



# Golf Course Environmental Profile

**Volume V**  
Pesticide Use on U.S. Golf Courses

With a Foreword by  
Sandy G. Queen, CGCS  
2012 GCSAA President

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Funded by the Environmental Institute for Golf, the philanthropic organization of the GCSAA.



Golf Course Superintendents Association of America

# Golf Course Environmental Profile

## Volume V

Pesticide Use Practices  
on U.S. Golf Courses

*Funded by*



The Environmental Institute for Golf

On the cover

Left: Photo © Montana Pritchard, Right: Photo by Larry Stowell, Pace Turf LLC

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## Our Mission



*The Golf Course Superintendents Association of America is dedicated to serving its members, advancing their profession, and enhancing the enjoyment, growth and vitality of the game of golf.*



*The Environmental Institute for Golf fosters sustainability through research, awareness, education, programs and scholarships for the benefit of golf course management professionals, golf facilities and the game.*

## Acknowledgments

*The Golf Course Superintendents Association of America and The Environmental Institute for Golf wish to thank*

*The thousands of golf course superintendents who took the time and effort to complete the survey*

*and*

*Golf's allied associations for their support in this endeavor.*

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## Foreword

Sandy G. Queen, CGCS

# An Eye on the Future

This report, “Pesticide Use Practices on U.S. Golf Courses,” is the final survey of the first phase of GCSAA’s Golf Course Environmental Profile. As an industry, we should be proud that we have collected valuable data that will provide a basis for our decision making and advocate for our industry.

Collectively, the surveys in the profile provide a better understanding of the diverse landscapes on golf courses, the management of natural resources and the inputs used to manage turfgrass, and they paint a reliable portrait of the practices used to condition golf courses throughout the United States. The data also offer answers to inquiries about the golf industry and allow productive discussions about the future of golf course management. With this information, we are able to make confident statements about the positive role golf courses play as a network of small businesses, delivering long-term value to the communities where they are located. The reports also indicate areas where we need to improve so that we can further protect and enhance natural resources.



This particular report describes the approaches used to manage pests on golf courses, shows how pesticides are handled and managed and offers suggestions on areas for improvement. It reveals that golf course superintendents use a variety of methods to prevent pest infestations from damaging playing surfaces. The data support the contention that an integrated approach to pest management is common practice on golf courses. The report also indicates that superintendents are diligent in obtaining state certification to apply pesticides and that most golf courses have a regulatory framework at the local, state and/or federal levels regarding the use of pesticides.

When we undertook this project years ago, we knew the data would be valuable in identifying areas where the industry should improve. In terms of pesticide use, this report notes that golf facilities should strive to develop formal integrated pest management (IPM) and pesticide emergency response plans. In addition, infrastructure elements of pesticide storage and mixing/loading areas show room for improvement. I am confident that the industry will take these recommendations seriously, as they are an investment in the game.

I thank the thousands of golf course superintendents and other facility managers who have participated in these surveys over the last several years. The high participation rate for each of the five surveys reflects a philosophy of focusing on continual improvement, and a commitment to the profession, the industry and the game of golf.

This project was funded through a grant from GCSAA’s philanthropic organization, the Environmental Institute for Golf. I appreciate the many individuals and organizations who contribute to the EIFG so that we can pursue projects that foster a sustainable approach to golf course management.

Sincerely,

A handwritten signature in black ink, appearing to read "Sandy G. Queen". The signature is fluid and cursive, written over a light-colored background.

Sandy G. Queen, CGCS  
2012 GCSAA President



## Executive Summary

GCSAA's Golf Course Environmental Profile is a data collection project that provides new insight into the property features, management practices and inputs associated with golf courses across the United States.

*Pesticide Use Practices on U.S. Golf Courses* is the fifth report produced from the project. The first, *Property Profile and Environmental Stewardship of Golf Courses*, was released in November 2007. The second report, *Water Use and Conservation Practices on U.S. Golf Courses*, was released in January 2009. The third report was *Nutrient Use and Management on U.S. Golf Courses* (2009), and the fourth was *Energy Use and Conservation Practices on U.S. Golf Courses* (2012).

The objectives of this survey were to determine pesticide use and investigate pesticide use practices and pest management tactics on golf courses in the U.S. and its agronomic regions. The pesticide use data proved to be too unreliable to confidently report the use of individual pesticide active ingredients by specific components of the golf course (greens, tees, fairways, rough). This report provides an accurate portrayal of pesticide use practices on golf courses in the U.S. including pesticide storage characteristics, pesticide mixing and loading practices, the use of written integrated pest management plans, pesticide application plans, pesticide emergency plans, the incidence of local restrictions to pesticide operations, number of certified pesticide applicators and other pest management tactics. These data establish a baseline that can be compared to data from future surveys to identify change over time.

### Methodology

Superintendents at all golf facilities (16,194) were invited to participate in the two-part survey. A total of 3,325 completed surveys were returned from 16,194 superintendents, yielding a 20.5% return rate for the first portion of the survey on pesticide use practices. Information on pesticide use was submitted by 1,671 participants. The data collected were not independently validated because of time and resource limitations. The pesticide use data were not reliable enough to confidently report pesticide active ingredients by specific components of the golf course (greens, tees,



GCSAA's survey on pesticide use found that golf course superintendents routinely used multiple tactics to manage pests and followed an integrated approach to pest management.  
Photo © Jim Krajicek

fairways, rough). Analysis of the first portion of the surveys indicated a representative sample of the golf facilities in the U.S. was received with the exception of facility type. Responses from private facilities accounted for 41% of the returned surveys but make up 28% of the known population of golf facilities. Therefore, proportions of the collected sample were weighted to resemble the known population. The data were analyzed and compared across facility types, maintenance budgets and agronomic regions.

### Results

#### *Pest management tactics*

- Superintendents commonly use multiple tactics to manage pests. The tactics most often used at 18-hole golf facilities were:
  - o routine monitoring of weather patterns (97%)
  - o use of cultural practices (96%)
  - o scouting (95%)
  - o recording pest outbreaks (86%)
  - o higher tolerance of pest damage (71%)
- The frequency of use of the multiple management practices listed was higher at facilities with more than nine holes and with an annual



Light traps can be used as a scouting device to determine the presence and population levels of various insect pests, and thereby allow superintendents to initiate control measures in an accurate and timely fashion. Photo by Tom Royer

maintenance budget greater than \$500,000.

- Public facilities and those with an annual maintenance budget of less than \$500,000 were more likely to tolerate a higher level of pest damage.
- Superintendents in the Northeast most frequently recorded pest outbreaks and used pest-tolerant turfgrass species and predictive models.
- Superintendents in the Southwest most frequently used biological controls, traps and sensors.

#### *Pesticide storage characteristics*

- Ninety-eight percent of average 18-hole golf facilities stored pesticides at the facility.
- The most common characteristics of the pesticide storage area were:
  - o locked or restricted access (94%)
  - o signs indicating pesticide storage (85%)
  - o emergency shower or eyewash station nearby (74%)
  - o impervious floor (68%)
  - o spill kits (67%)
  - o floors capable of containing liquid spills (63%)
  - o passive venting (58%)
  - o separate/dedicated building (54%)
  - o impervious shelving (51%)
  - o powered venting (50%)
  - o explosion-proof fixtures (30%)
- Pesticide storage facilities at private, 27-hole facilities with higher maintenance budgets were more likely to have the features listed above than were public 18- or 9-hole facilities with maintenance budgets less than \$1,000,000.
- Golf facilities in the Northeast, Southeast, Southwest and Pacific agronomic regions were more likely to have these characteristics than

facilities in the North Central, Transition or Upper West/Mountain regions.

#### *Mixing and loading characteristics*

- The most common characteristics of mixing and loading sites were:
  - o spill kit located near mix/load area (60%)
  - o anti-siphoning device on water line (56%)
  - o emergency water shut-off valve (45%)
  - o impervious floor (45%)
  - o recycling of pesticide containers (36%)
  - o tank-filling capacity greater than 50 gallons per minute (36%)
  - o floors capable of containing liquid spills (35%)
  - o overhead protection from weather (29%)
  - o pesticide rinsate collection (27%)
  - o stand-alone pesticide mixing tank (15%)
- Mixing and loading sites at private, 27-hole facilities with higher maintenance budgets were more likely to have the characteristics listed above than public, 18- or 9-hole facilities with maintenance budgets less than \$1,000,000.
- Golf facilities in the North Central, Southeast, and Southwest agronomic regions were significantly more likely to have these characteristics than facilities in the Northeast, Transition, Upper West/Mountain and Pacific regions.

#### *Written integrated pest management (IPM) plan*

- Forty-one percent of average 18-hole golf facilities had a written IPM plan.
- Written IPM plans were significantly more common on 27-hole (41%) and 18-hole (41%) golf facilities than 9-hole (33%) golf facilities.
- Private and public golf facilities were equally likely to have a written IPM plan.
- Written IPM plans were more prevalent at facilities with higher maintenance budgets.
- Golf facilities in the Pacific and Southwest agronomic regions were significantly more likely to have a written IPM plan than facilities in the other agronomic regions.
- Voluntary action initiated by the golf facility board, committee, or superintendent (68%) was the most common reason given for adoption of a written IPM plan.
- The second and third most common reasons given for adopting a written IPM plan were voluntary participation with a non-governmental agency (16%) and requirement of a government or tribal authority (14%).
- Golf facilities in the Upper West/Mountain (23%) and Pacific (22%) regions were the most likely to adopt a written IPM plan because of voluntary participation with a non-governmental agency.

- Golf facilities in the Pacific (22%) and Southwest (20%) regions were most likely to adopt a written IPM plan because of a requirement by a government or tribal authority.

#### *Written pesticide management plan*

- Sixty-six percent of average 18-hole golf facilities had a written pesticide application plan.
- The size of the golf facility did not significantly affect the likelihood that it had a written pesticide application plan.
- Private facilities were more likely to have a written pesticide application plan than public facilities.
- Facilities with an annual maintenance budget greater than \$1,000,000 were more likely to have a written pesticide application plan than facilities with lower maintenance budgets.
- Golf facilities in the North Central and Transition agronomic regions were more likely to have a written pesticide application plan than facilities in the other agronomic regions.
- The most common reason given for the adoption of a written pesticide application plan was voluntary action initiated by the golf facility board, committee or superintendent.

- The next most common reason was a requirement by a government or tribal authority.

#### *Written pesticide emergency response plan*

- Approximately 50% of average 18-hole facilities had a pesticide emergency response plan.
- Pesticide emergency response plans were more common at 27-hole facilities than facilities with fewer holes.
- Private golf facilities were more likely than public facilities to have a written pesticide emergency response plan.
- Golf facilities with an annual maintenance budget greater than \$1,000,000 were more likely to have a written pesticide emergency response plan than facilities with lower maintenance budgets.
- Average 18-hole golf facilities in the Southwest and Pacific regions were significantly more likely to have a written pesticide emergency response plan than facilities in other regions.

#### *Certified pesticide applicators*

- Almost all golf facilities employed one or more certified pesticide applicators.
- The number of certified pesticide applicators



Average 18-hole golf facilities in the Southwest and Pacific regions were significantly more likely to have a written pesticide emergency response plan than facilities in other regions. Photo by Jim Key, CGCS



*GCSAA recommends that all golf courses have a written integrated pest management plan that incorporates a pesticide application plan. It is also recommended that superintendents continually strive to use innovative practices and technology to strengthen their plant and pest management strategies.*

was significantly higher at 27-hole (2.7) and 18-hole (2.1) golf facilities than at 9-hole (1.2) golf facilities.

- Private golf facilities employed more certified pesticide applicators than public golf facilities.
- Golf facilities with higher maintenance budgets had a higher number of certified pesticide applicators on staff.

#### *Pesticide regulations and restrictions*

- A large majority of golf facilities were affected by regional or local government regulations in addition to federal and state regulations covering pesticide operations. The most common regulations were:
  - mandated pesticide recordkeeping (79%)
  - pesticide posting/notification (62%)
  - pesticide storage (62%)
- Additional regulations covering pesticide operations were most common for average 18-hole golf facilities in the Southwest and Pacific regions.
- For some golf facilities, local governments or tribal authorities also restricted pesticide use. Responses indicated that twenty-six percent of average 18-hole golf facilities had one or more restrictions on their pesticide applications enacted by local government or tribal authorities.
- The most common restrictions were:
  - prohibition of a specific pesticide product(s) (72%)
  - limitation on the total amount of a specific product applied (72%)
  - limitation on the amount of a specific product applied per application (57%)
- Average 18-hole golf facilities in the Southwest (46%) and Pacific (43%) regions were more likely to have one or more local restrictions on pesticide applications.

#### *Trends in pesticide use*

Nationally, the use of fungicides, insecticides and herbicides stayed relatively the same in 2007 compared to previous years, but there was moderate change depending on the component of the golf course where the pesticides were applied. The use of plant growth regulators increased relative to typical use in previous years on tees and fairways, and most notably on putting greens.

- The greatest increase in the use of plant growth regulators was on putting greens: 44% of average 18-hole golf facilities reported an increase in use and 8% reported a decrease. Fungicide use on putting greens increased slightly.
- The use of fungicides and insecticides on tees decreased slightly. On tees, there was relatively

no change in herbicide use, but plant growth regulator use increased.

- On fairways, fungicide use decreased slightly, insecticide use showed little change, herbicide use increased moderately and plant growth regulator use increased.
- On roughs, fungicide use decreased and herbicide use increased, but insecticide and plant growth regulator use were relatively unchanged.

## **Recommendations and conclusions**

### *Pesticide storage characteristics*

GCSAA recommends that all golf facilities storing pesticides use an area specifically designed for the purpose. All pesticide storage areas should have impervious floors and shelving and have spill kits available in the area. All golf facilities should invest in the proper devices to minimize potential risks from storing pesticides.

### *Pesticide mixing and loading*

GCSAA recommends that mixing and loading areas be designed for this purpose and be equipped with appropriate safety devices. Improvement is needed in the following areas:

- spill kits located near mix/load area
- anti-siphoning device on water line
- emergency water shut-off valve
- impervious floor
- recycling of pesticide containers
- floors capable of containing liquid spills
- overhead protection from weather

### *Pesticide emergency response plan*

GCSAA recommends that all golf facilities have a pesticide emergency response plan to enhance preparedness should an accident occur that involves application or storage of pesticide products.

### *IPM plan and pest management tactics*

GCSAA recommends that all golf courses have a written integrated pest management (IPM) plan that incorporates a pesticide application plan. It is also recommended that superintendents continually strive to use innovative practices and technology to strengthen their plant and pest management strategies. This survey indicated that golf course superintendents routinely used multiple tactics to manage pests and followed an integrated approach to pest management, even though less than half of 18-hole golf facilities had developed a formal, written IPM document.



## Introduction

GCSAA's Golf Course Environmental Profile is a data collection project that provides new insight into the property features, management practices and inputs associated with golf courses across the United States. The objectives of this survey were to determine pesticide use and investigate pesticide use practices and pest management tactics on golf courses in the U.S. and its agronomic regions. The areas evaluated included pesticide storage characteristics, pesticide mixing and loading practices, use of written integrated pest management plans, pesticide application plans, pesticide emergency plans, incidence of restrictions to pesticide operations, number of certified pesticide applicators and other pest management tactics. These data establish a baseline that can be compared to data from future surveys to identify change over time.

In 2004, Golf course superintendents, golf industry leaders, golf association leaders, environmental advocates, university turfgrass scientists and environmental regulators began participating in meetings, symposiums and conferences hosted by the Golf Course Superintendents Association of America (GCSAA) and the Environmental Institute for Golf to discuss environmental issues facing the golf industry and to identify future research, education and outreach opportunities. The group reached several important conclusions about the environmental aspects of golf including:

- The golf industry lacks comprehensive national data on the property features, management practices and inputs associated with golf courses and golf course maintenance.
- Although many individual golf courses were environmentally proactive, no systematic process was in place to document current practices or track changes that the golf industry nationwide has made to protect and enhance the environment.

In 2006, GCSAA initiated a project, funded by the Environmental Institute for Golf to collect data nationally on the property features, management practices and inputs associated with golf courses and golf course maintenance. To collect the data, five surveys were conducted from 2006 through 2009. The intention is to repeat the surveys in future years to measure changes on golf courses and in golf course maintenance practices over time.

The first survey was conducted in 2006 and its manuscript, "Golf Course Profile Describes Turfgrass, Landscape and Environmental Stewardship Features," was published in November 2007 in *Applied Turfgrass Science*, a peer-reviewed scientific journal (3). Its companion report, *Property Profile and Environmental Stewardship of Golf*

*Courses*, was also produced in November 2007. The second survey of the series was conducted in late 2006 and its manuscript, "Golf Course Environmental Profile Measures Water Use, Source, Cost, Quality and Management and Conservation Strategies," was published in *Applied Turfgrass Science* in 2009 (9). Its companion report, *Water Use and Conservation Practices on U.S. Golf Courses*, was also produced in 2009.

In 2007, the third survey of the series was completed and its manuscript, "Golf Course Environmental Profile Measures Nutrient Use and Management and Fertilizer Restrictions, Storage and Equipment Calibration," was published in *Applied Turfgrass Science* in 2009 (8). Its companion report, *Nutrient Use and Management on U.S. Golf Courses*, was also published in 2009. The fourth survey was conducted in 2009. The resulting article, "Golf Course Environmental Profile Measures Energy Use and Energy Conservation Practices," was published in *Applied Turfgrass Science* in 2012 (3). Its companion report, *Energy Use and Energy Conservation Practices on U.S. Golf Courses*, was also produced in 2012.

Key results from the first four published surveys indicated that: an average 18-hole golf course is 150 acres, of which, 100 acres is maintained turfgrass; U.S. golf courses irrigate an estimated 1,198,381 acres of turfgrass; total annual water use averaged over 2003, 2004 and 2005 was estimated at 2,312,701 acre-feet; in 2006, summed over all golf course components and all golf facilities, a total of 101,096 tons of nitrogen and 36,810 tons of phosphate were applied to 1,311,000 acres and 99,005 tons potash was applied to 1,260,000 acres; and golf facilities consumed an average of 6.134 million BTU annually (3,4,8,9).

All the published Golf Course Environmental Profile reports and journal articles are available on GCSAA's website, ([www.gcsaa.org/course/environment/default.aspx](http://www.gcsaa.org/course/environment/default.aspx)). For more information on the Golf Course Environmental Profile, please contact the Environmental Institute for Golf at 800-472-7878.

## Summary of Methodology

Input on the survey questions was collected from golf, environmental, academic and regulatory sources. GCSAA staff drafted survey questions, which were reviewed and revised by a group of golf course superintendents, golf association leaders and turfgrass scientists.

The National Golf Foundation (NGF) was contracted to conduct the survey, manage the recruitment of participants and complete the analysis of data in collaboration with GCSAA.

The NGF adheres to The Code of Marketing Research Standards developed by the Marketing Research Association (5). The NGF refined and formatted the survey instrument for online and paper versions. Survey questions were developed following the same process used for the other surveys (3,4,8,9). To make the survey manageable for respondents and to achieve an acceptable response rate, data collected were limited to fungicides, herbicides, insecticides and plant growth regulators applied to turfgrass growing on greens, tees, fairways, and rough. The National Golf Foundation (Jupiter, Fla.) conducted the survey and analyzed the data.

## Survey Procedures

The same survey procedures were used for this survey as for the other surveys (3,4,8,9). An attempt was made to recruit 16,194 superintendents at golf facilities in the U.S. to complete the survey. Surveys were sent beginning Jan. 23, 2008 by email or mail and accepted until June 20, 2008. Several reminders to complete and submit the survey were sent by email and mail.

The survey had two components. The first was designed to investigate pesticide use practices and

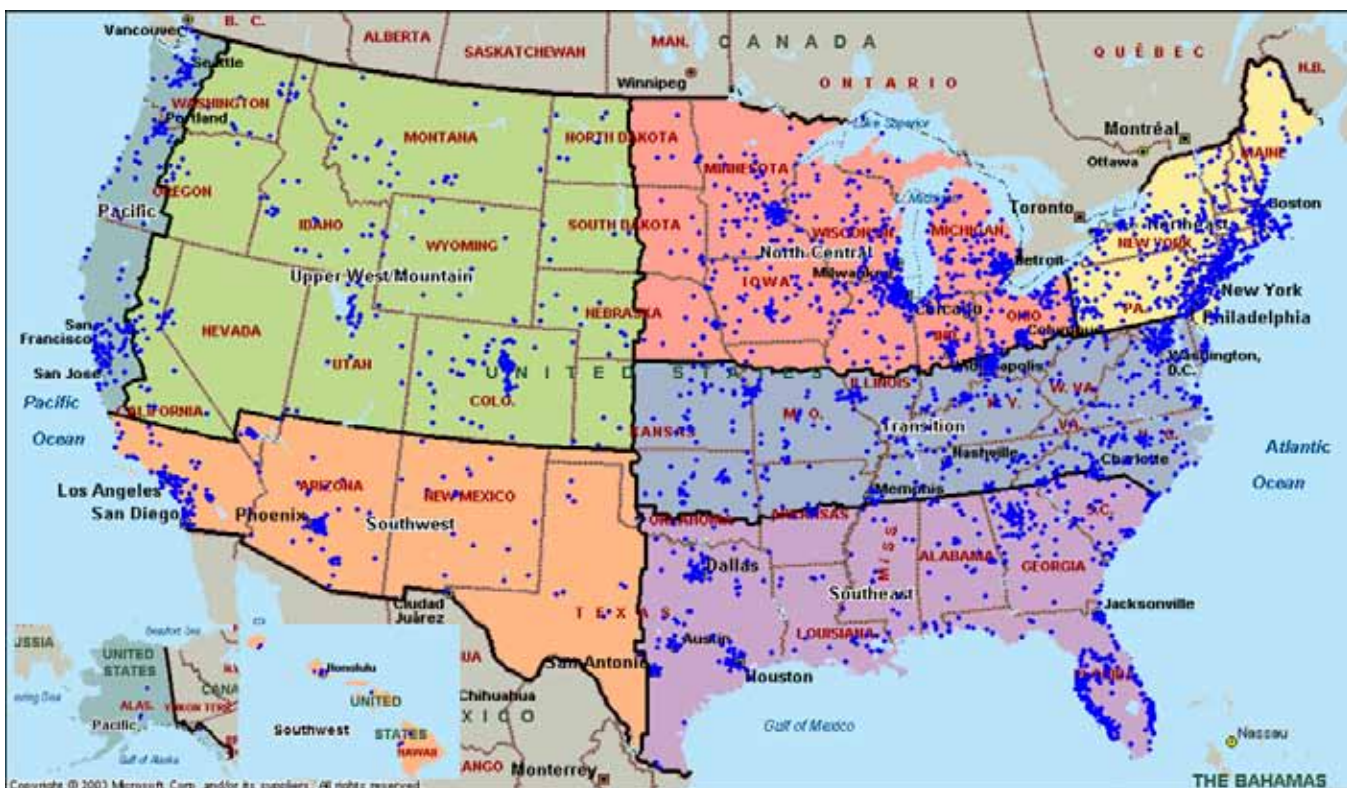
pest management tactics. The second portion was designed to collect pesticide use records on specific components of the golf course — tees, greens, fairways and rough. For the first component of the survey, a total of 3,325 of 16,194 superintendents, returned completed surveys, yielding a 20.5% return rate (Figure 1). For the second component of the survey, 1,671 participants submitted information from their pesticide use records.

The data collected were not independently validated because of time and resource limitations. The pesticide use data proved to be too unreliable to confidently report the use of individual pesticide active ingredients on specific components of the golf course (greens, tees, fairways, rough).

All completed surveys were screened to determine whether the response provided for any single question was reasonable in the context of the rest of the responses on that survey following the procedures used in the previously published surveys (3,4,8,9).

Analysis of the completed surveys indicated a representative sample of the golf facilities in the U.S. was received with the exception of facility type. Responses from private facilities accounted for 41% of the returned surveys but made up 28% of the known population of golf facilities (Table

## Survey respondents



**Figure 1.** Surveys were sent to 16,194 superintendents, and 3,325 completed surveys were returned. Blue dots indicate the locations of superintendents who completed the survey.

A1). Therefore, proportions of the collected sample were weighted to resemble the known population. Weighted data are presented in this report. Agronomic regions and the location of golf facilities responding to the survey are shown in Figure 1. Agronomic regions were delineated by grouping geographic areas with similar agronomic and climatic characteristics using previously published regions as a guide (1,7). Boundaries were drawn using county borders.

Data were analyzed using Quantum crosstabs and SPSS analytics software (SPSS 15.0 for Windows, SPSS Inc., Chicago, Ill.) to run descriptive statistics, and *t*-tests were performed to explore relationships between categorical variables such as agronomic region, course type and number of holes. Confidence intervals of 90% were used for mean separation.

The facility type was characterized as private or public. Private facilities require a membership, and public facilities allow anyone to play for a fee. Golf facilities were divided into three annual maintenance budget categories: more than \$1 million, \$500,000 to \$999,999 and less than \$500,000.

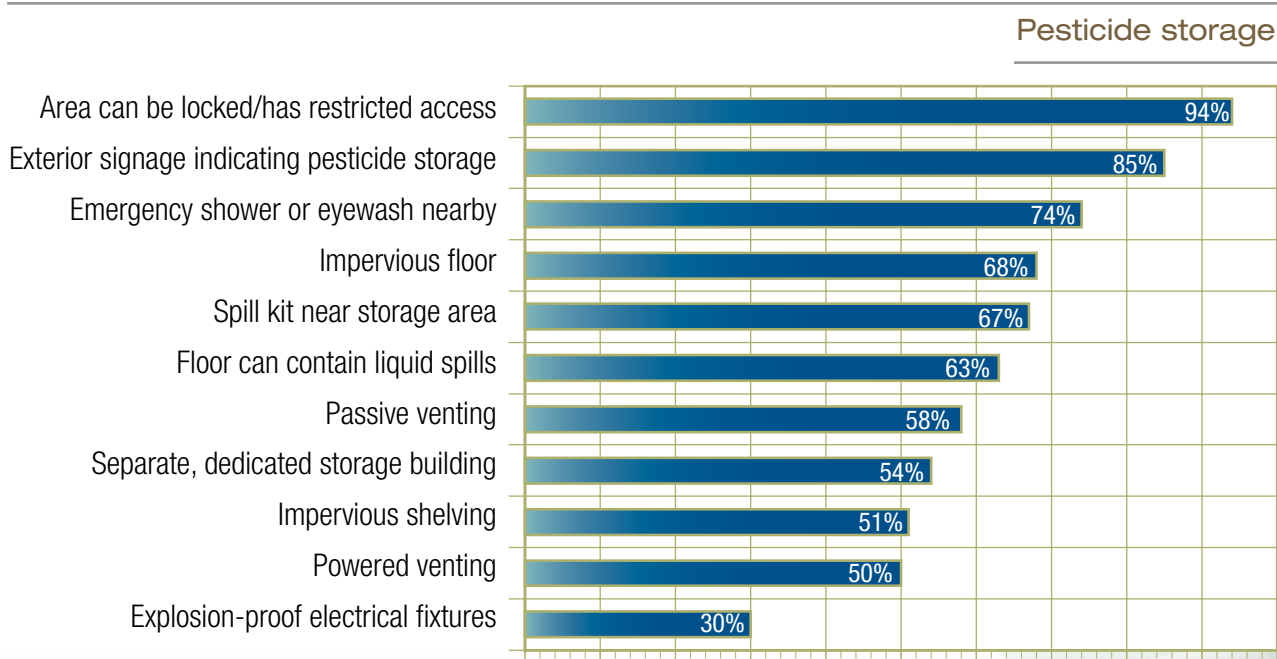
The final major comparison was by agronomic region. The continental U.S. was divided into seven agronomic regions: Northeast, North Central, Transition, Southeast, Southwest, Upper West/Mountain and Pacific. The regional analysis identifies variation in pesticide use practices. Where 18-hole equivalent data are presented, data within a region were averaged over facility type and budget. The number of 18-hole equivalents in the U.S. is 14,969 and was determined by tak-

ing the total number of golf holes and dividing by 18 (6).

The words “significant” and “significantly” are used frequently in the report to describe statistical differences. For example, “Private golf facilities (55%) were significantly more likely than public facilities (50%) to have a written pesticide emergency response plan.” In the mathematical sense, “significant” means that differences are important, distinct and too great to be caused by chance. The data have been analyzed and compared across facility types, maintenance budgets and agronomic regions.

## Survey Results

In the first portion of the survey, respondents were asked to indicate several aspects of their pesticide use practices and pest management tactics. The responses helped to portray specific physical elements of golf facilities such as pesticide storage and pesticide mixing and loading areas. The respondents indicated their use of pesticide application plans, pesticide emergency plans, governmental restrictions to their pesticide operations and the number of certified pesticide applicators employed at golf facilities. Pest management tactics such as the use of integrated pest management plans and specific practices associated with IPM were also evaluated by this survey. The second portion of the survey was designed to better understand pesticide use characteristics for specific components of the golf course. The pesticide use data proved to be too unreliable to confidently report the use of individual pesticide active ingre-



**Figure 2.** Pesticide storage facility characteristics for the average 18-hole golf facility in the U.S.



dients by specific components of the golf course (greens, tees, fairways, rough).

*Pesticide storage characteristics*

It is commonplace for pesticides to be stored on site at golf facilities. The survey indicated that 98% of average 18-hole golf facilities stored pesticides on the property. There was no significant difference in the percentage of golf facilities storing pesticides based on the number of holes, facility type (private vs. public) or maintenance budget. The most common characteristics of the pesticide storage area were: locked or restricted access (94%); signs indicating pesticide storage (85%); emergency shower or eyewash station nearby (74%); impervious floor (68%); spill kits (67%); floors capable of containing liquid spills (63%); passive venting (58%); separate/dedicated building (54%); impervious shelving (51%); powered venting (50%); and explosion-proof fixtures (30%) (Figure 2).

Pesticide storage facilities at private facilities with an annual maintenance budget greater than

\$1,000,000 were significantly more likely to have the listed pesticide storage characteristics than public 18- or 9-hole facilities with maintenance budgets less than \$1,000,000. Average 18-hole golf facilities in the Northeast, Southeast, Southwest and Pacific regions were significantly more likely to have the listed pesticide storage characteristics than facilities in the North Central, Transition, or Upper West/Mountain regions.

*Pesticide mixing and loading*

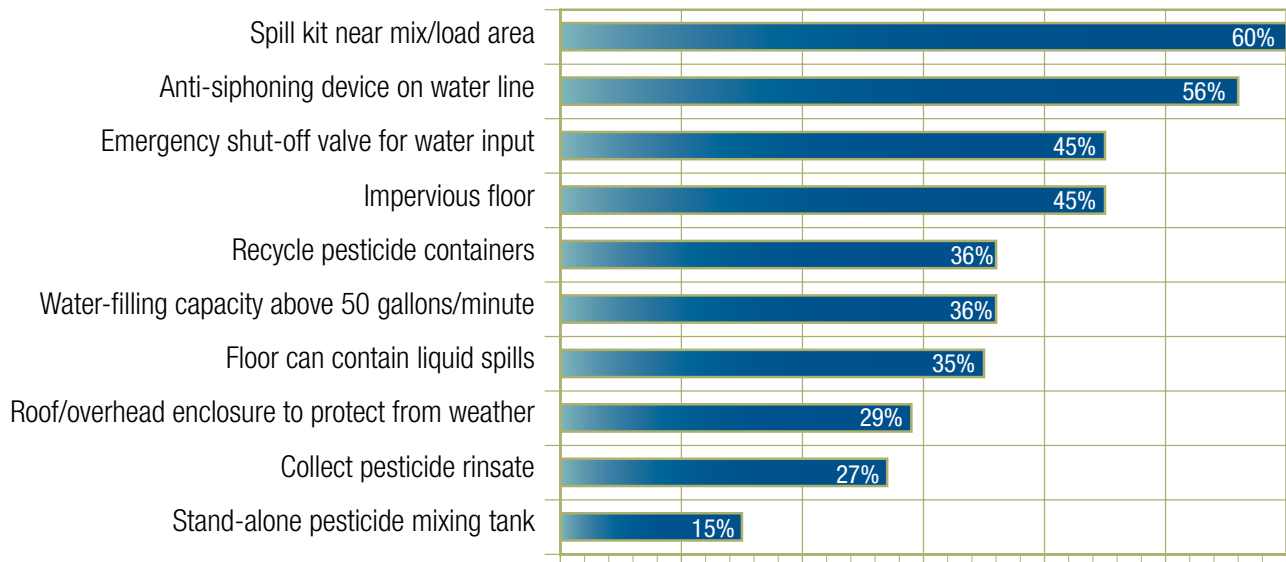
In general, a mixing and loading station is a dedicated area where pesticides are measured, mixed and loaded into the application equipment. These areas should have specific safety features that will protect environmental resources from potential contamination during the mixing and loading procedure. Respondents identified the types of features that were present at their mixing and loading station by selecting from a pre-populated list within the survey question. The most common characteristics of mixing and loading stations for average 18-hole golf facilities were: spill kit located near mix/load area (60%); anti-siphoning device on water line (56%); emergency water shut-off valve (45%); impervious floor (45%); recycling of pesticide containers (36%); tank-filling capacity greater than 50 gallons per minute (36%); floors capable of containing liquid spills (35%); overhead protection from weather (29%); pesticide rinsate collection (27%); and stand-alone pesticide mixing tank (15%) (Figure 3).

The larger the facility and the larger the budget, the more likely the facility was to have more



Pesticide storage and mixing/loading areas should have an emergency shower or eyewash station nearby. Photo © Montana Pritchard

**Pesticide mixing and loading areas**



**Figure 3.** Pesticide mixing and loading area characteristics for the average 18-hole golf facility in the U.S.

of the safety measures listed. Mixing and loading sites at private, 27-hole facilities with an annual maintenance budget greater than \$1,000,000 were significantly more likely to have the listed mixing and loading characteristics than public, 18- or 9-hole facilities with maintenance budgets less than \$1,000,000. Approximately 17% of 9-hole facilities reported none of the listed features at the mixing and loading area. Average 18-hole golf facilities in the North Central, Southeast, and Southwest agronomic regions were significantly more likely to have the listed mixing and loading characteristics than facilities in the Northeast, Transition, Upper West/Mountain and Pacific regions.

#### Written pesticide emergency response plan

Respondents were asked to indicate whether they had developed a written emergency response plan. These plans are designed to prepare the staff to effectively respond if an accident should occur within the pesticide operation or the pesticide storage area. Approximately 50% of average 18-hole facilities had a pesticide emergency response plan.

Pesticide emergency response plans were significantly more common at 27-hole facilities (63%) than at 18-hole (51%) or 9-hole (37%) facilities. Private golf facilities (55%) were significantly more likely than public facilities (50%) to have a written pesticide emergency response plan. Golf facilities with an annual maintenance budget greater than \$1,000,000 (67%) were significantly more likely to have a written pesticide emergency response plan than facilities with a maintenance budget of

\$500,000 to \$999,999 (51%), which were significantly more likely to have a written pesticide emergency response plan than facilities with a maintenance budget less than \$500,000 (44%).

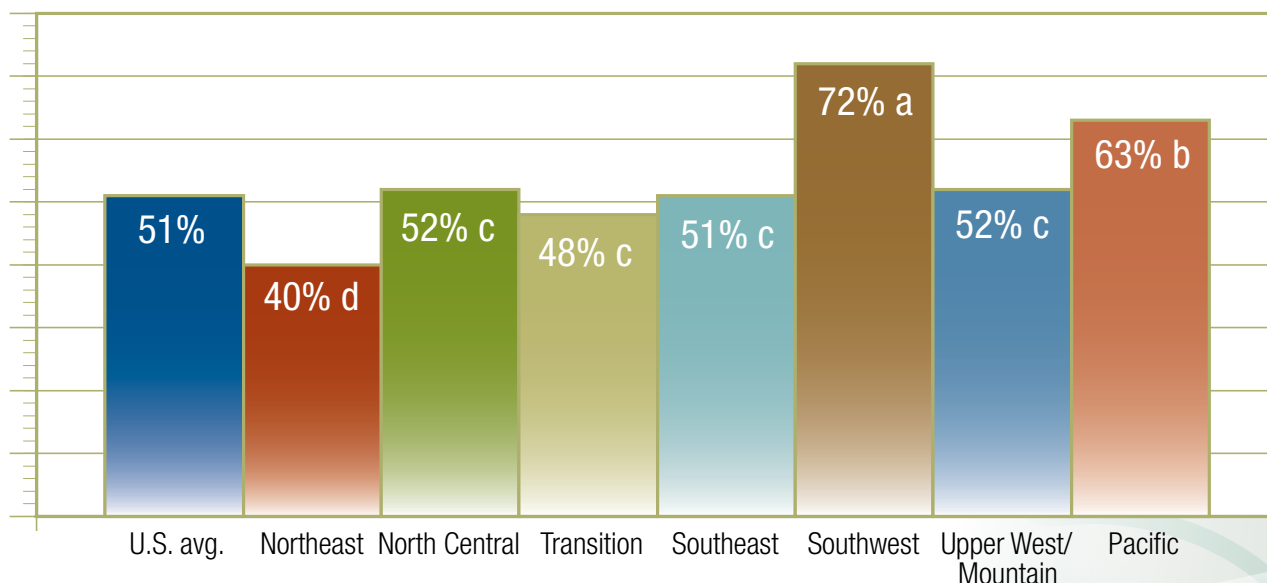
Average 18-hole golf facilities in the Southwest (72%) and Pacific (63%) agronomic regions were significantly more likely to have a written pesticide emergency response plan than facilities in the North Central (52%), Upper West/Mountain (52%), Southeast (51%), Transition (48%) and Northeast (40%) regions (Figure 4).

#### Written Integrated Pest Management plan

The concept and practices of Integrated Pest Management (IPM) have been researched and developed for golf courses for many years. In general, the system is based on routine scouting, proper pest identification, setting pest/damage thresholds, using multiple control tactics and progressive management of the turfgrass stand to optimize its ability to withstand pest damage. For the purposes of this survey, an IPM plan was defined as a written, comprehensive document that describes the strategies and tactics implemented to manage pests on the golf course. The plan relies on commonsense practices in which monitoring is used, pests are positively identified, damage thresholds established, all possible control

*For the purposes of this survey, an IPM plan was defined as a written, comprehensive document that describes the strategies and tactics implemented to manage pests on the golf course.*

### Written pesticide emergency response plan



**Figure 4.** Prevalence of a written pesticide emergency response plan at 18-hole golf facilities by U.S. agronomic region. Percentages followed by the same letter are not significantly different from one another. Letters denote significance at the 90% confidence level.

options (including pesticides) are considered, and appropriate controls are implemented.

Survey questions were developed to identify how many golf courses had a written IPM plan and to investigate the use of specific practices known to be useful in using this approach. Forty-one percent of average 18-hole golf facilities had a written IPM plan. Written IPM plans were significantly more common on 27-hole (41%) and 18-hole golf facilities (41%) than 9-hole (33%) golf facilities. Private (42%) and public (41%) golf facilities were equally likely to have a written IPM plan. Golf facilities with an annual maintenance budget greater than \$1,000,000 (50%) were significantly more likely to have a written IPM plan than facilities with a maintenance budget of \$500,000 to \$999,999 (42%), which were significantly more likely to have a written IPM plan than facilities with a maintenance budget

less than \$500,000 (38%). Average 18-hole golf facilities in the Pacific and Southwest regions were significantly more likely to have a written IPM plan than facilities in the other agronomic regions (Figure 5).

Voluntary action initiated by the golf facility board, committee or superintendent (68%) was the most common reason given for adoption of a written IPM plan by an average 18-hole golf facility. The second and third most common reasons given for adopting a written IPM plan were voluntary participation with a non-governmental agency (16%) and requirement of a government or tribal authority (14%) (Table A2).

Eighteen-hole golf facilities in the Upper West/Mountain (23%) and Pacific (22%) regions were the most likely to adopt a written IPM plan because of voluntary participation with a non-governmental agency, and 18-hole golf facilities in the Pacific (22%) and Southwest (20%) regions were most likely to adopt a written IPM plan because of a requirement by a government or tribal authority.

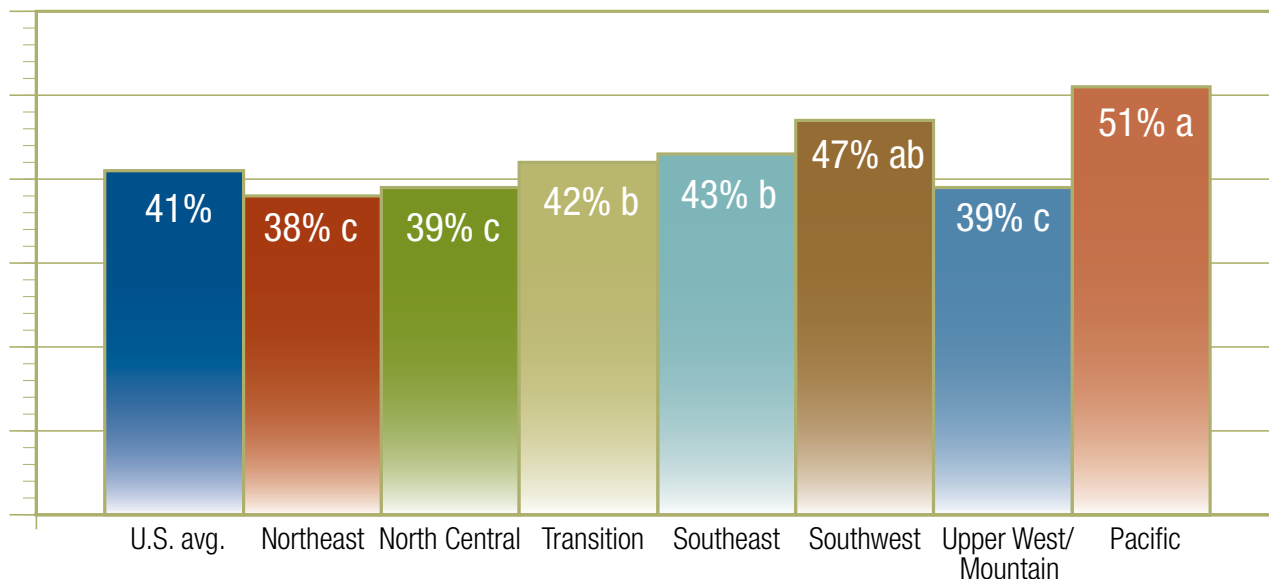
#### Written pesticide application plan

Respondents were asked if they had a written application plan, defined as a document that describes the pesticide applications anticipated for the year. The plan could also include nutrient and plant growth regulator applications anticipated for the year. These plans are used by superintendents for a number of purposes including the development of an annual budget and seasonal staffing plans. A golf facility may have a written pesticide application plan that works in



Monitoring for soil moisture can help to avoid turf stress, which in turn allows the turf to fend off attack from diseases, insects and weeds (2). Photo by Larry Stowell, PACE Turf LLC

### Written IPM plan



**Figure 5.** Prevalence of a written integrated pest management plan at 18-hole golf facilities by U.S. agronomic region. Percentages followed by the same letter are not significantly different from one another. Letters denote significance at the 90% confidence level.



# GCSAA's IPM Planning Guide

The purpose of the Golf Course Environmental Profile is to collect data that will provide "insight into the property features, management practices and inputs associated with golf courses across the United States." Each survey in the profile has achieved that goal, shedding light on the industry's successes and on areas that need improvement.

The results of the fifth survey in the profile, *Pesticide Use Practices on U.S. Golf Courses*, cover pesticide storage, use, planning, management tactics and regulations and restrictions. The conclusions section of the survey report contains several GCSAA recommendations based on the survey results, including the importance of a written integrated pest management (IPM) plan that incorporates a pesticide application plan. At the time of the survey, 66% of average 18-hole golf facilities had a written pesticide application plan and 41% had a written IPM plan.

In 2006 the Environmental Institute for Golf awarded a two-year grant to a group of scientists from universities and from the industry to develop a template that would guide superintendents in drawing up written IPM plans designed specifically for their facility. The scientists who produced the guide are: Wendy Gelernter, Ph.D., and Larry Stowell, Ph.D., PACE Turf LLC; Rick Brandenburg, Ph.D., North Carolina State University; Dave Kopec, Ph.D., University of Arizona; Kai Umeda, M.S., University of Arizona; and Fred Yelverton, Ph.D., North Carolina State University.

As a result of this project, the IPM Planning Guide was made available without charge on GCSAA's website ([www.gcsaa.org/environment/ipm-guide/](http://www.gcsaa.org/environment/ipm-guide/)), and an article introducing the planning guide was published in *Golf Course Management* ("Bringing IPM to the next level," July 2010, Pages 72-78).

The planning guide provides superintendents with the necessary tools for creating and implementing an IPM program for a golf course or other turfgrass facility. The guide includes references; instructions; forms, calendars and spreadsheets for record keeping and budgeting; and sample forms filled out by actual superintendents for their courses. The planning guide is divided into five sections: goal setting (identify the goals, assess your progress, communicate your vision for the golf course); climate appraisal; management zone inventory; integrated pest management (identify key pests



Cultural practices such as rolling have been shown to reduce disease incidence. The photo shows Crystal Downs CC, Frankfort, Mich. Photo by Mike Morris

and the practices and products needed for pest management); and the IPM planner. Going through all the steps requires two to three hours of work per management zone.

As the planning guide states, "Once you have completed this (the final) step, you will have — in a single piece of paper — summarized the complex interactions among forces such as climate, pests, turfgrass growth and golf play, and demonstrated the science and logic on which your IPM agronomic practices are based."

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## IPM Planning Guide Review Panel

The IPM Superintendent Review Panel, assembled by the scientists developing the IPM Planning Guide, provided invaluable guidance in the development of the template. The panel members helped to ensure that the final product would be a helpful, user-friendly tool that would incorporate the real-world technical issues superintendents face. The following individuals participated in the review panel (affiliations were correct at the time the panel was in place):

Mike Claffey, Cape Fear CC, Wilmington, N.C.  
Dan Dinelli, CGCS, North Shore CC, Glenview, Ill.  
Shawn Emerson, Desert Mountain, Scottsdale, Ariz.  
Larry Gilhuly, USGA Green Section, Northwest Region  
Kevin Hutchins, Mission Viejo (Calif.) CC  
Jon Jennings, CGCS, Chicago Golf Club, Wheaton, Ill.  
Michael O'Connor, CGCS, GreenSpace Sustainable Environments LLC  
Clark Throssell, Ph.D., Director of Research, GCSAA



conjunction with a written IPM plan. And while these facilities may develop and use both types of plans, some may use one or the other, or neither.

Sixty-six percent of average 18-hole golf facilities had a written pesticide application plan. The size of the golf facility did not significantly affect the likelihood that it had a written pesticide application plan (27 holes, 65%; 18 holes, 63%; and 9 holes, 58%). Private facilities (68%) were significantly more likely to have a written pesticide application plan than public facilities (61%). Facilities with an annual maintenance budget greater than \$1,000,000 were significantly more likely to have a written pesticide application plan than facilities with a maintenance budget of \$500,000 to \$999,999 (62%) and less than \$500,000 (62%).

Average 18-hole golf facilities in the North Central and Transition agronomic regions were significantly more likely to have a written pesticide application plan than facilities in the other agronomic regions (Figure 6, Table A3). The most common reason given for the adoption of a written pesticide application plan was voluntary

action initiated by the golf facility board, committee or superintendent (74%). The next most common reason was that a government or tribal authority required the plan.

Eighteen-hole golf facilities in the Southwest (31%), Northeast (23%) and Pacific (21%) regions were the most likely to adopt a written pesticide application plan because of a requirement by a government or tribal authority.

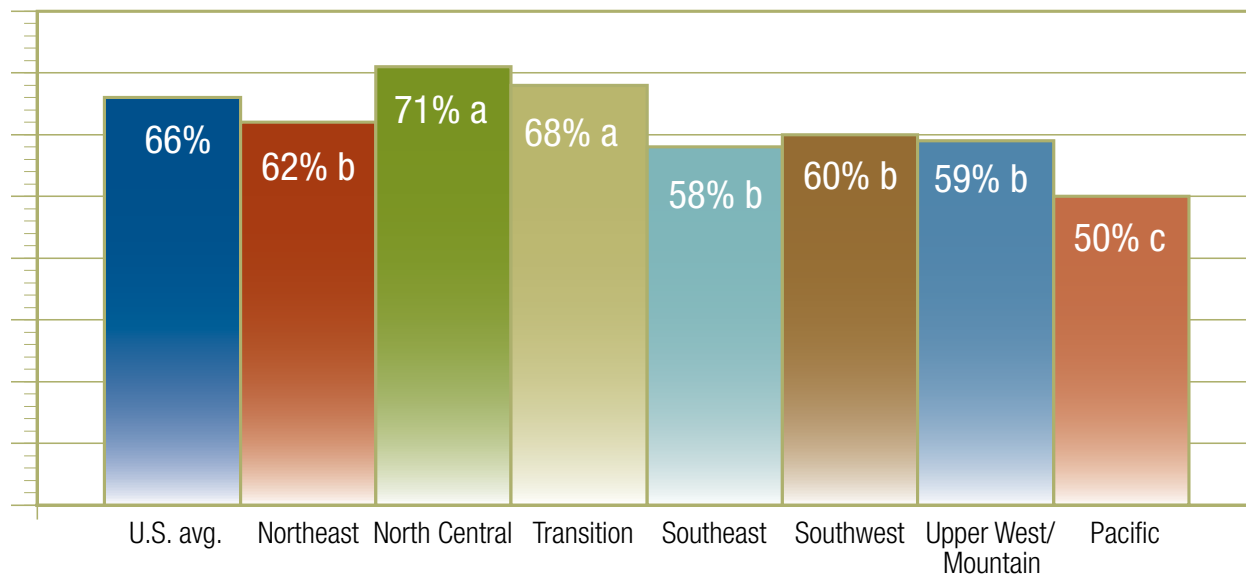
#### *Pesticide regulation and restrictions*

Respondents were asked whether their pesticide operation was regulated by local government as well as state and federal governments. A majority of golf facilities had additional regional or local government restrictions on their pesticide operations. The most common were mandated pesticide recordkeeping (79%), pesticide posting/notification (62%) and pesticide storage (62%) (Figure 7) (Table A4). Average 18-hole golf facilities in the Southwest and Pacific regions were most likely to face additional regulations covering pesticide operations (Table A4).

Respondents were also asked whether a local government or tribal authority placed additional restrictions on their pesticide use. Twenty-six percent of average 18-hole golf facilities had one or more restrictions on their pesticide applications enacted by a local government. The most common restrictions were prohibition of a specific pesticide product(s) (72%), limits on the total amount of a specific product applied (72%) and limits on the amount of a specific product in a single application (57%) (Figure 8, Table A5). Average 18-hole golf facilities in the Southwest (46%)

*The most common reason given for the adoption of a written pesticide application plan was voluntary action initiated by the golf facility board, committee or superintendent (74%). The next most common reason was that a government or tribal authority required the plan.*

### Written pesticide application plans



**Figure 6.** Prevalence of a written pesticide application plan at 18-hole golf facilities by U.S. agronomic region. Percentages followed by the same letter are not significantly different from one another. Letters denote significance at the 90% confidence level.

and Pacific (43%) regions were more likely to have one or more restrictions on pesticide applications than facilities in other regions (Table A5).

The effect of these local pesticide application restrictions was reported as: none (9%), minimal (50%), some (30%) and significant (11%). No attempt was made to determine the specific effect.

*Certified pesticide applicators*

Every state in the U.S. offers a professional certified applicator credential based on federal guidelines. To achieve certification, an individual must pass a written examination and complete renewal requirements to remain current. Respondents were asked to identify how many individuals with state-certified pesticide credentials were employed at their facility. Almost all golf facilities employed one or more certified pesticide applicators. The number of certified pesticide applicators was significantly higher at 27-hole (2.7) and 18-hole (2.1) golf facilities than at 9-hole (1.2) golf facilities. Private golf facilities employed significantly more certified pesticide applicators (2.6) than public (2.0) golf facilities. Golf facilities with an annual maintenance budget of \$500,000 to \$999,999 (2.2) or greater than \$1,000,000 (3.0) had a significantly higher number of certified pesticide applicators on staff than facilities with a maintenance budget less than \$500,000 (1.6).

*Pest management tactics*

Respondents were asked to identify the frequency of use (never, rarely, sometimes, frequently or unknown) for specific pest management prac-

tices at their golf facility. Most of the practices listed in the survey question are commonly used as part of an IPM approach to managing pests.

The results indicate that superintendents used multiple tactics to manage pests. The tactics most often used at 18-hole golf facilities were: routine monitoring of weather patterns (97%), cultural practices (96%), scouting (95%) and recording pest outbreaks (86%) (Figure 9, Table A6). Cultural practices for pest management include a wide range of tactics to mitigate pest damage or enhance turfgrass health. However, only 18% of



Cultural practices such as frequent light sand topdressing have been shown to significantly reduce damage from a range of problems, including anthracnose, black layer, puffiness and softness on greens (2). Photo by Larry Stowell, PACE Turf LLC

**Pesticide regulations**

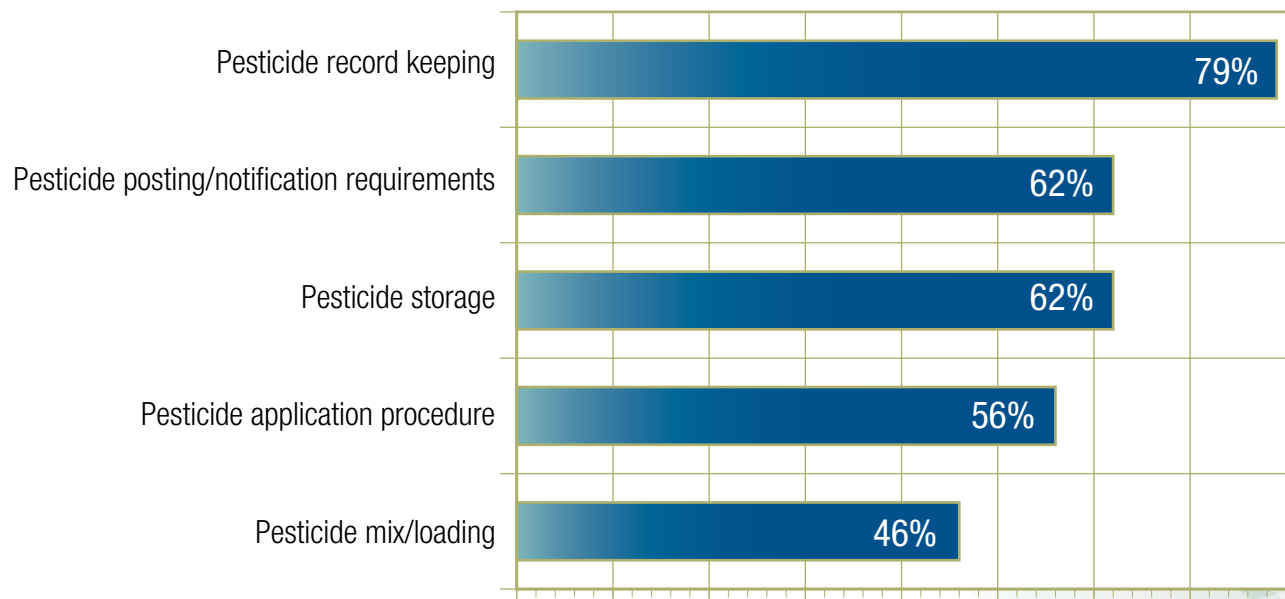


Figure 7. Local regional pesticide regulations affecting average 18-hole golf facilities.



respondents used sensors adapted for use on golf courses. Biological controls were used frequently or sometimes by 46% of respondents, indicating superintendents have an interest in biological controls (Figure 9).

The frequency of use of the pest management practices listed was significantly higher at 18- and 27-hole facilities with an annual maintenance budget greater than \$500,000. Public and private facilities used the pest management practices with nearly equal frequency. One notable exception was that public facilities and those with an annual maintenance budget of less than \$500,000 were more likely to tolerate a higher level of pest damage. Superintendents in the Northeast most frequently recorded pest outbreaks and used pest-tolerant turfgrass species and predictive models, but superintendents in the Southwest most frequently used biological controls, traps and sensors (Table A6).

*Trends in pesticide use*

Respondents were asked to indicate whether their pesticide use had increased, decreased or stayed the same on greens, tees, fairways and rough in 2007 as compared to the typical use of these products in previous years. Nationally, the use of fungicides, insecticides and herbicides stayed relatively the same in 2007 compared to previous years, but there was moderate change depending on which component of the golf course received the pesticide application

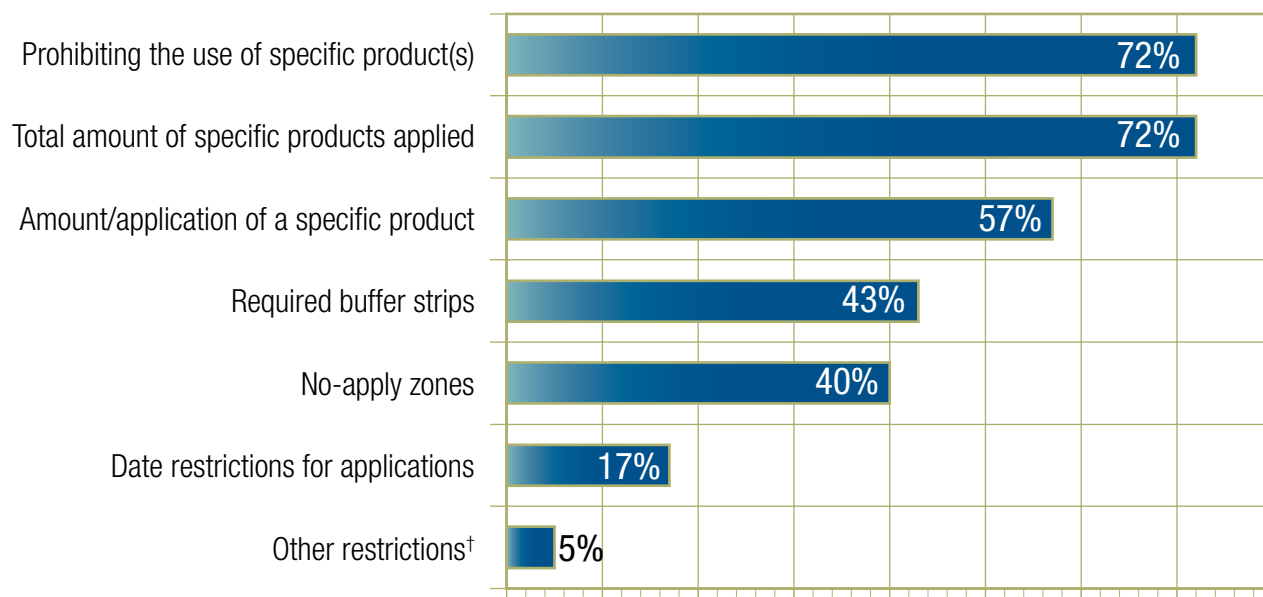
*Greens.* The largest increase in the use of

plant growth regulators was on putting greens: 44% of average 18-hole golf facilities reported an increase in the use of plant growth regulators, and 8% reported a decrease in use. The increase was relatively the same across all regions. Nationally, fungicide use on greens increased slightly: 25% reported an increase, 19% reported a decrease and 55% stayed the same. The greatest increase in fungicide use on putting greens was in the Southeast, where 33% reported increased use, 25% decreased their use and 40% stayed the same. Respondents reported an overall decrease in insecticide and herbicide use on putting greens. The greatest relative decrease was in the Pacific region, where respondents indicated an overall 28% decrease in the use of insecticides and 2% reported an increase. All regions reported a relatively equal decrease in herbicide use on putting greens.

*Tees.* On tees, fungicide and insecticide use decreased slightly. For fungicides, 19% reported a decrease in use, 10% indicated an increase and 67% remained the same. The use of fungicides on tees was relatively consistent across all regions. For insecticide use, 18% reported a decrease, 11% indicated an increase and 68% remained the same. The greatest decrease was seen in the Transition and Pacific regions. Herbicide use on tees showed little change. Plant growth regulator use on tees increased by 25% nationally, with 9% of facilities reporting a decrease and 60% staying the same. The greatest increases were reported in the Northeast and Southeast regions.

*Fairways.* For fungicide use on fairways, 19%

**Local pesticide restrictions**



**Figure 8.** Type of local pesticide restrictions for the average 18-hole golf facilities in the U.S. (among 18-hole golf facilities with pesticide restrictions).

## Frequency of pest management practices

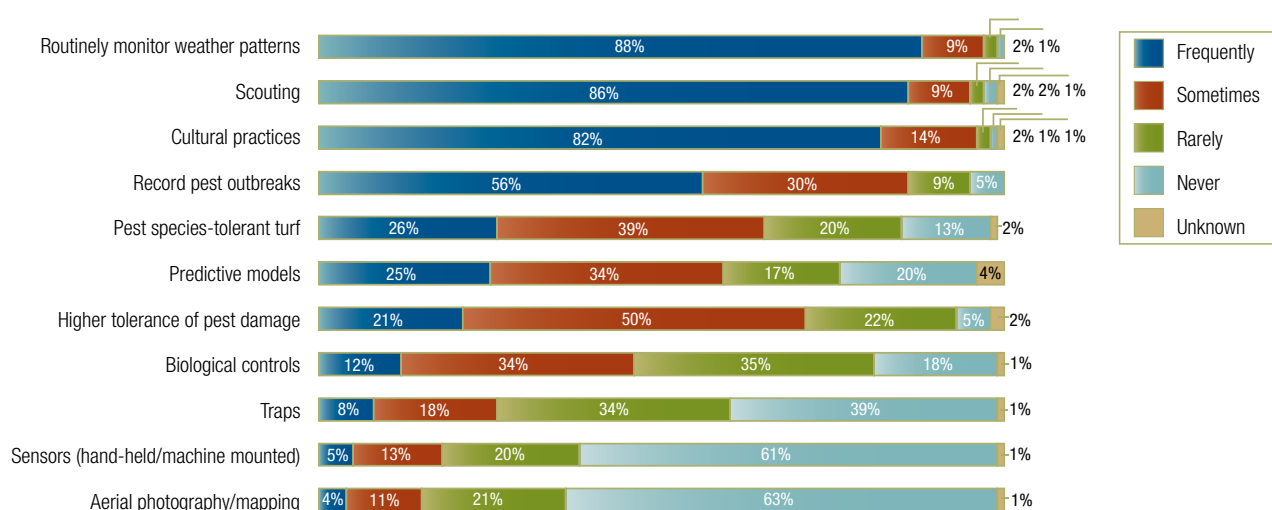


Figure 9. Frequency of use of pest management practices for the average 18-hole golf facility in the U.S.

of respondents reported a decrease, 15% indicated an increase and 61% reported no change. The greatest decreases were reported in the Transition, Southeast and Southwest regions. Although there was relatively no change in insecticide use on fairways, 24% of respondents indicated an increase in herbicide use, 17% reported a decrease and 57% reported no change. The greatest increase in herbicide use was noted in the Upper West/Mountain, Southeast and Southwest regions. Plant growth regulator use increased nationally on fairways, with 28% of respondents reporting an increase, 10% a decrease and 56% no change. The greatest increases were reported in the Northeast, Southeast, Pacific and Southwest regions.

**Roughs.** On roughs, fungicide use decreased and herbicide use increased. Insecticide and plant growth regulator use on roughs was relatively unchanged. For fungicides, 14% reported a decrease, 3% indicated an increase and 73% stayed the same. Fungicide use varied little among the regions. For 56% of respondents, herbicide use in roughs stayed the same, but 25% reported an increase, and 16% reported a decrease. The greatest change was reported from the Northeast and Upper/West Mountain regions.

## Recommendations

### Pesticide storage

The survey indicated that nearly all golf facilities stored pesticides on the property and that a large percentage of these areas had basic safety and security features. Most respondents had the ability to lock or restrict access to the storage areas



GCSAA recommends that mixing and loading areas have several safety features including an impervious floor capable of containing liquid spills with overhead protection from the weather. Photo © Montana Pritchard

(94%), and most storage areas had signage identifying the pesticide storage area (85%).

Additional progress needs to be made to reduce the potential for environmental contamination. GCSAA recommends that all golf facilities that store pesticides use a designated area specifically designed for this purpose. All pesticide storage areas should have impervious floors and shelving and have spill kits available in the area. Survey responses showed that approximately 68% had impervious floors, 58% had impervious shelving and 67% had spill kits available. The industry should improve in these specific areas. All golf facilities should invest in the proper devices to minimize potential risks from storing pesticides.

### Pesticide mixing and loading

Pesticide mixing and loading stations are areas designed specifically for measuring, mixing and loading pesticide products into the application equipment with minimal risk to workers and the environment. GCSAA recommends that mixing and loading areas be designed for this purpose and be equipped with appropriate safety devices. Because pesticide products are handled and transferred in concentrated form at these stations, proper equipment is vital to minimize the potential for exposure and environmental contamination. Improvement is needed in the following areas:

- spill kits located near mix/load area
- anti-siphoning device on water line
- emergency water shut-off valve
- impervious floor
- recycling of pesticide containers
- floors capable of containing liquid spills
- overhead protection from weather



The severity of anthracnose can be significantly reduced through the use of cultural practices such as light, frequent sand topdressing and lightweight rolling (2). Photo by Larry Stowell, PACE Turf LLC

### Pesticide emergency response plan

The survey indicated that approximately half of the 18-hole facilities in the U.S. had a pesti-

cide emergency response plan. GCSAA recommends that all golf facilities have such a plan to enhance preparedness should an accident occur that involves the application or storage of pesticide products.

### IPM plan and pest management tactics

Forty-one percent of average 18-hole golf facilities had a written IPM plan, and 66% had a written pesticide application plan. GCSAA recommends that all golf courses have a written IPM plan that incorporates a pesticide application plan. GCSAA recommends an integrated approach to golf course maintenance to optimize plant health while managing pests within acceptable thresholds in order to provide marketable playing conditions. It is also recommended that superintendents continually strive to use innovative practices and technology to strengthen their plant and pest management strategies. This survey indicated that golf course superintendents routinely used multiple tactics for pest management.

A high percentage of facilities (96%) used cultural practices to manage pests. Cultural practices represent a wide range of tactics including aeri-

## Change in pesticide use

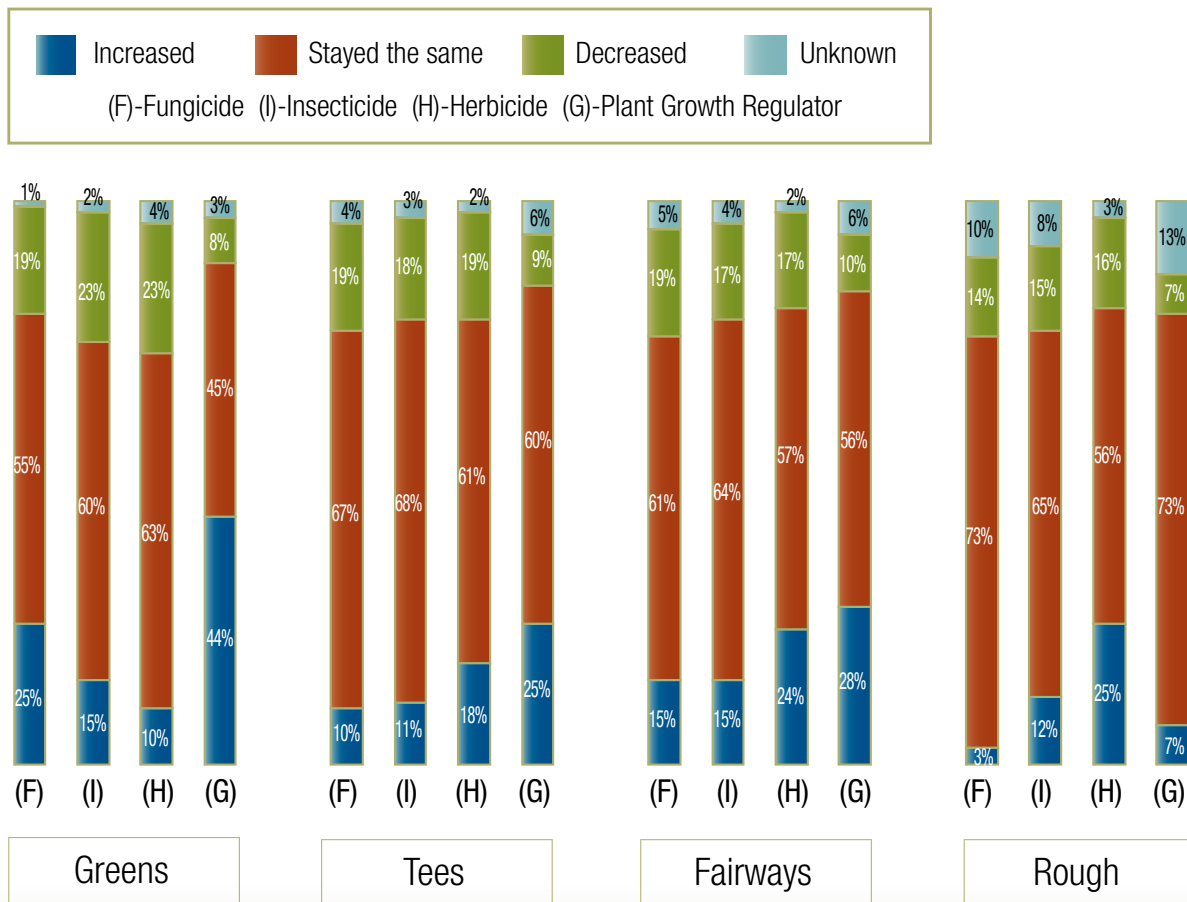


Figure 10. Change in pesticide use for average 18-hole golf facilities in the U.S. Values are the percentage of average 18-hole golf facilities reporting an increase, decrease, no change or unknown change in pesticide use in 2007 as compared to an average year.



fication, changing the height of cut, improving drainage, removing dew, rolling, nutrient applications and irrigation scheduling to name a few. The response to this survey question shows that the practices involved in an integrated approach were used routinely, even though less than half of 18-hole golf facilities had developed a formal, written IPM document.

## Conclusions

The Golf Course Environmental Profile surveys have provided a better understanding of specific management practices and features at golf facilities on a national and regional basis.

This survey found that improvements are needed in pesticide storage, mixing and loading stations, emergency response plans and the development of formal IPM plans. It also showed that superintendents were routinely using multiple methods to manage pests. It is expected that superintendents will increasingly integrate technology into their pest management strategies.

In general, this survey found that golf facilities with larger budgets and more than 18 holes — and, in some cases, private facilities — had more sophisticated pest management strategies and were equipped with appropriate safety devices related to the pesticide operation. It is important for all golf facilities to continuously elevate their professionalism in relation to the use of pesticide products.

The survey also showed that golf course superintendents were diligent in obtaining state-authorized pesticide certification credentials. Almost all golf facilities had at least one certified pesticide applicator on staff, and many facilities had two or more.

A majority of golf facilities reported that they were governed by local and regional pesticide regulations and restrictions. Only a low percentage of golf facilities indicated that local/regional pesticide regulations/restrictions had a significant negative effect on their pest management programs. Regulations and restrictions regarding pesticide use are likely to increase in the future, and the golf industry should recognize the importance of advocating for practical public policy in order to maintain the professional and judicious use of pesticide products.

This survey offers a snapshot of pesticide use trends for fungicides, insecticides, herbicides and plant growth regulators across several components of the golf course. In general, at the time of the survey (2007), respondents reported that their use of fungicides, insecticides and herbicides had not changed in comparison to earlier years, while some moderate increases or decreases

had occurred on specific components of the golf course. Fairways and roughs represent the largest acreage of maintained turfgrass on the golf course. The survey indicated a slight decrease in the use of fungicides and insecticides on these areas and a slight increase in herbicide use. The use of plant growth regulators increased on tees, fairways and, in particular, putting greens. The increased use of plant growth regulators was consistent across all regions of the country. Given the beneficial turfgrass response to plant growth regulators (consistent turfgrass growth characteristics, appealing playability, reduced mowing demands), their use will likely continue to expand.

Although this survey was not able to produce an accurate accounting of pesticide active ingredient use across golf course components and agronomic regions, the attempt provided significant insight about the process for collecting this type of data. GCSAA is grateful to those who submitted data for this purpose.

## Literature cited

1. Christians, N.E. 1998. *Fundamentals of Turfgrass Management*. Ann Arbor Press, Chelsea, Mich.
2. Gelernter, W., L. Stowell, R. Brandenburg, D. Kopec, K. Umeda and F. Yelverton. Bringing IPM to the next level. *Golf Course Management* 78(7):72-78.
3. Lyman, G.T., M.E. Johnson, G.A. Stacey and C.D. Brown. 2012. Golf course environmental profile measures energy use and energy management practices. Online. *Applied Turfgrass Science* doi: 10.1094/ATS-2012-0228-01-RS.
4. Lyman, G.T., C.S., Throssell, M.E. Johnson, G.A. Stacey and C.D. Brown. 2007. Golf course profile describes turfgrass, landscape and environmental stewardship features. Online. *Applied Turfgrass Science* doi: 10.1094/ATS-2007-1107-01-RS.
5. Marketing Research Association. 2008. The code of marketing research standards. Online. Marketing Research Association, Glastonbury, Conn. [www.mranet.org/pdf/expanded\\_code.pdf](http://www.mranet.org/pdf/expanded_code.pdf)
6. National Golf Foundation. 2007. *Golf facilities in the U.S.*, 2007 ed. National Golf Foundation, Jupiter, Fla.
7. Shurtleff, M.C., T.W. Fermanian and R. Randell. 1987. *Controlling Turfgrass Pests*. Prentice-Hall, Englewood Cliffs, N.J.
8. Throssell, C.S., G.T. Lyman, M.E., Johnson, G.A. Stacey and C.D. Brown. 2009. Golf course environmental profile measures nutrient use and management and fertilizer restrictions, storage, and equipment calibration. Online. *Applied Turfgrass Science* doi:10.1094/ATS-2009-1203-01-RS.
9. Throssell, C.S., G.T. Lyman, M.E. Johnson, G.A. Stacey and C.D. Brown. 2009. Golf course environmental profile measures water use, source, cost, quality, and management and conservation strategies. Online. *Applied Turfgrass Science* doi: 10.1094/ATS-2009-0129-01-RS.

# Appendix

## Survey response

	Golf facility superintendents		Completed surveys <sup>†</sup>			
	No. <sup>‡</sup>	% of total no.	No. rec'd	% of total	Response rate (%) <sup>§</sup>	Margin of error (%) <sup>  </sup>
<b>Region</b>						
Northeast	2,772	17.1	545	16.4	19.7	3.2
North Central	4,095	25.3	765	23.0	18.7	2.7
Transition	2,984	18.4	614	18.5	20.6	3.0
Southeast	3,316	20.5	694	20.9	20.9	2.8
Southwest	1,259	7.8	255	7.7	20.3	4.6
Upper West/Mountain	1,087	6.7	293	8.8	27.0	4.1
Pacific	681	4.2	159	4.8	23.3	5.7
<b>Type</b>						
Daily fee	9,184	56.7	1,381	41.5	15.0	2.0
Municipal	2,506	15.5	570	17.1	22.7	3.0
Private	4,504	27.8	1,374	41.3	30.5	1.9
<b>No. of holes</b>						
9	4,573	28.2	264	7.9	5.8	4.9
18	9,939	61.4	2,504	75.3	25.2	1.4
27+	1,682	10.4	557	16.8	33.1	2.8

<sup>†</sup>The total number of completed surveys was 3,325.

<sup>‡</sup>The total number of golf facility superintendents was 16,194.

<sup>§</sup>Response rate is the percentage of the total number of completed surveys received for each region, course type and course classification (9, 18, or 27+ holes).

<sup>||</sup>At 90% confidence interval.

**Table A1.** Number of golf facility superintendents, percent of total number of golf facility superintendents, completed surveys received, percent of the total completed surveys received, response rate within the category, and margin of error by agronomic region, course type, and number of holes.

## Written IPM plan

IPM plans/reasons for implementation	US	Agronomic region <sup>†</sup>						
		NE	NC	Trans	SE	SW	UW/Mtn	Pac
<b>% 18-hole golf facilities<sup>‡</sup></b>								
Use a written IPM plan	41	38d	39cd	42bcd	43bc	47ab	39cd	51a
Voluntary (board, committee, or superintendent initiated)	68	65ab	72a	69a	69a	66ab	68ab	56b
Voluntary participation with non-regulatory organizations	16	18abc	17abc	15bc	15abc	11c	23a	22ab
Required by government / tribal authority	14	16ab	9c	14abc	13abc	20a	9bc	22a
Unknown	2	1	2	2	3	3	0	0

<sup>†</sup>Agronomic regions: NE, Northeast; NC, North Central; Trans, Transition; SE, Southeast; SW, Southwest; UW/Mtn, Upper West/Mountain; Pac, Pacific.

<sup>‡</sup>Within a row, values followed by the same letter are not significantly different from one another. Letters denote significance at the 90% confidence level.

**Table A2.** Percent of 18-hole golf facilities using a written IPM plan and the reasons for implementing a written IPM plan in the U.S. and its agronomic regions.

## Written pesticide application plans

Pesticide application plans/ reasons for implementation	US	Agronomic region <sup>†</sup>						
		NE	NC	Trans	SE	SW	UW/Mtn	Pac
	<b>% 18-hole golf facilities<sup>‡</sup></b>							
Written pesticide application plan	63	62b	71a	68a	58a	60b	59b	50c
Voluntary (initiated by board/committee/ superintendent)	74	71	78	76	71	65	74	68
Required by government/tribal authority	19	23ab	15c	17bc	19bc	31ab	15c	21ab
Voluntary participation with non-regulatory organizations	6	6abc	6abc	6bc	8abc	4c	11a	11ab
Unknown	1	0	1	1	2	0	0	0

<sup>†</sup>Agronomic regions: NE, Northeast; NC, North Central; Trans, Transition; SE, Southeast; SW, Southwest; UW/Mtn, Upper West/Mountain; Pac, Pacific.

<sup>‡</sup>Within a row, values followed by the same letter are not significantly different from one another. Letters denote significance at the 90% confidence level.

**Table A3.** Percent of 18-hole golf facilities using a written pesticide application plan and the reasons for implementing a written pesticide application plan in the U.S. and its agronomic regions.

## Local/regional pesticide regulations

Pesticide application operation	US	Agronomic region <sup>†</sup>						
		NE	NC	Trans	SE	SW	UW/Mtn	Pac
	<b>% 18-hole golf facilities<sup>‡</sup></b>							
Record keeping	79	80bcd	71e	82bc	79c	90a	76de	86ab
Posting/notification	62	70a	61b	61b	54c	74a	58bc	76a
Storage	62	52d	53d	71b	64c	85a	57d	67bc
Application procedure	56	57bc	50d	55bcd	59bc	76a	52cd	62b
Mixing/loading	46	30e	50bc	45bcd	44cd	74a	40d	49bc

<sup>†</sup>Agronomic regions: NE, Northeast; NC, North Central; Trans, Transition; SE, Southeast; SW, Southwest; UW/Mtn, Upper West/Mountain; Pac, Pacific.

<sup>‡</sup>Within a row, values followed by the same letter are not significantly different from one another. Letters denote significance at the 90% confidence level.

**Table A4.** Percent of 18-hole golf facilities that have elements of their pesticide operations regulated by local or regional entities in addition to state and federal regulation in the U.S. and its agronomic regions.



## Government/tribal regulations

Pesticide application restriction	US	Agronomic region <sup>†</sup>						
		NE	NC	Trans	SE	SW	UW/Mtn	Pac
	<b>% 18-hole golf facilities<sup>‡</sup></b>							
One or more restrictions	26	30b	19d	20cd	25c	46a	26bc	43a
Prohibition of specific pesticide(s)	72	78ab	58c	54c	71b	83a	87a	86a
Total amount of specific pesticide	72	80a	80a	72ab	73ab	64bc	52c	65bc
Amount/application of specific product	57	62a	64a	59ab	63a	50bc	44c	40c
Required buffer strips	43	45ab	43ab	40b	52a	35b	42ab	43ab
No-apply zones	40	46ab	28c	33c	51a	36bc	47ab	37bc
Date restrictions for applications	17	9c	11bc	16abc	25a	17ab	19ab	23a
Other restrictions	5	7a	7a	1b	3ab	6a	7a	9a

<sup>†</sup>Agronomic regions: NE, Northeast; NC, North Central; Trans, Transition; SE, Southeast; SW, Southwest; UW/Mtn, Upper West/Mountain; Pac, Pacific.

<sup>‡</sup>Within a row, values followed by the same letter are not significantly different from one another. Letters denote significance at the 90% confidence level.

**Table A5.** Percent of 18-hole golf facilities that have restrictions on their pesticide applications by government or tribal authorities in the U.S. and its agronomic regions.

## Pest management practices

Pest management tactic	US	Agronomic region <sup>†</sup>						
		NE	NC	Trans	SE	SW	UW/Mtn	Pac
	<b>% 18-hole golf facilities<sup>‡</sup></b>							
Routinely monitor weather	97	99a	97ab	97b	98ab	94c	97abc	96bc
Cultural practices	96	98a	97ab	95bc	97ab	96abc	96bc	93c
Scouting	95	98a	96ab	96ab	96b	92c	91c	98ab
Record pest outbreaks	86	92a	87b	85bc	84bc	85bc	83bc	81c
Higher tolerance of pest damage	71	71ab	75a	68b	70b	69b	73ab	75ab
Pest-tolerant turfgrass species	65	78a	59c	72b	60c	61c	62c	57c
Predictive models	59	67a	66a	61b	53cd	58bc	44e	47de
Biological controls	46	42c	43c	47bc	51ab	56a	44bc	42c
Traps	26	15e	22d	26cd	27cd	48a	28c	38b
Sensors (handheld or machine-mounted)	18	20b	15c	17bc	19b	31a	16bc	19bc
Aerial photography/mapping	15	16ab	14b	12b	16b	16ab	21a	17ab

<sup>†</sup>Agronomic regions: NE, Northeast; NC, North Central; Trans, Transition; SE, Southeast; SW, Southwest; UW/Mtn, Upper West/Mountain; Pac, Pacific.

<sup>‡</sup>Within a row, values followed by the same letter are not significantly different from one another. Letters denote significance at the 90% confidence level.

**Table A6.** Percent of 18-hole golf facilities that frequently or sometimes use the listed pest management practice in the U.S. and its agronomic regions.





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1421 Research Park Drive  
Lawrence, KS 66049-3859  
Toll Free 800.472.7878