



# Golf Course Environmental Profile

## Phase III, Volume III

A continued investigation  
into pest management practices on U.S.  
golf courses

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Golf Course Superintendents Association of America

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## Phase III, Volume III

# A continued investigation into pest management practices on U.S. golf courses

The third phase of the Golf Course Environmental Profile was conducted  
by the Golf Course Superintendents Association of America.



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## Pest Management Practices Survey Documents Important Management Activities

On behalf of the Golf Course Superintendents Association of America (GCSAA), our GCSAA board and members, we are pleased to present the third edition of the GCSAA Pest Management Practices report.

Environmental stewardship is paramount to GCSAA, and this important industry review continues our work to identify trends in management practices to offer insights and support the continued improvement in professional golf course management. The data powering this report is based on input from superintendents from across the United States.

Since the 2007 baseline, Pest Management Practices used in the U.S. vary. Some management activities' percentages remain high, others are down, and some are statistically the same. It's not always easy to identify why not all trends meet the desired outcomes. However, it's important to remember that the need for pest management practices depend upon pest pressures, climate, and other environmental factors that significantly vary across the U.S. Superintendents must incorporate the best management practices and demonstrate our industry's professional land management.

In total, 1,444 responses were recorded for this tracking. I want to personally thank those who participated as well as the GCSAA Staff and members who have provided ongoing support for this important project.

In addition, I would like to recognize the United States Golf Association for their ongoing collaboration and support to advance science and data-based decision-making in golf course management.

If you have questions, please feel to reach out to Mark Johnson, GCSAA Director of Environmental Programs, 1-800-472-7878.

Thank you for the Essential Work You and Your Teams Deliver Every Day Toward Golf's Success



A handwritten signature in black ink, appearing to read 'Kevin P. Breen'.

Kevin P. Breen, CGCS  
2022 GCSAA President

## Introduction

Over the past 15 years, the Golf Course Superintendents Association of America has been benchmarking the management practices, property features, and environmental stewardship of U.S. golf courses. This endeavor, referred to as the Golf Course Environmental Profile (GCEP) Survey Series, is now in its third iteration. Since its inception in 2006, industry surveys have yielded data on issues ranging from land use to regulations and practices governing water use, nutrients, and pest control. Data from these surveys provide scientifically valid measurements of industry change as it relates to these surveys (Energy Use and Environmental Practices on U.S. Golf Courses, Land Use Characteristics and Environmental Stewardship Programs on U.S. Golf Courses, Pest Management Practices on U.S. Golf Courses, Nutrient Use and Management on U.S. Golf Courses, and Water Use and Conservation Practices on U.S. Golf Courses).

The GCEP survey results are published in the peer-reviewed scientific journal *Crop, Forage and Turfgrass Management* (previously *Applied Turfgrass Science*) and *HortTechnology* benefiting scientists who routinely use the survey data to inform their research direction and regulators who must make evidence-based decisions. Results are also published in *Golf Course Management* and online (<https://www.gcsaa.org/Environment/golf-course-environmental-profile>) where the information is used by the GCSAA and other golf-centric organizations to communicate to the public the golf industry's commitment to environmental stewardship and to promote the efforts golf course superintendents are making on their golf courses. GCEP survey data are also used to assist in determining the future direction of GCSAA environmental efforts, to identify key issues for potential research projects, to respond to governmental and public inquiries, and to provide a solid basis for comments on proposed regulatory issues affecting the golf industry.

Pest management practices on U.S. golf facilities were previously documented in 2007 and 2015 in prior GCEP

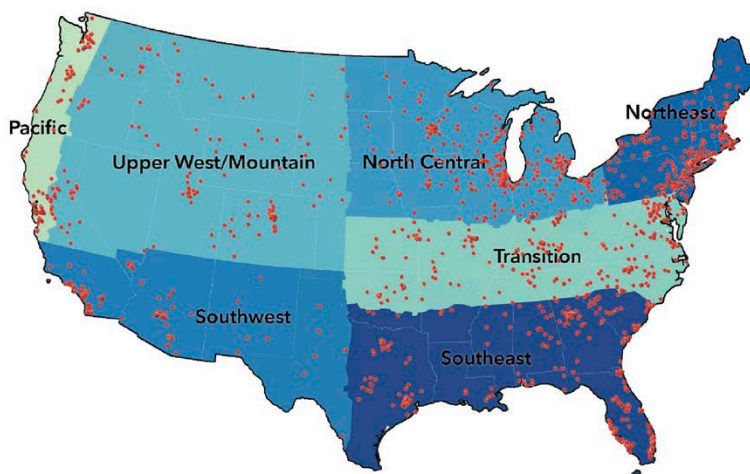


Figure 27. Distribution of the 2021 survey responses within the seven agronomic regions.

surveys. In their continued commitment to servicing the golf course industry, the GCSAA conducted a third survey in 2021. The objective of the 2021 survey was to compare results from 2007 to determine where changes have occurred in the following areas:

- Reliance on pest management practices
- Frequency of pesticide storage attributes
- Frequency of pesticide mixing and loading attributes

## Methodology

In order to compare changes from prior surveys, questions were identical to those used in 2006 and 2014. A survey link was emailed to golf facilities using the mailing lists of the National Golf Foundation and the Golf Course Superintendents Association of America, which resulted in the link being sent to 14,033 unique golf facilities. A golf facility was defined as a business where golf could be played on one or more golf courses. The survey and the link were also promoted on social media by GCSAA staff. The survey was available for completion for seven consecutive weeks beginning on April 1, 2022. Respondents remained anonymous within the data file by omitting their names and assigning a unique identification number. Data were merged with data from the same survey conducted in 2006 and 2014 to allow for a measurement of change over time.

Responses were received from 1,444 facilities, which represented 10.3% of the known total of U.S. golf facilities.

Respondents were grouped by agronomic region (Figure 27). To provide a valid representation of U.S. golf courses, data were weighted. Responses were categorized into one of 35 categories depending upon the facility type (public or private), number of holes (9, 18, or 27+), and public green fee (<\$55 or ≥ \$55 per round) (Table A1). The weights were calculated by determining the proportion of each group within the total survey response.

Golf facility frequencies were calculated using statistical software. Differences among years were determined using the  $\chi^2$  test at the 10% significance level.

## Results National Summary

### Frequency of pest management practices

- Only photographic documentation, use of traps, and use of remote sensors increased from 2007 to 2021 (Table 1).
- The frequency of most of the remaining pest management practices declined between 2007 and 2021; and between 2015 and 2021.

### Reliance on pest management practices

- From 2015 to 2022, U.S. golf facilities have increased their reliance upon pesticides within each pesticide class (Figure 1).
- U.S. golf facilities also slightly increased their reliance upon the non-chemical pesticide class, plant growth regulators (PGRs), but decreased their reliance upon biological control options.



### Written pest management plans

- The percentage of U.S. golf facilities that have a written integrated pest management (IPM) plan remained equivalent to that in 2007 at 44% (Table 2).
- The percentage of U.S. golf facilities that have a written pesticide application plan remained equivalent to that in 2007 at 63%.
- The percentage of U.S. golf facilities that have a pesticide emergency response plan increased between 2007 and 2021 to 57%.

**Table 1.** Frequency of pest management practices used on U.S. golf facilities in 2007, 2015, and 2021.

Management practice	2007	2015	2021
	Golf facilities (%)		
Monitor weather patterns	96 a <sup>i</sup>	95 ab	93 b
Scouting	95 a	95 a	93 a
Pesticide resistance management strategies	ND <sup>ii</sup>	92 a	90 a
Monitor weather patterns conducive to outbreaks	ND	93 a	90 b
Improve turfgrass health	ND	95 a	90 b
Cultural practices	95 a	96 a	90 b
Spot treat damage	ND	92 a	86 b
Record pest outbreaks	83 a	77 b	75 b
Higher pest tolerance	71 a	72 a	66 b
Predictive models	56 a	52 b	60 a
Pest-tolerant turfgrass	61 a	52 b	55 b
Map pest damage	ND	52 a	53 a
Pest ID by university or independent laboratory	ND	51 a	49 a
Photograph documentation	14 b	37 a	36 a
Biological controls	47 a	41 b	33 c
Traps	28 b	34 a	33 a
Remote sensors	17 c	31 a	21 b

<sup>i</sup> Within rows, values followed by a common letter are not significantly different according to the  $\chi^2$  test at the 10% significance level. <sup>ii</sup> No data. Question was not asked in 2007.

- The percentage of U.S. golf facilities that have a written IPM or a pesticide application plan remained equivalent to that in 2007 at 71%.

### Mixing and loading attributes

- From 2007 to 2021, the attributes of pesticide mixing and loading areas remained mostly unchanged except for the percentage of facilities that have spill kits and collect rinsate, which both increased to 60% and 26%, respectively (Table 3).

### Storage attributes

- From 2007 to 2021, the attributes of pesticide storage areas remained mostly unchanged except for the percentage of facilities that have spill kits, which increased to 65% and the percentage of facilities that can be locked, have passive venting, and have explosion-proof electrical fixtures, which declined to 87%, 52%, and 21%, respectively (Table 4).

### Budget

- A greater percentage of U.S. golf facilities that operate with an annual budget greater than \$1 million have a written IPM plan, pesticide application plan, and pesticide emergency response plan than compared with facilities that operate with an annual budget less than \$500,000 (Figure 2).
- Each attribute of pesticide mixing and loading areas on U.S. golf facilities with annual operating budgets greater than \$1 million were more frequent than on facilities with annual operating budgets less than \$500,000 (Figure 3).
- Each attribute of pesticide storage areas on U.S. golf facilities with annual operating budgets greater than \$1 million were more frequent than on facilities with annual operating budgets less than \$500,000 (Figure 4).

### COVID-19 Pandemic

- The COVID-19 pandemic did not influence pesticide usage on 89% of U.S. golf facilities (Figure 5).

**Table 2.** Frequency of written pest management plans on U.S. golf facilities in 2007, 2015, and 2021.

Pest management plan	2007	2015	2021
	Golf facilities (%)		
Integrated Pest Management (IPM) Plan	41 a <sup>1</sup>	32 b	44 a
Pesticide Application Plan	63 a	58 b	63 a
Pesticide Emergency Response Plan	52 b	53 ab	57 a
Either IPM plan or Pesticide Application Plan	71 a	66 b	71 a

<sup>1</sup>Within rows, values followed by a common letter are not significantly different according to the  $\chi^2$  test at the 10% significance level.

**Table 3.** Frequency of mixing and loading area attributes on U.S. golf facilities in 2007, 2015, and 2021.

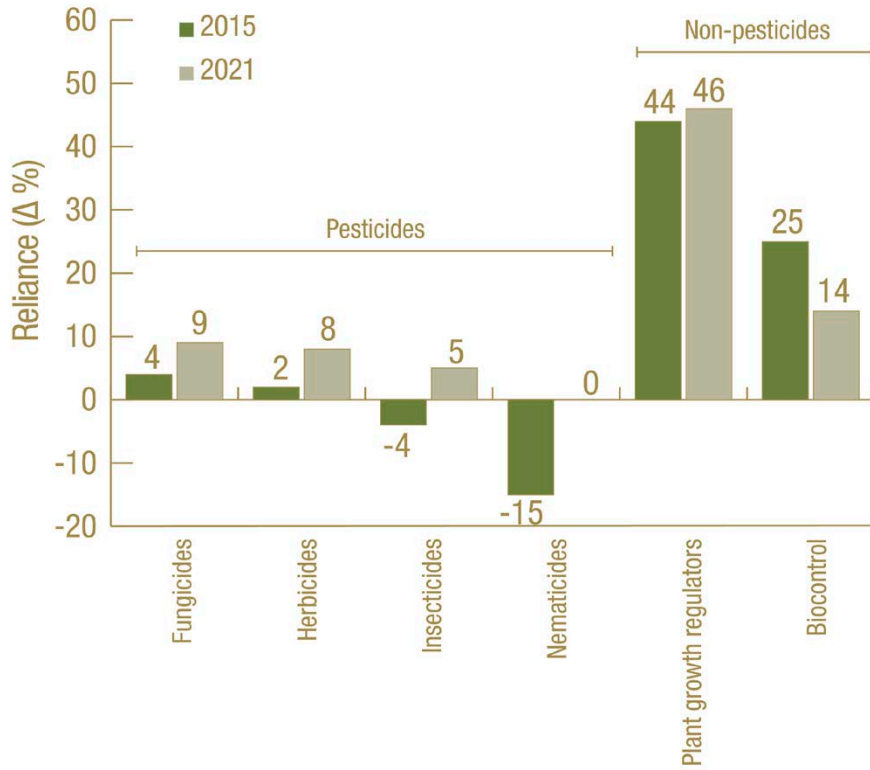
Attribute	2007	2015	2021
	Golf facilities (%)		
Spill kit	53 b <sup>1</sup>	54 b	60 a
Anti-siphoning on water line	52 a	52 a	53 a
Impervious floor	40 a	37 a	38 a
Emergency water shut-off	37 a	37 a	37 a
Recycle pesticide containers	35 ab	38 a	34 b
Floor contains spills	31 ab	30 b	33 a
Roof	28 a	27 a	29 a
Water filling capacity > 50 gallons per minute	29 a	28 a	27 a
Collect rinsate	22 b	24 ab	26 a
Stand-alone pesticide mixing tank	14 a	14 a	14 a

<sup>1</sup>Within rows, values followed by a common letter are not significantly different according to the  $\chi^2$  test at the 10% significance level.

**Table 4.** Frequency of storage facility attributes on U.S. golf facilities in 2007, 2015, and 2021.

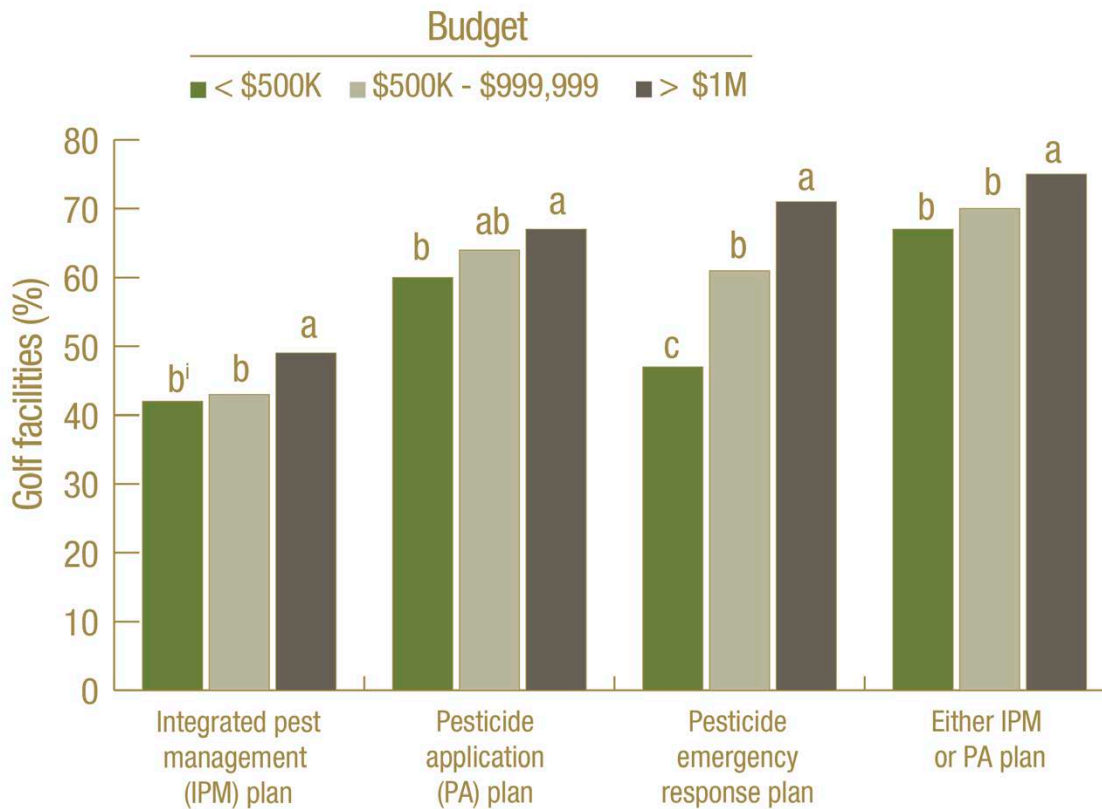
Attribute	2007	2015	2021
	Golf facilities (%)		
Can be locked	90 a <sup>1</sup>	89 ab	87 b
Signage indicating pesticides inside	78 a	78 a	76 a
Impervious Floor	64 a	58 b	66 a
Spill kit	60 b	60 b	65 a
Emergency shower/eyewash	66 a	64 a	64 a
Floor can contain spills	57 a	54 a	57 a
Passive venting	58 a	48 c	52 b
Dedicated storage building	47 a	49 a	49 a
Impervious Shelving	45 a	41 b	47 a
Powered venting	40 a	42 a	41 a
Explosion-proof electrical fixtures	25 a	24 ab	21 b

<sup>1</sup>Within rows, values followed by a common letter are not significantly different according to the  $\chi^2$  test at the 10% significance level.



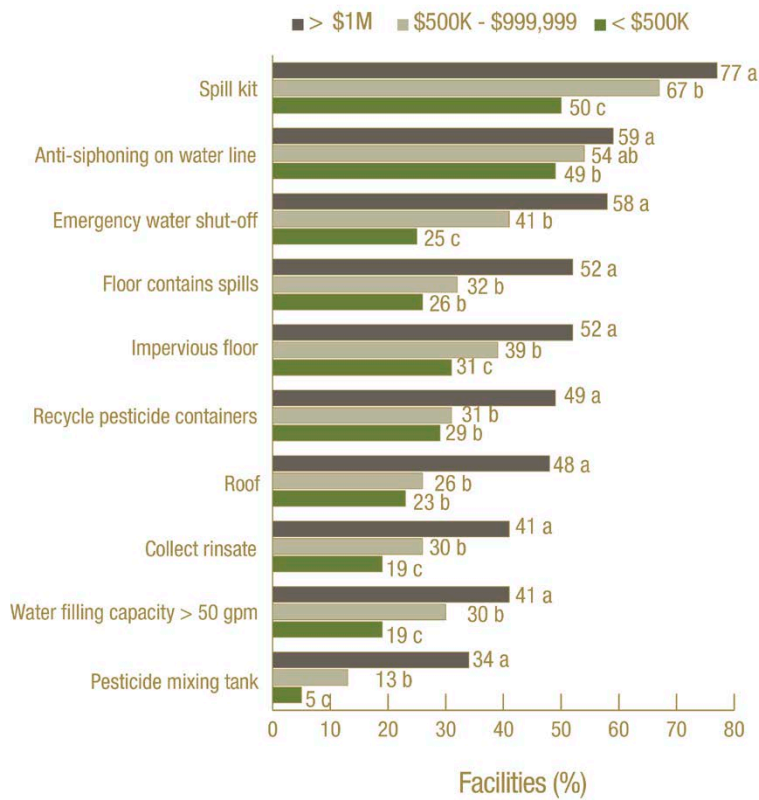
**Figure 1.** Reliance of U.S. golf facilities on pest management practices during the three years prior to 2015 and 2022.

**Figure 2.** Frequency of written pest management plans on U.S. golf facilities in 2021 as influenced by the facilities annual budget. Bars with a common letter are not significantly different according to the  $\chi^2$  test at the 10% significance level.



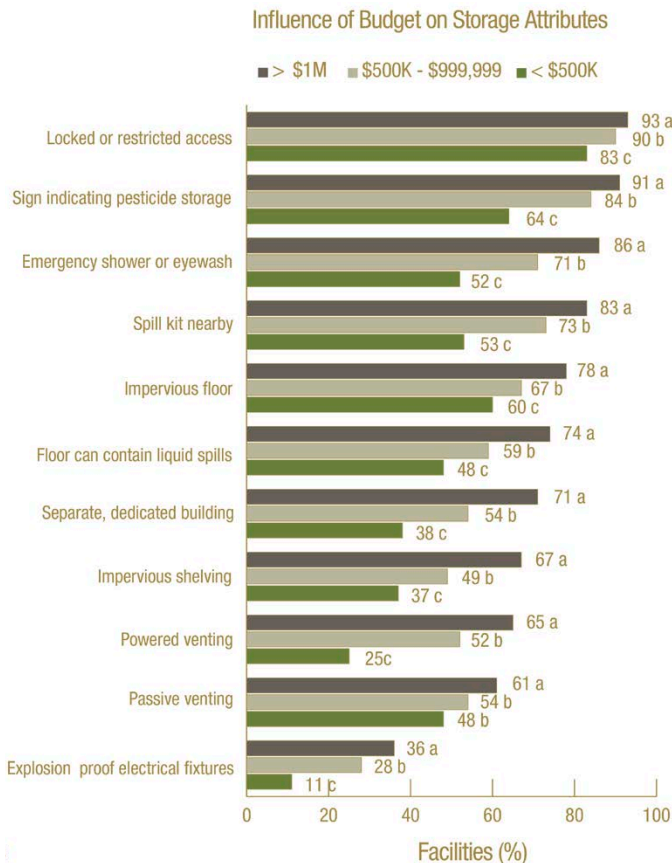


**Influence of Budget on Mixing Attributes**

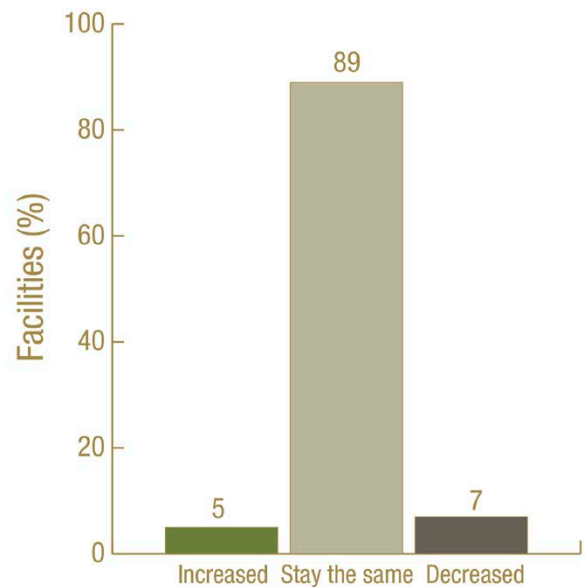


**Figure 3.** Effect of golf facility annual budget on the properties of pesticide mixing and loading areas for all golf facilities in 2021

**Figure 4.** Effect of golf facility annual budget on the properties of pesticide storage areas for all golf facilities in 2021.

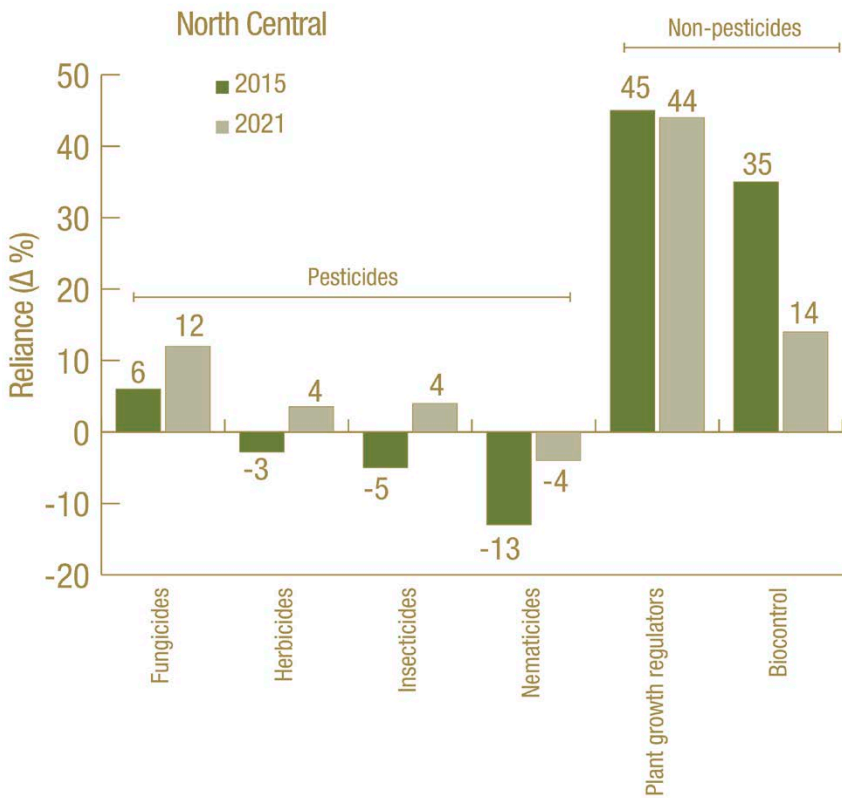


**Figure 5.** Influence of the COVID-19 pandemic on pest product use on U.S. golf facilities in 2021.

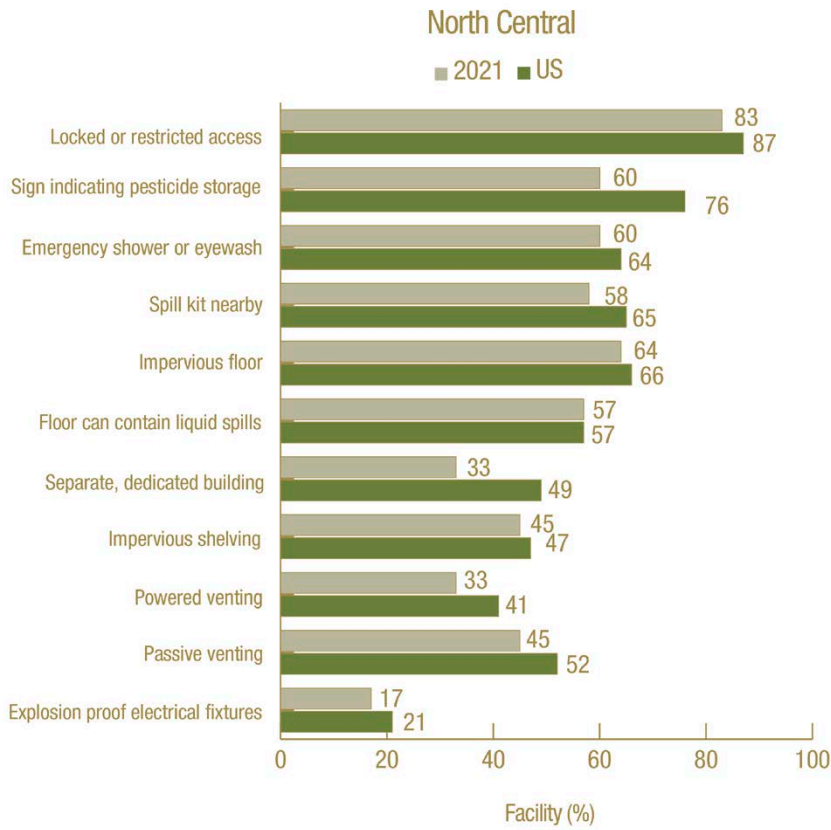


## Regional Results North Central

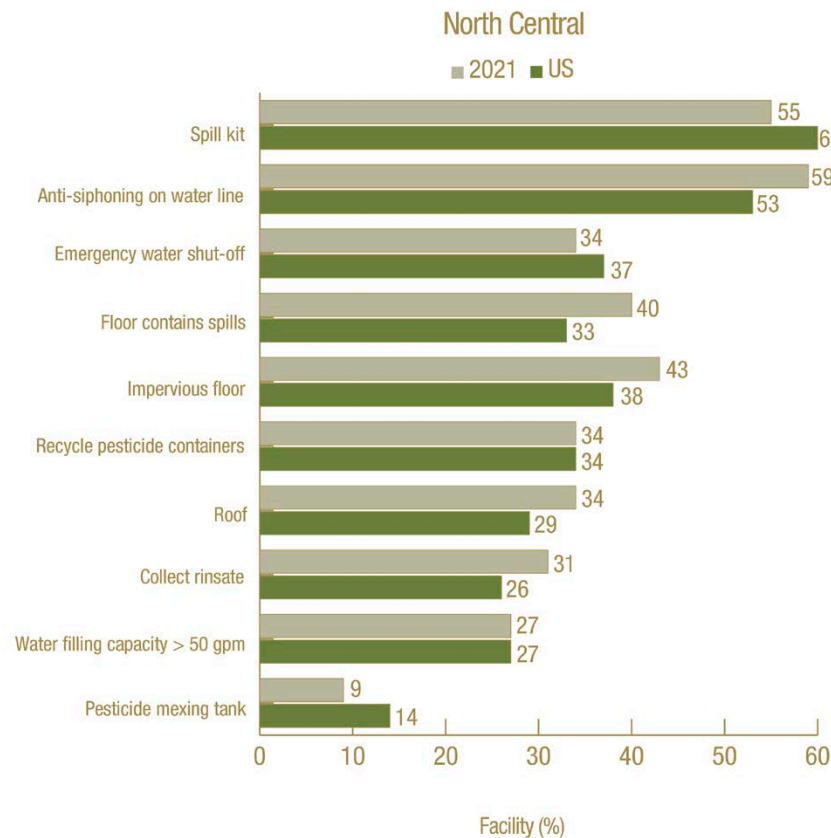
- Reliance upon PGRs remained approximately equal from 2015 to 2021 (Figure 6). Reliance upon biological control products declined to 14% from 2015 to 2021. Reliance upon each class of chemical pest control products increased from 2015 to 2021.
- The percentage of golf facilities that have the listed pesticide storage attributes were equal to or less than the national average (Figure 7).
- The percentage of golf facilities that have the listed pesticide mixing and loading attributes were greater than the national average for anti-siphoning water line, floor contains spills, impervious floor, roof, and collect rinsate; and were less than the national average for spill kit, emergency water shut-off, and pesticide mixing tank (Figure 8). All other attributes were approximately equal to the national average.



**Figure 6.** Reliance of U.S. golf facilities on pest management practices during the three years prior to 2015 and 2022 in the North Central region.



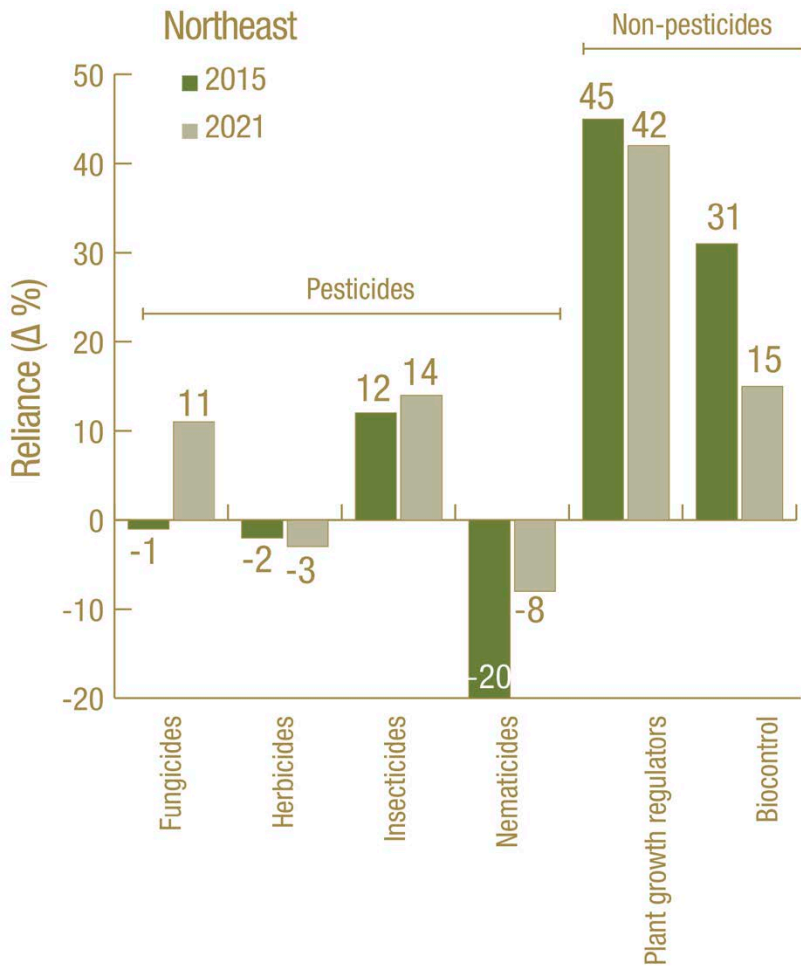
**Figure 7.** Frequency of pesticide storage area properties for all golf facilities in the North Central region in 2021.



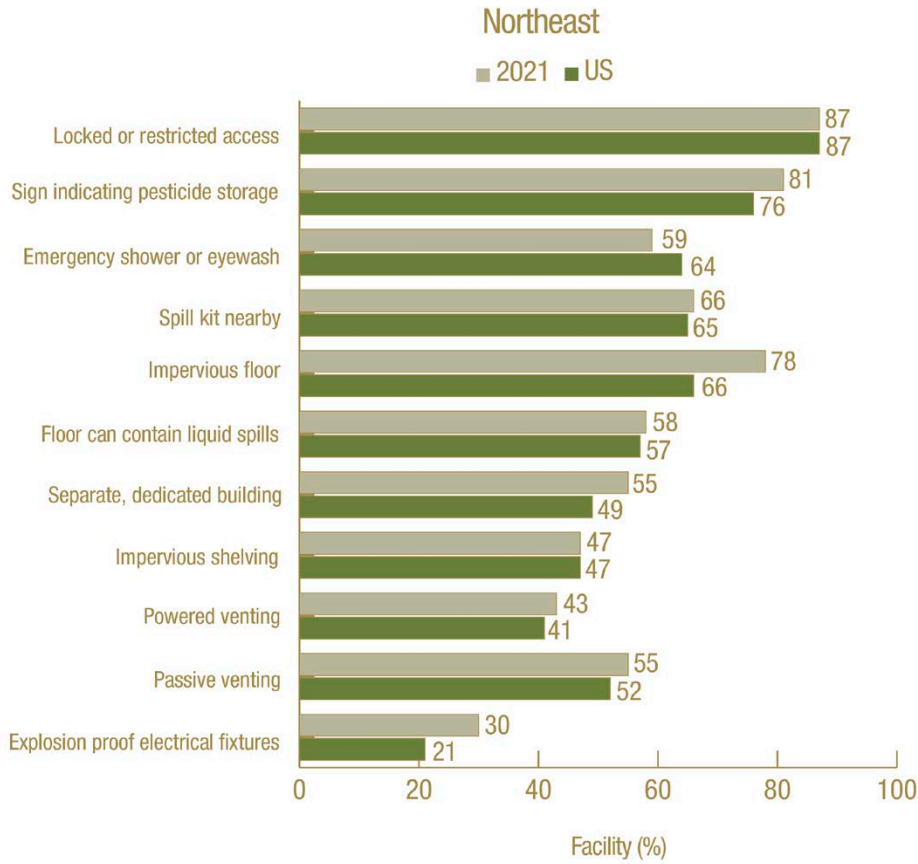
**Figure 8.** Frequency of pesticide mixing and loading area properties for all golf facilities in the North Central region in 2021.

**Northeast**

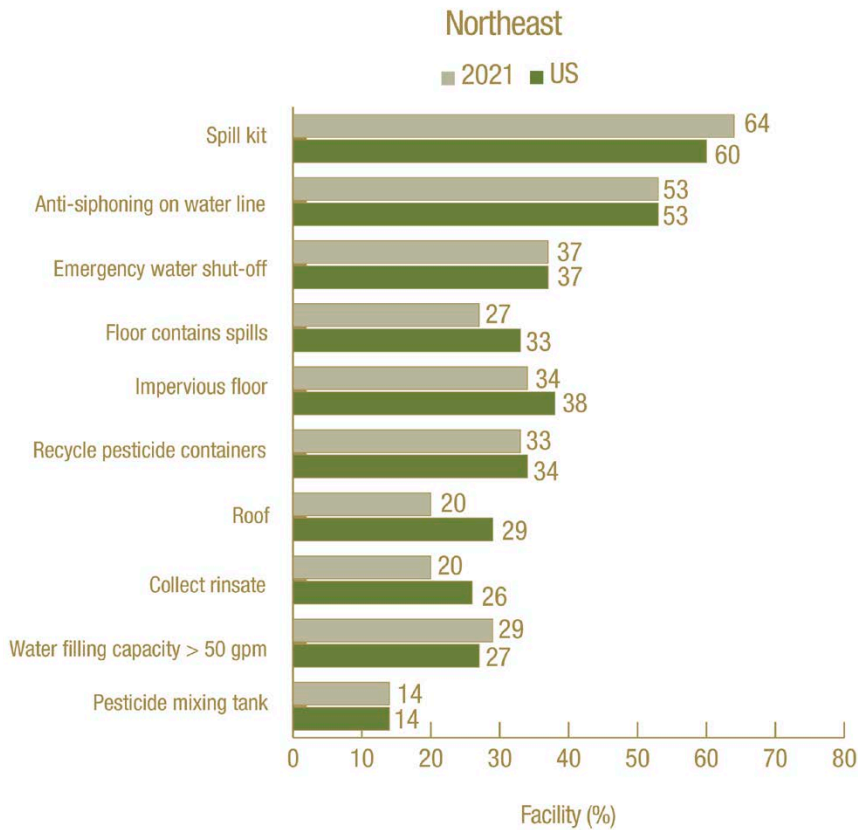
- Reliance upon PGRs and biological control products declined to 42% and 15%, respectively, from 2015 to 2021 (Figure 9). Reliance upon each class of chemical pest control products increased from 2015 to 2021, except reliance upon herbicides which was approximately equal to 2015.
- The percentage of golf facilities that have the listed pesticide storage attributes were equal to or greater than the national average except for the emergency shower or eyewash, which was slightly less than the national average (Figure 10).
- The percentage of golf facilities that have the listed pesticide mixing and loading attributes were greater than or equal to the national average for spill kit, anti-siphoning water line, emergency water shut-off, recycle pesticide containers, water filling capacity > 50 gpm, and pesticide mixing tank. All other attributes were less than the national average (Figure 11). All other attributes were approximately equal to the national average.



**Figure 9.** Reliance of U.S. golf facilities on pest management practices during the three years prior to 2015 and 2022 in the Northeast region.



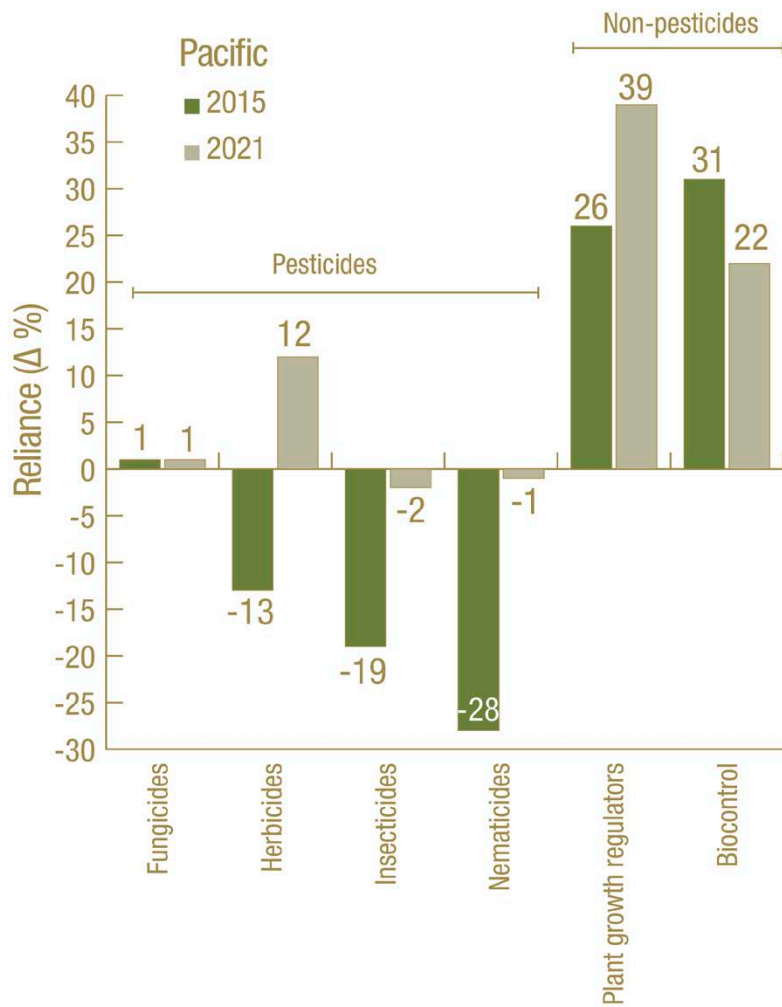
**Figure 10.** Frequency of pesticide storage area properties for all golf facilities in the Northeast region in 2021.



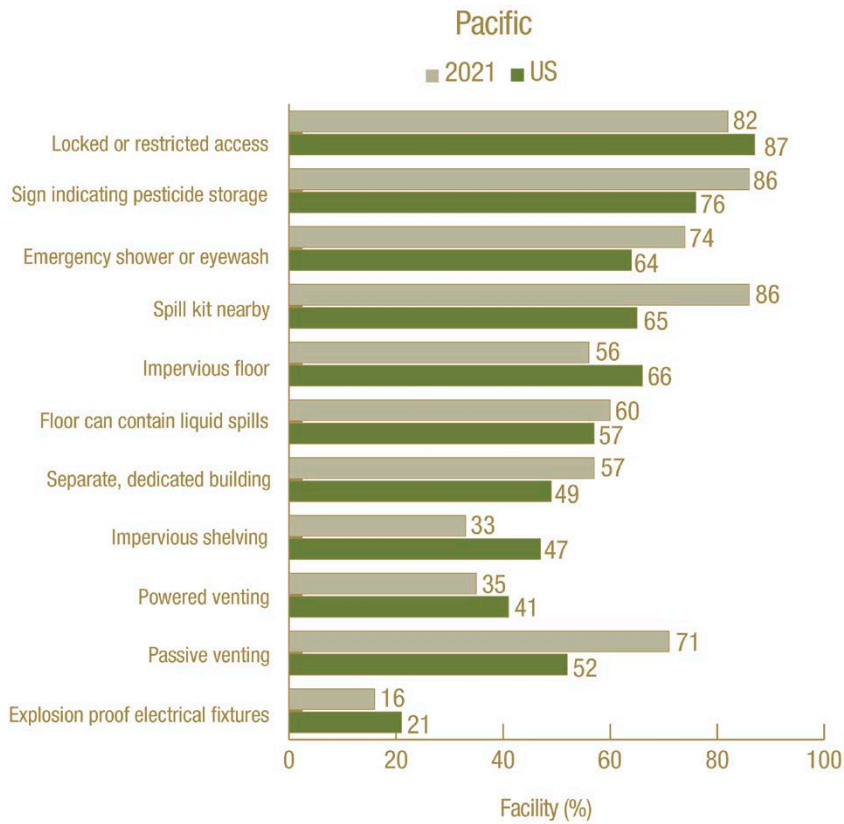
**Figure 11.** Frequency of pesticide mixing and loading area properties for all golf facilities in the Northeast region in 2021.

## Pacific

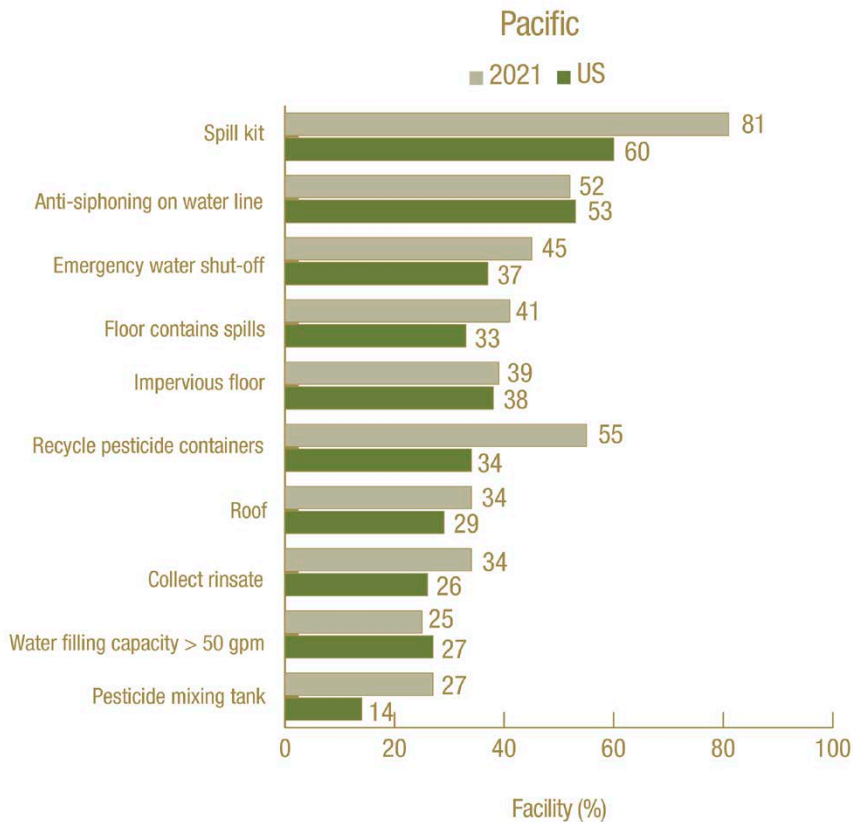
- Reliance upon PGRs increased to 39% from 2015 to 2021, whereas reliance upon biological control products declined to 22% from 2015 to 2021 (Figure 12). Reliance upon each class of chemical pest control products increased from 2015 to 2021, except reliance upon fungicides, which was equal to 2015.
- The percentage of golf facilities that have the listed pesticide storage attributes were equal to or greater than the national average except for locked or restricted access, impervious floor, impervious shelving, powered venting, and explosion proof electrical fixtures (Figure 13).
- The percentage of golf facilities that have the listed pesticide mixing and loading attributes were greater than or equal to the national average for each attribute except water filling capacity > 50 gpm, which was slightly less than the national average (Figure 14).



**Figure 12.** Reliance of U.S. golf facilities on pest management practices during the three years prior to 2015 and 2022 in the Pacific region.



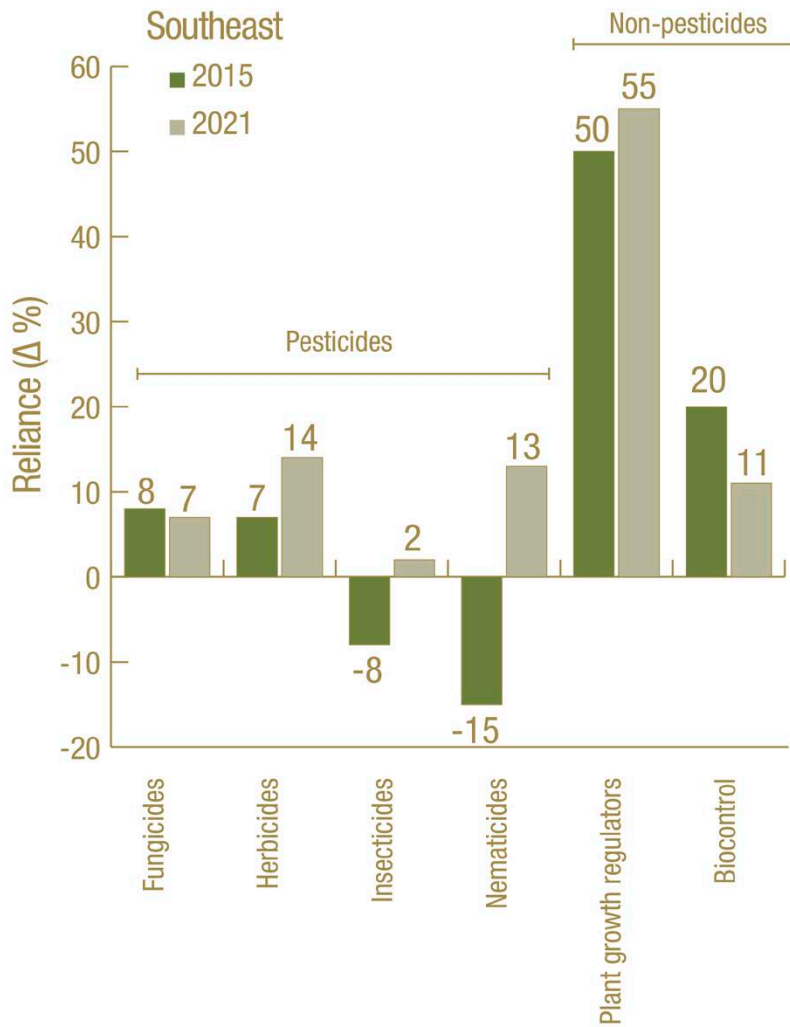
**Figure 13.** Frequency of pesticide storage area properties for all golf facilities in the Pacific region in 2021.



**Figure 14.** Frequency of pesticide mixing and loading area properties for all golf facilities in the Pacific region in 2021.

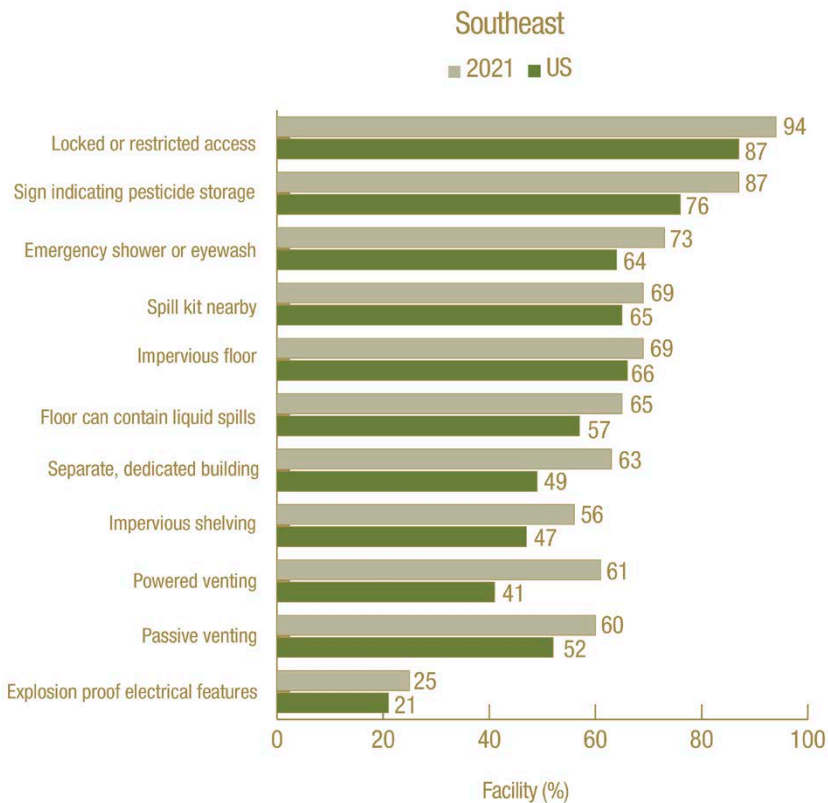
### Southeast

- Reliance upon PGRs increased to 55% from 2015 to 2021, whereas reliance upon biological control products declined to 11% from 2015 to 2021 (Figure 15). Reliance upon each class of chemical pest control products increased from 2015 to 2021, except reliance upon fungicides, which was approximately equal to 2015 at 7%.
- The percentage of golf facilities that have the listed pesticide storage attributes were equal to or greater than the national average (Figure 16).
- The percentage of golf facilities that have the listed pesticide mixing and loading attributes were greater than or equal to the national average for each attribute except spill kit and anti-siphoning on water line, which were less than the national average (Figure 17).

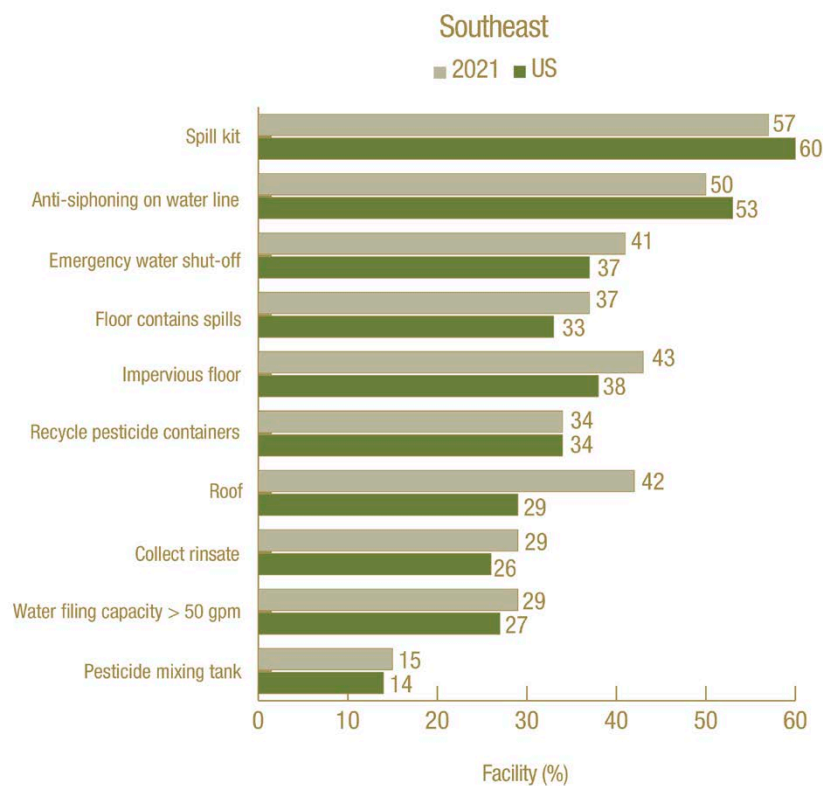


**Figure 15.** Reliance of U.S. golf facilities on pest management practices during the three years prior to 2015 and 2022 in the Southeast region.





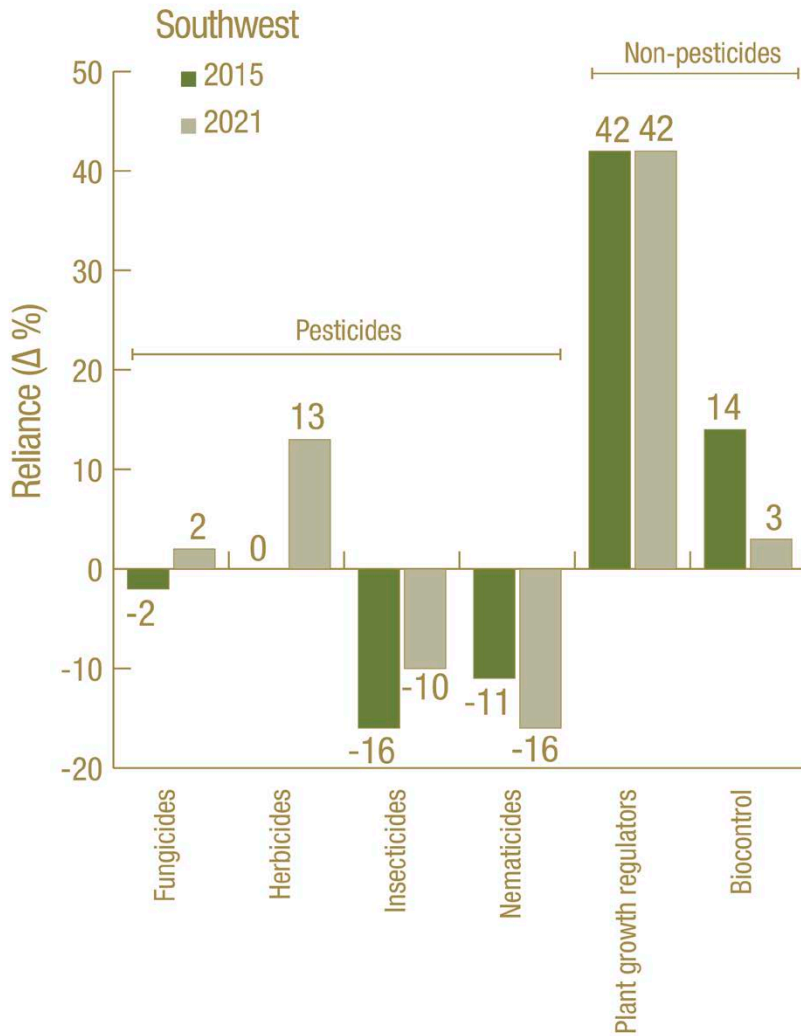
**Figure 16.** Frequency of pesticide storage area properties for all golf facilities in the Southeast region in 2021.



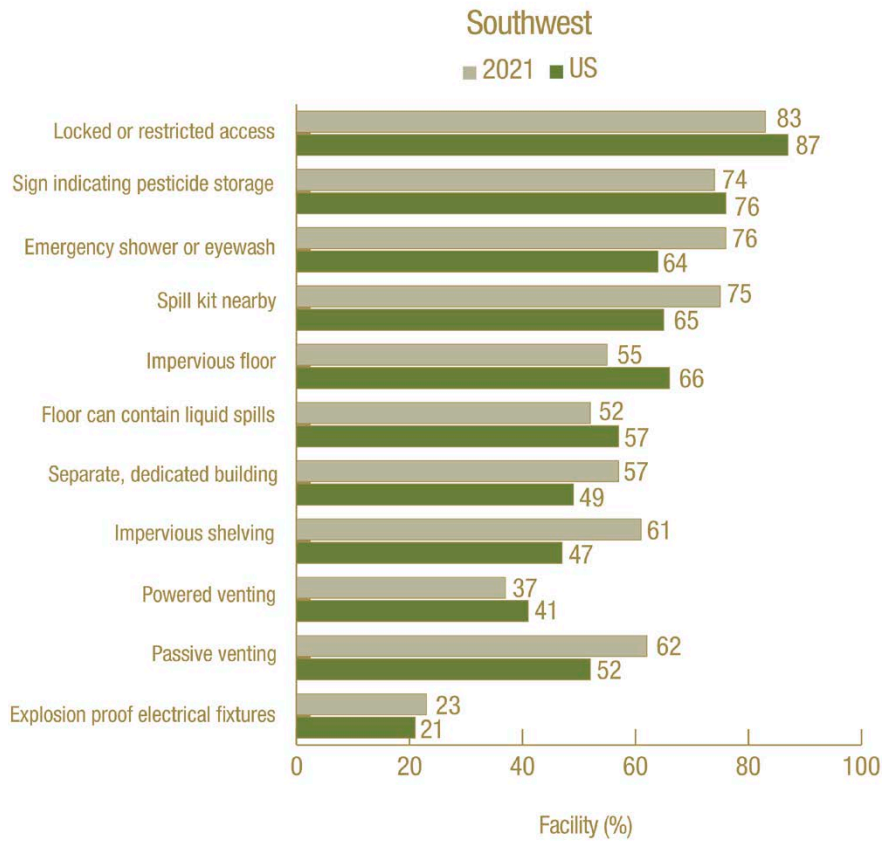
**Figure 17.** Frequency of pesticide mixing and loading area properties for all golf facilities in the Southeast region in 2021.

### Southwest

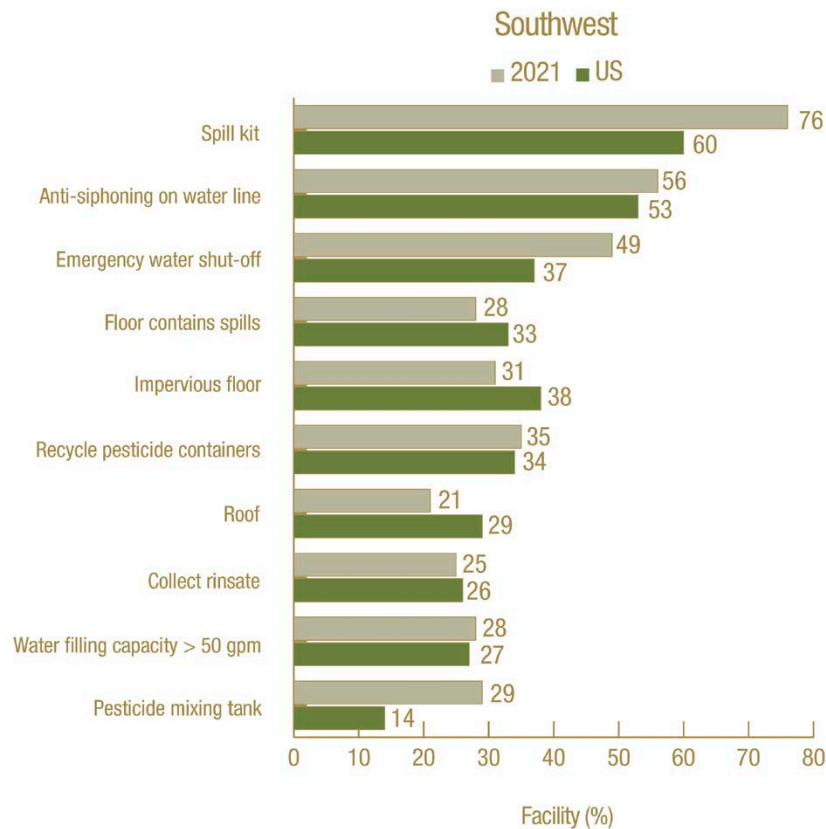
- Reliance upon PGRs did not change from 2015 to 2021, whereas reliance upon biological control products declined to 3% from 2015 to 2021 (Figure 18). Reliance upon each class of chemical pest control products increased from 2015 to 2021, except reliance upon nematicides, which declined from 2015 to 2021 to -16%.
- The percentage of golf facilities that have the listed pesticide storage attributes were equal to or greater than the national average except for locked or restricted access, sign indicating pesticide storage, impervious floor, floor contains liquid spills, and powered venting, which were less than the national average (Figure 19).
- The percentage of golf facilities that have the listed pesticide mixing and loading attributes were greater than or equal to the national average for each attribute except floor contains spills, impervious floors, and roof, which were less than the national average (Figure 20).



**Figure 18.** Reliance of U.S. golf facilities on pest management practices during the three years prior to 2015 and 2022 in the Southwest region.



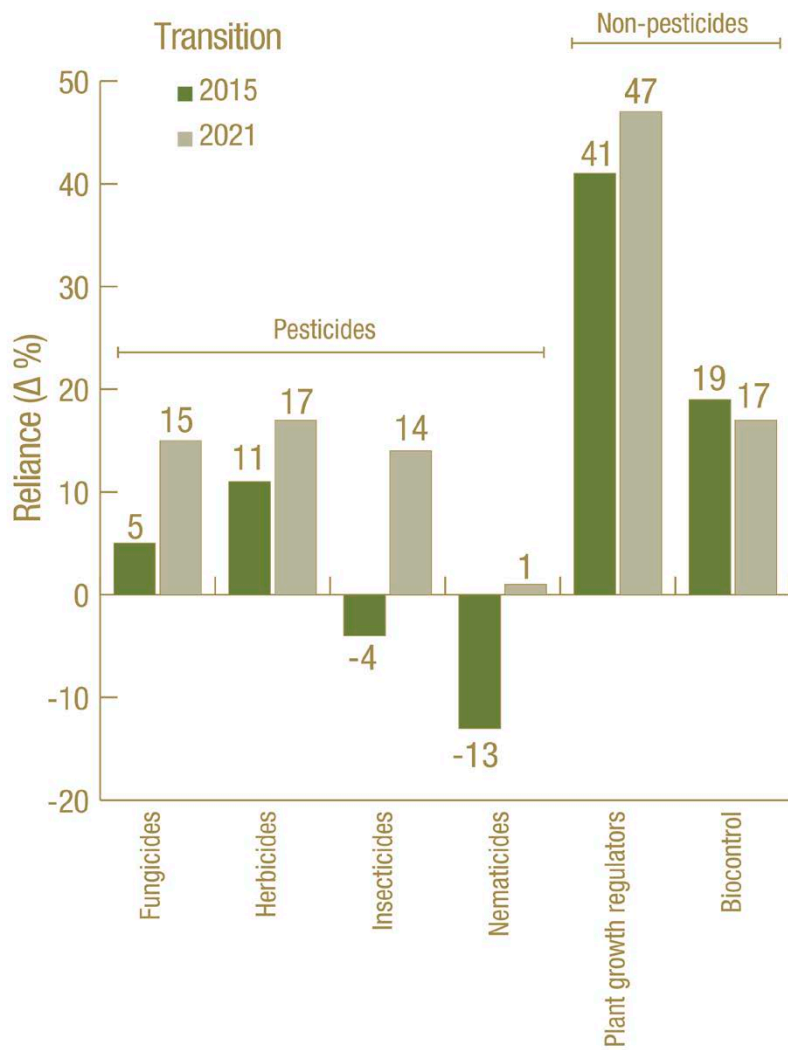
**Figure 19.** Frequency of pesticide storage area properties for all golf facilities in the Southwest region in 2021.



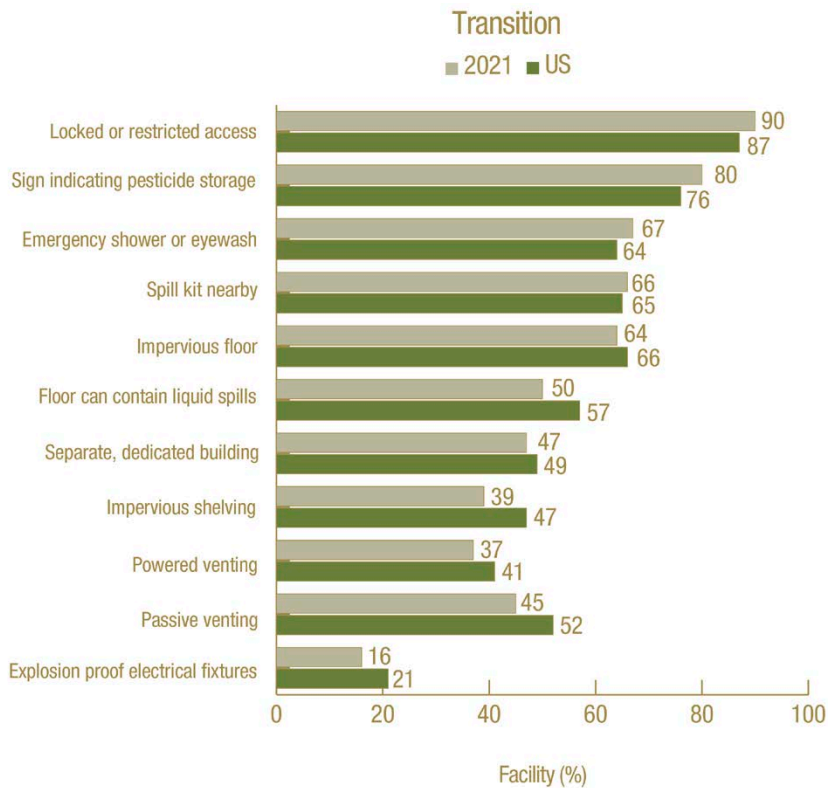
**Figure 20.** Frequency of pesticide mixing and loading area properties for all golf facilities in the Southwest region in 2021.

## Transition

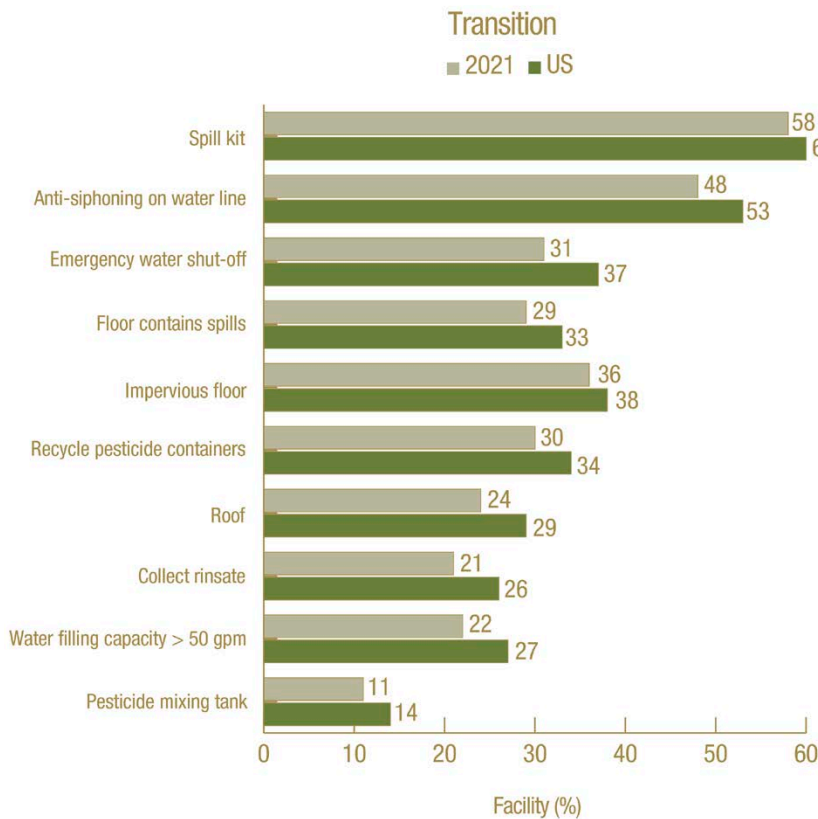
- Reliance upon PGRs increased from 2015 to 2021 to 47%, whereas reliance upon biological control products declined slightly to 17% from 2015 to 2021 (Figure 21). Reliance upon each class of chemical pest control products increased from 2015 to 2021.
- The percentage of golf facilities that have the listed pesticide storage attributes were equal to or greater than the national average except for floor contains liquid spills, separate building, impervious shelving, powered venting, passive venting, and explosion proof electrical fixtures, which were less than the national average (Figure 22).
- The percentage of golf facilities that have the listed pesticide mixing and loading attributes were less than or equal to the national average (Figure 23).



**Figure 21.** Reliance of U.S. golf facilities on pest management practices during the three years prior to 2015 and 2022 in the Transition region.



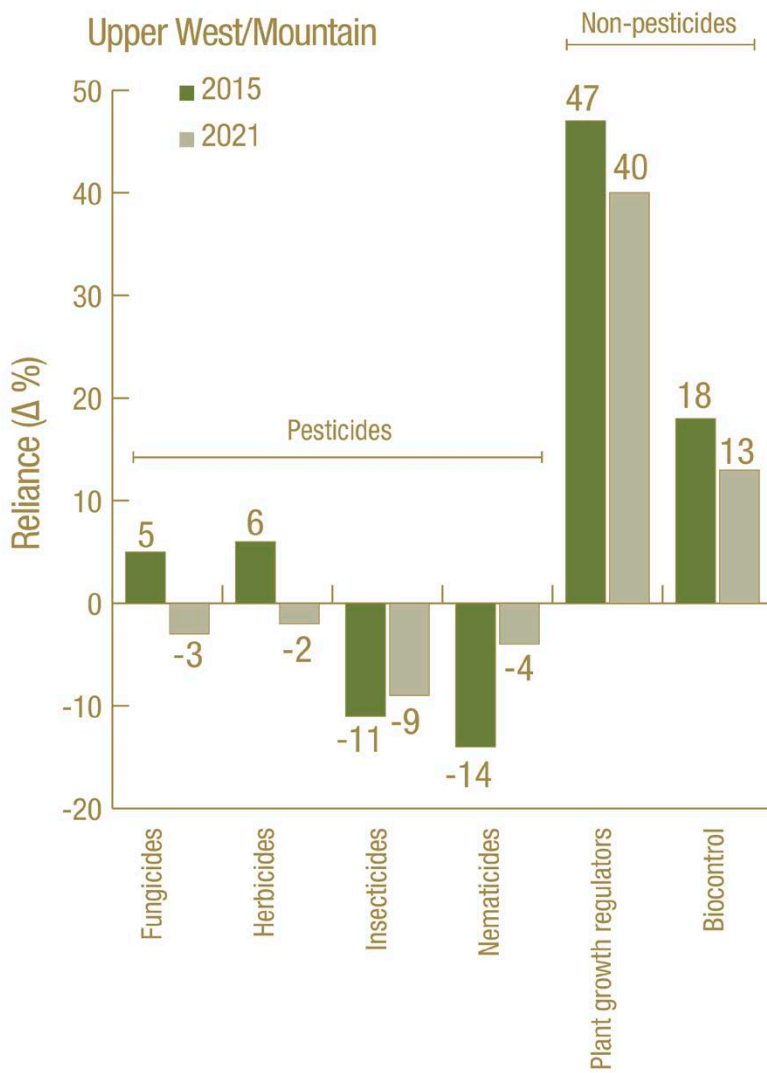
**Figure 22.** Frequency of pesticide storage area properties for all golf facilities in the Transition region in 2021.



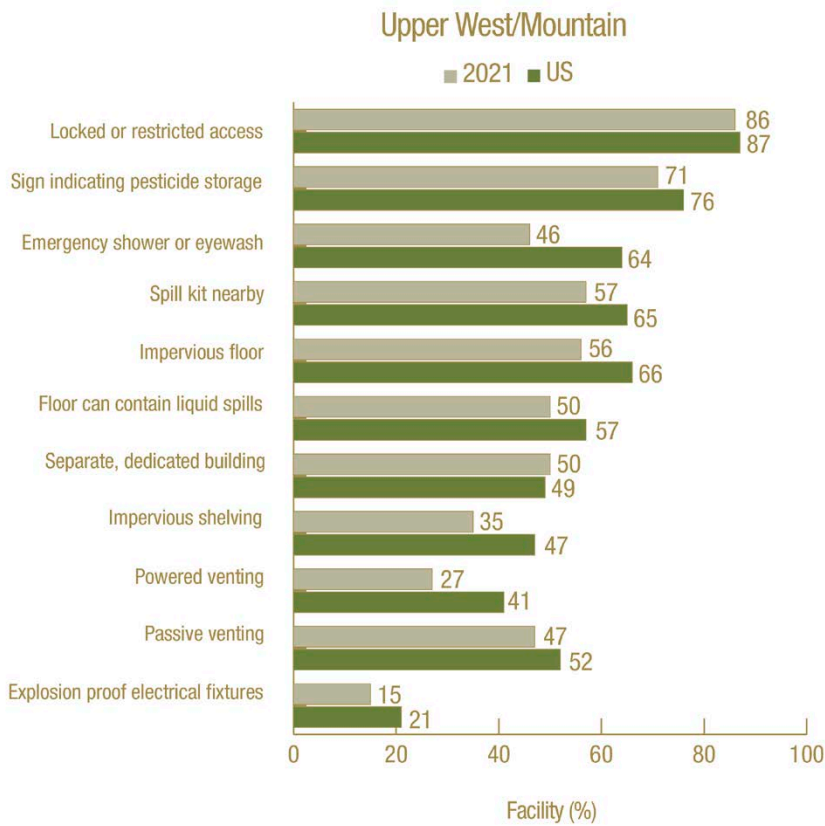
**Figure 23.** Frequency of pesticide mixing and loading area properties for all golf facilities in the Transition region in 2021.

### Upper West/Mountain

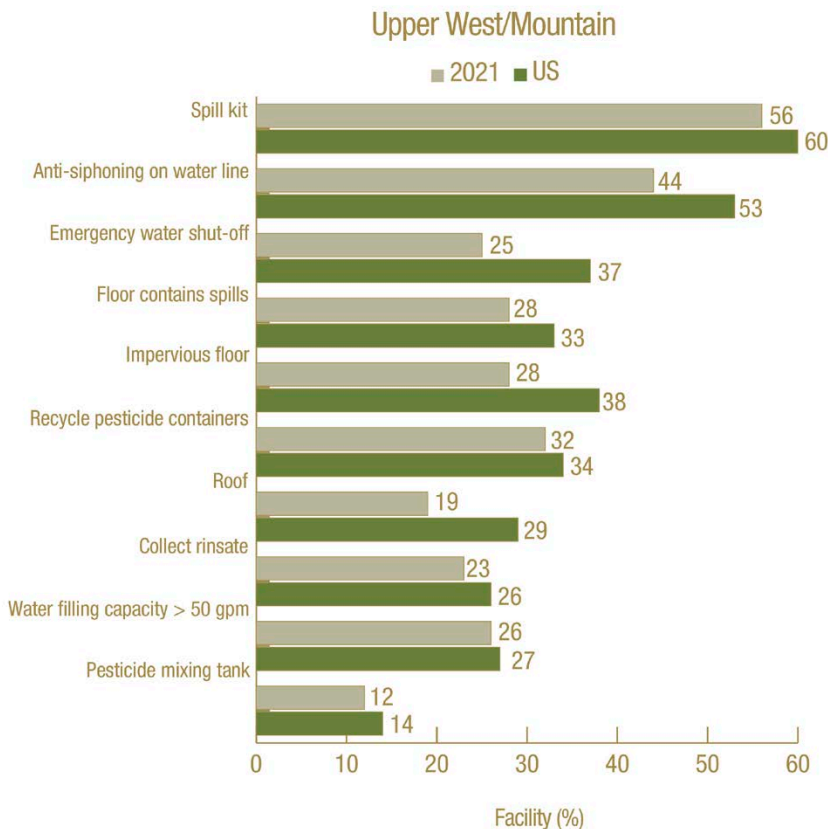
- Reliance upon PGRs and biocontrol products decreased from 2015 to 2021 to 40% and 13%, respectively (Figure 24). Reliance upon insecticides and nematocides increased, whereas reliance on fungicides and herbicides decreased from 2015 to 2021.
- The percentage of golf facilities that have the listed pesticide storage attributes were less than or equal to the national average (Figure 25).
- The percentage of golf facilities that have the listed pesticide mixing and loading attributes were less than or equal to the national average (Figure 26).



**Figure 24.** Reliance of U.S. golf facilities on pest management practices during the three years prior to 2015 and 2022 in the Upper West/Mountain region.



**Figure 25.** Frequency of pesticide storage area properties for all golf facilities in the Upper West/Mountain region in 2021.



**Figure 26.** Frequency of pesticide mixing and loading area properties for all golf facilities in the Upper West/Mountain region in 2021.



## Conclusions and Recommendations

The percentage of golf facilities that engage in the pest management options listed in the survey remains high with more than 50% of facilities reporting that they employ 13 of the 17 practices. However, the percentage of golf facilities using many of these practices have declined over time. The reasons for these changes are not known. Increasing awareness via educational endeavors should be employed.

Reliance upon chemical pesticides increased nationally from 2015 to 2021, whereas reliance upon biocontrol products declined. This increased reliance may be attributed to reduced pest tolerance, which may be driven by golfer expectations. Similarly, reliance upon non-chemical pest management practices may concomitantly increase reliance upon chemical pesticides. In general, the efficacy of biocontrol products is lower than that of conventional pesticides. As such, biocontrol products are often used to augment conventional pest control products, which may reflect the reduced reliance.

The percentage of facilities that use written pest management plans generally remained unchanged from 2007 to 2021 suggesting that improvements in this

area are needed. Written plans are key to producing high quality playing surfaces and protecting the environment. Written plans lead to more effective decision-making, improved site-specific planning, and improved communication. GCSAA has produced excellent tools for developing written IPM plans (<https://www.gcsaa.org/environment/environmental-by-topic/ipm-resources>).

The percentage of facilities that have the listed attributes for pesticide mixing and loading areas and for storage remained generally unchanged from 2007 to 2021. Capital investments in pesticide storage facilities and mixing and loading stations can be cost prohibitive. However, modest investments in existing facilities can be made including floor sealing, the installation of anti-siphoning and emergency shut-off devices. The costs associated with improvements in pesticide related facilities should be measured against potential worker and environmental risk.

Golf facilities that operate with budgets greater than \$1 million more frequently have written pest management plans and have mixing and loading areas with more safety attributes than facilities with budgets less than \$500,000. These

facilities typically have the labor and fiscal resources to devote to pest management planning. However, IPM resources made available by GCSAA will aid facilities in developing these necessary plans.

The COVID-19 pandemic had negligible influence on pesticide usage in 2021. This differs somewhat from nutrient usage during the pandemic when slightly over one-half of the facilities that reported an increase in applied nutrients attributed the increase to more rounds being played. Similarly, golf course superintendents reported a 19% increase in water usage during the pandemic although the factors contributing to these changes are not clearly defined.



## Appendix

**Table A1.** 2021 pest survey responses and weighting factors categorized by region, facility type, number of holes, and green fee.

Region	Facility type	Holes	Green fee	Golf facilities		Survey responses		Weight
		(No.)	(\$)	(No.)	(%)	(No.)	(%)	
Northeast	All	9	All	647	4.6	28	1.9	2.378
Northeast	Public	18	< 55	508	3.6	26	1.8	2.011
Northeast	Public	18	≥ 55	557	4.0	65	4.5	0.882
Northeast	Private	18	All	579	4.1	99	6.9	0.602
Northeast	All	27+	All	179	1.3	27	1.9	0.682
North Central	All	9	All	1144	8.2	22	1.5	5.351
North Central	Public	18	< 55	1183	8.4	64	4.4	1.902
North Central	Public	18	≥ 55	472	3.4	73	5.1	0.665
North Central	Private	18	All	451	3.2	83	5.7	0.559
North Central	All	27+	All	305	2.2	33	2.3	0.951
Transition	All	9	All	640	4.6	17	1.2	3.874
Transition	Public	18	< 55	818	5.8	61	4.2	1.380
Transition	Public	18	≥ 55	355	2.5	52	3.6	0.702
Transition	Private	18	All	520	3.7	90	6.2	0.595
Transition	All	27+	All	176	1.3	27	1.9	0.671
Southeast	All	9	All	458	3.3	6	0.4	7.855
Southeast	Public	18	< 55	744	5.3	59	4.1	1.298
Southeast	Public	18	≥ 55	503	3.6	66	4.6	0.784
Southeast	Private	18	All	684	4.9	136	9.4	0.518
Southeast	All	27+	All	348	2.5	62	4.3	0.578
Southwest	All	9	All	241	1.7	4	0.3	6.200
Southwest	Public	18	< 55	169	1.2	13	0.9	1.338
Southwest	Public	18	≥ 55	335	2.4	44	3.0	0.783
Southwest	Private	18	All	225	1.6	40	2.8	0.579
Southwest	All	27+	All	168	1.2	15	1.0	1.152
Upper West/Mountain	All	9	All	384	2.7	12	0.8	3.293
Upper West/Mountain	Public	18	< 55	179	1.3	27	1.9	0.682
Upper West/Mountain	Public	18	≥ 55	272	1.9	59	4.1	0.474
Upper West/Mountain	Private	18	All	149	1.1	35	2.4	0.438
Upper West/Mountain	All	27+	All	75	0.5	13	0.9	0.594
Pacific	All	9	All	162	1.2	6	0.4	2.778
Pacific	Public	18	< 55	52	0.4	3	0.2	1.784
Pacific	Public	18	≥ 55	184	1.3	42	2.9	0.451
Pacific	Private	18	All	112	0.8	26	1.8	0.443
Pacific	All	27+	All	55	0.4	9	0.6	0.629



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