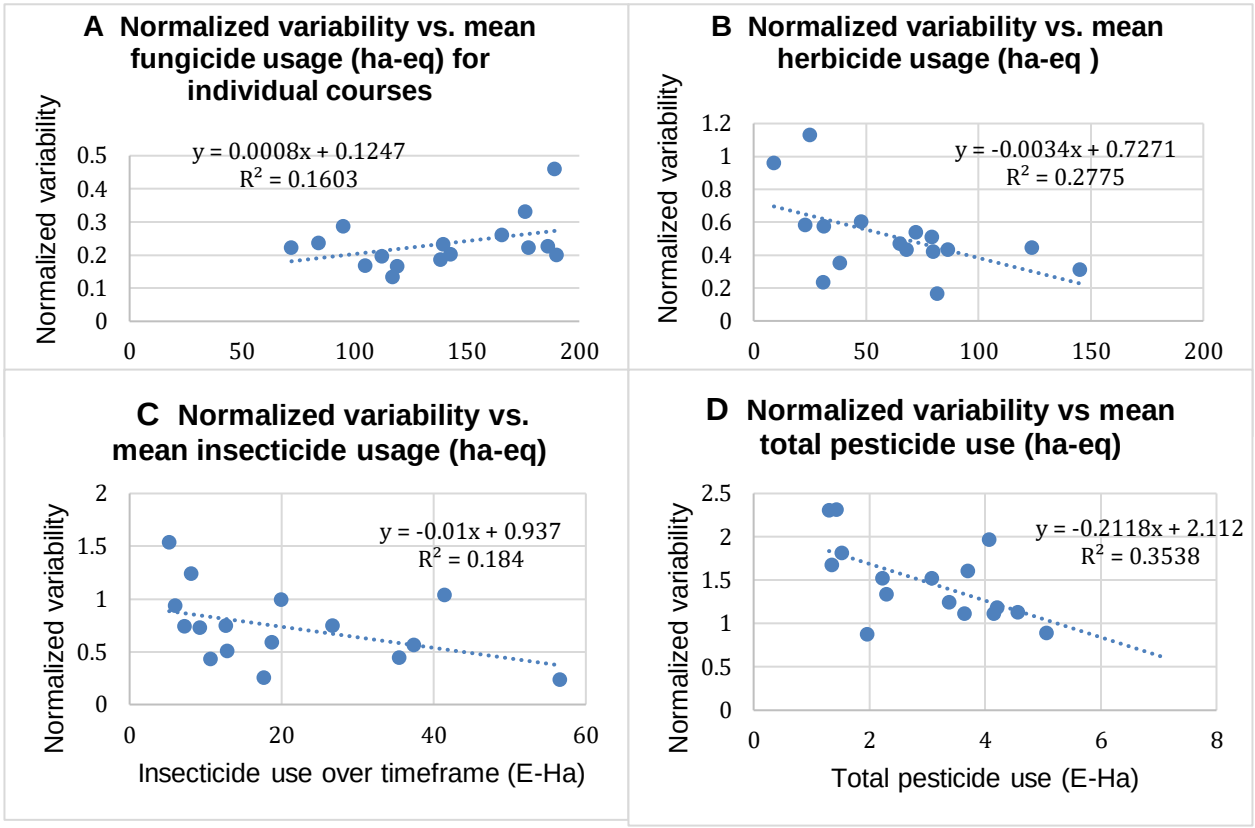
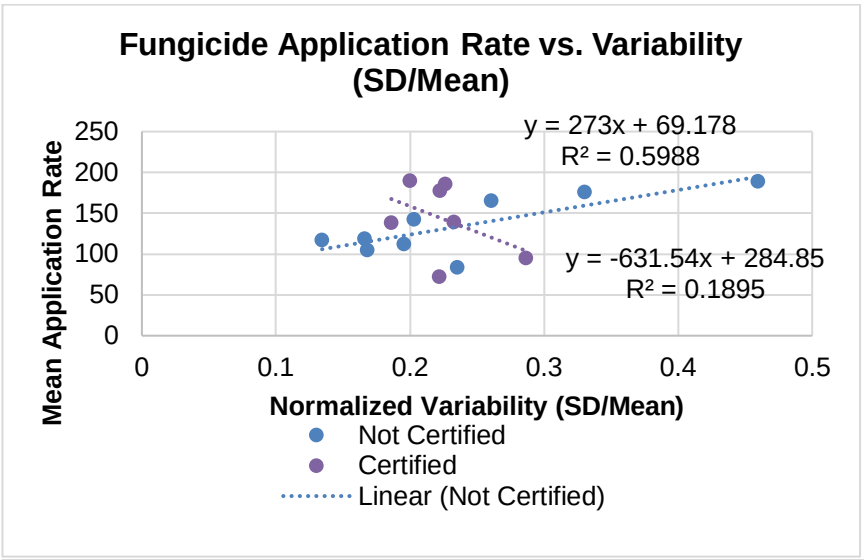
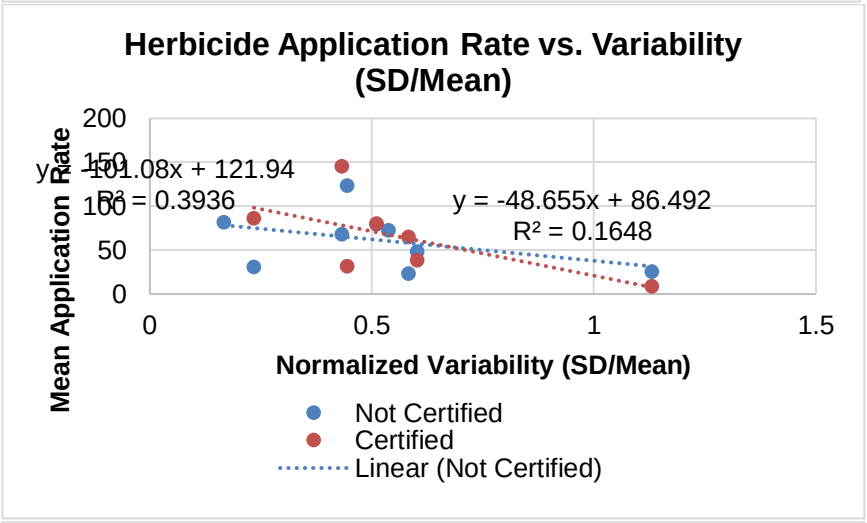


https://www.ontario.ca/laws/regulation/090063/v19#BK37

Appendix 1. Statistical Trend Analyses

Figure A-1. Normalized variability versus pesticide use for individual courses, from 2010 to 2017, for fungicides (A), herbicides (B), insecticides (C) and total pesticides (D)





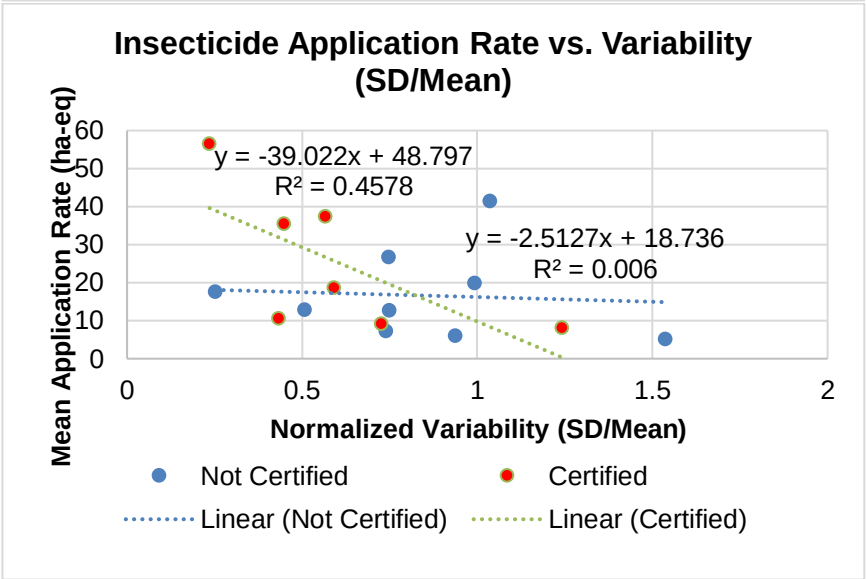


Figure A-2. Normalized variability (standard deviation/mean) versus pesticide use by Audubon-certified and uncertified courses, from 2010 to 2017, for fungicides, herbicides and insecticides

Appendix 2. Canadian Federal Pesticide Regulation: Why Other Levels of Government Require Least-Toxic Approaches to Pest Control

Many Canadian jurisdictions restrict the use of registered pesticides, surpassing federal label requirements. This summary is to help you understand why.

Pesticides are products that destroy or control "pests," which are defined as organisms that are "harmful, noxious or troublesome." Pesticides include herbicides against plants, insecticides, fungicides, rodenticides, algaecides, etc. Disinfectants for surfaces are also pesticides. Every pesticide product is registered for use, contingent on following specific, legally enforceable instructions.

Health Canada's Pest Management Regulatory Agency (PMRA) regulates pesticides, under the Pest Control Products Act (PCPA).[1] The PMRA uses a two-step process of risk assessment, identifying hazards and then assessing risk on the basis of exposure. Risk management amounts to controlling exposure by adjusting application rate, conditions and frequency, and protective measures (e.g., protective equipment and restricting access to treated areas). Products are registered for sale and assigned a PCPA number if the pesticide poses "acceptable risks" according to scientific assessments.

Hazards, instructions for use, risk mitigation and other details are on pesticide labels. These legal documents may be found on the PMRA website.[2] Labels must be adhered to, under the PCPA.

While the PMRA registers products for sale and use, provincial governments are responsible to qualify and licence applicators, and can further restrict pesticides to protect human and environmental health. In most provinces, municipal governments may impose further restrictions. The most progressive jurisdictions such as Ontario (population almost 15 million) and Halifax require least-toxic approaches, particularly for "cosmetic" uses for turf and landscaping.

Practical limitations of Canadian federal pesticide management

The PMRA only assesses pesticides for which it has data packages. These are assembled by firms that anticipate financial gain from sales of the proposed product. There are many means to control pests that pose lower risks, but these are not legally available or used if there is no PCPA number.

Scientific limitations of Canadian federal pesticide regulation

The PMRA and the health and medical community often reach opposite conclusions regarding pesticides and human health. Doctors, who urge precautionary minimization of exposures, rely upon the publicly available, real-life human epidemiological research rather than the confidential industry-produced animal test data relied upon by the PMRA. The PMRA conducts virtually no testing itself, and does not systematically assess the publicly available existing science.[3,4] Rather, it conducts a paper audit of data submitted by the pesticide manufacturers. The PMRA assessment of human health risk has many shortcomings:

1. **High-dose animal testing in labs is of limited relevance for people.** Testing determines the maximum dose that does not make an animal (usually a rodent such as a rat or mouse) seriously ill. Rodents are different from humans, in that they have enzymes that help to metabolize poisons. Humans do not have the same enzymes and, of course, tests are not conducted on humans. That would be unethical. Also, tests do not generally cover the animal's lifespan, and further generations. In humans, exposures that may cause no symptoms in the mother can cause life-long harm to her unborn child, and childhood exposures can cause symptoms in adulthood. Some effects may be passed through generations due to changes in gene expression, called epigenetic effects. Finally, when a substance causes cancer in animals, it is not considered a human carcinogen until there is evidence in people. This can take a generation or longer, and many contributors to cancer may never be convincingly proven in people. Substances may work in concert to cause cancer,[5] or the signal of cancer from one substance may be obscured by other exposures.

2. **Tests do not address low-dose or cumulative effects, as they build up with multiple exposures and over time.** The regulatory system does not require, and in effect dissuades companies from doing low-dose, environmentally relevant testing, because any findings of adverse effects would preclude the product being registered. This highlights the need for independent research, and for this information to be considered in decisions. Some health effects occur at doses commonly encountered in the environment, including developmental harms, and effects that may predispose people to cancers as well as other major chronic diseases. One important mechanism by which this happens is endocrine disruption.[6]

3. **No testing is done on endocrine disruption – an important mechanism behind many pesticides' chronic toxicities.**[6] Many pesticides have already been found to disrupt the endocrine or hormone systems.[7] Hormones orchestrate every step of development from gestation through the entire lifespan. Endocrine-disrupting chemicals act at extremely low concentrations in the body, and can have different, even opposite effects at higher doses.[8] Alterations to hormone levels during critical windows of development can cause permanent changes to children's lives, affecting their intelligence and behaviour, and making them more susceptible to infections, asthma, obesity, diabetes, reproductive failure, cardiovascular disease and cancers. One 2011 study reviewed endocrine effects of 91 pesticides.[7] A second study confirmed previously known androgen (male hormone) effects of some pesticides,[9] while among previously untested pesticides nine were anti-androgenic and seven were androgenic. The US Environmental Protection Agency and the European Union are screening pesticides for effects related to actions of estrogen, androgen, thyroid and other hormones. A 2012 review of 845 scientific papers showed evidence that endocrine-disrupting chemicals have adverse health impacts at very low doses in animals and humans.[10] The Endocrine Society – a global group of medical science professionals [11] – published in 2015 a 150-page updated research review and statement calling for scientific and regulatory attention to endocrine-disrupting chemicals.[8] In 2020, scientists called for a body comparable to the International Agency for Research on Cancer to assess EDCs.[12]

4. **Only active ingredients are tested – not the products on the shelf.** Products can contain more than one pesticide ingredient. As well, additives, "adjuvants" or "formulants" are used in pesticide products to slow metabolism of the active ingredient (i.e., prolong its effect), and to improve spreading and absorption of the product. Additives can do the same when pesticides contact humans. A 2014 study found that 8 of 9 common commercial products tested were hundreds of times more toxic to human cells than just the pure pesticide active ingredient without formulants.[13]

5. **Pesticides are not tested in combination.** While we know that chemicals can act very differently in combination, single pesticides (and often only one active ingredient of pesticides) are assessed in isolation. Greater toxicity when mixed with additives to improve effectiveness, or multiple pesticides in combination (as on a golf course), are not assessed.

6. **Pesticide registration is based on all directions being followed.** Even if people make the effort to access the label fine print, instructions are extremely difficult to follow. For example: "avoid inhaling"; "avoid contact with the skin or eyes"; and "apply only when there are no children, pregnant women, elderly persons, pets or animals present."

7. **The PMRA does not take into account much of the medical literature.** Methods and standards are developed for systematic review in environmental health (e.g., by the US National Toxicology Program[4,14]). Real-life study of the effects of pesticides is difficult, and the PMRA dismisses this information as showing only correlation and not as the level of causation requiring protective action. The PMRA is of the opinion that it is virtually impossible to *prove* that chronic pesticide exposures cause harm to humans, leaving the federal regulator relying upon industry-supplied high-dose animal testing. As reported in 2017 in the prestigious journal *Science*, ignoring the majority of the science is the status quo among regulators.[15]

8. **Precautionary Principle is *not* up front.** Health Canada and industry groups point out that the Precautionary Principle is incorporated in the *Pest Control Products Act*. In fact, this is quite limited because precautionary approaches are only incorporated late in the process, during risk management, such as determinations of permissible exposures (noted below, an additional margin introduced in 2002, to protect the most vulnerable, is rarely if ever being implemented). Application of the Precautionary Principle to the first step – hazard identification – could potentially push the process towards least-toxic choices. On the other hand, industry representatives have been known to turn this approach upside-down, advocating precaution against rushing to remove "tools from the toolbox" before being 100% certain that any pesticides are causing substantial harm. The Precautionary Principle is operationalized with the Substitution Principle;[16,17] i.e., informed substitution with a least-toxic option. Such options (e.g., dish soap against insects) may not be profitable, but with no data package a product cannot be registered, or sold or used commercially.

Federal audits of Health Canada's pesticide management

The Federal Commissioner of the Environment and Sustainability in the 2015 audit of pest control products found glaring deficiencies and concerns regarding pesticide registration.[18] Some concerns are as follows:

- The PMRA had made little progress since the 2008 audit to limit the duration of some conditional registrations (when pesticide sales are permitted pending further information to complete the assessment). Eight of nine products that had been registered conditionally for a decade or more were neonicotinoids, a class of neurotoxic insecticides that have been linked to Bee Colony Collapse Disorder and the death of other pollinators and aquatic species.
- Under conditional registrations the PMRA permits use of the pesticide without having received and assessed the risk and value assessments to determine the impacts on human health and the environment. At the time, 80 out of 7,000 pesticide products were conditionally registered. None of the industry studies are available to the public until the pesticide is fully registered, and even then an individual must personally visit offices in Ottawa and record relevant information with pen and paper. Many of these conditional registrations have been finalized since.
- The PMRA has never exercised its authority to cancel a conditional registration when a registrant has failed to satisfy conditions of registration, within a five-year period.
- Re-evaluations of older pesticides are behind schedule.
- Cumulative health impacts have not been addressed when required in the re-evaluations of pesticides.
- It took the filing of a lawsuit before the PMRA began to consider whether special reviews were deemed necessary for pesticides banned since 2013 in OECD countries.
- PMRA has not promptly cancelled the registrations of some pesticides when risks were deemed unacceptable. In one case it took 11 years to cancel the registration of a pesticide after it was determined the risks posed to human health were unacceptable.
- Lengthy phase-out periods have been allowed to occur despite the risks posed to human health of continued use.
- An additional "uncertainty factor" to protect the most vulnerable individuals, introduced to the *Pest Control Products Act* in 2002, is very rarely incorporated in assessments.

For more information, please contact *Prevent Cancer Now*. Info@PreventCancerNow.ca

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November 2020

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Prevent Cancer Now is a Canadian organization of science and health professionals, and concerned citizens, who work to "stop cancer before it starts," by addressing environmental contributors to cancer through science, education and advocacy.
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The full report is available at:
http://www.preventcancernow.ca/wp-content/uploads/OntGolfIPM-FullReport-Nov2020.pdf
A summary report is available at:
http://www.preventcancernow.ca/wp-content/uploads/OntGolfIPM-SUMMARY-Nov2020.pdf