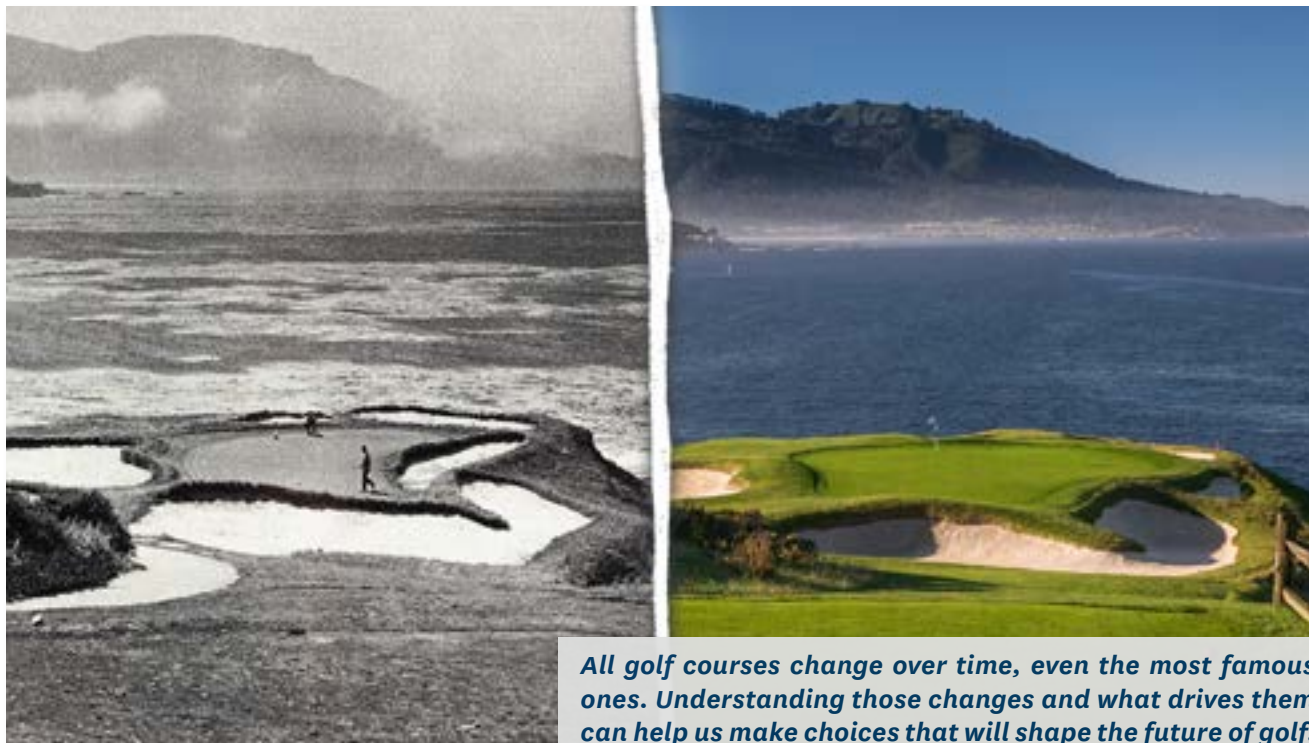


Green Section Record

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MAPPING THE PAST, PRESENT AND FUTURE OF GOLF COURSES

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Key Takeaways:

- To better understand how golf courses have evolved, the USGA undertook an extensive study of golf course aerial photos from courses that opened in the 1920s to the present, mapping each course at various points in its history
- This research identified important trends in how golf courses change over time and raised interesting questions about the future.
- Modern courses have a larger footprint than older courses.
- The average area of fairways, greens, and bunkers tends to decrease at courses over time.
- There were clear distance impacts on how courses evolve, and those impacts have become more pronounced in recent decades.

All golf courses change over time. Whether that change is slow and subtle or fast and dramatic, it is inevitable. Tree growth, shifting mowing lines and continual bunker edging are good examples of processes that have gradual, but significant impacts on golf courses. Change can also happen quickly through renovation or redesign, land sales, or even the intrusion of roads and highways. Whatever the drivers of change are, the fact remains that golf courses begin changing from the day they open and continue to do so throughout their existence..

Along with the evolution that every individual golf course experiences, we also see changes in how new golf courses are built. A golf course opening in 1925 would look different in many ways from a new course opening in 2021. Changes in golf course development are driven by fashions and preferences in design, changing expectations for what a golf facility should provide, and changes in how the game is played – including increased hitting distance.

To better understand how golf courses have evolved, the USGA undertook an extensive study of golf course aerial photos as part of the [Distance Insights Project](#). We looked at courses that opened from the 1920s to the present, mapping aerial images from various points in their history using digital mapping software. Through that research we sought to learn more about how individual courses change over time, how courses from different decades differ from one another, and how golf courses may evolve going forward.

While the primary motivation for this research was to better understand how golf courses have been affected by increased hitting distance, we also learned a lot about the basic physical features of golf courses, how



older courses differ from newer ones, and some of the trends that drive golf course change along with hitting distance. This article provides an overview of the research and covers some of the key findings and questions that emerged. The full report, titled “[How Golf Courses Change](#),” is available on [USGA.org](#) for those interested in delving deeper into this extensive study.

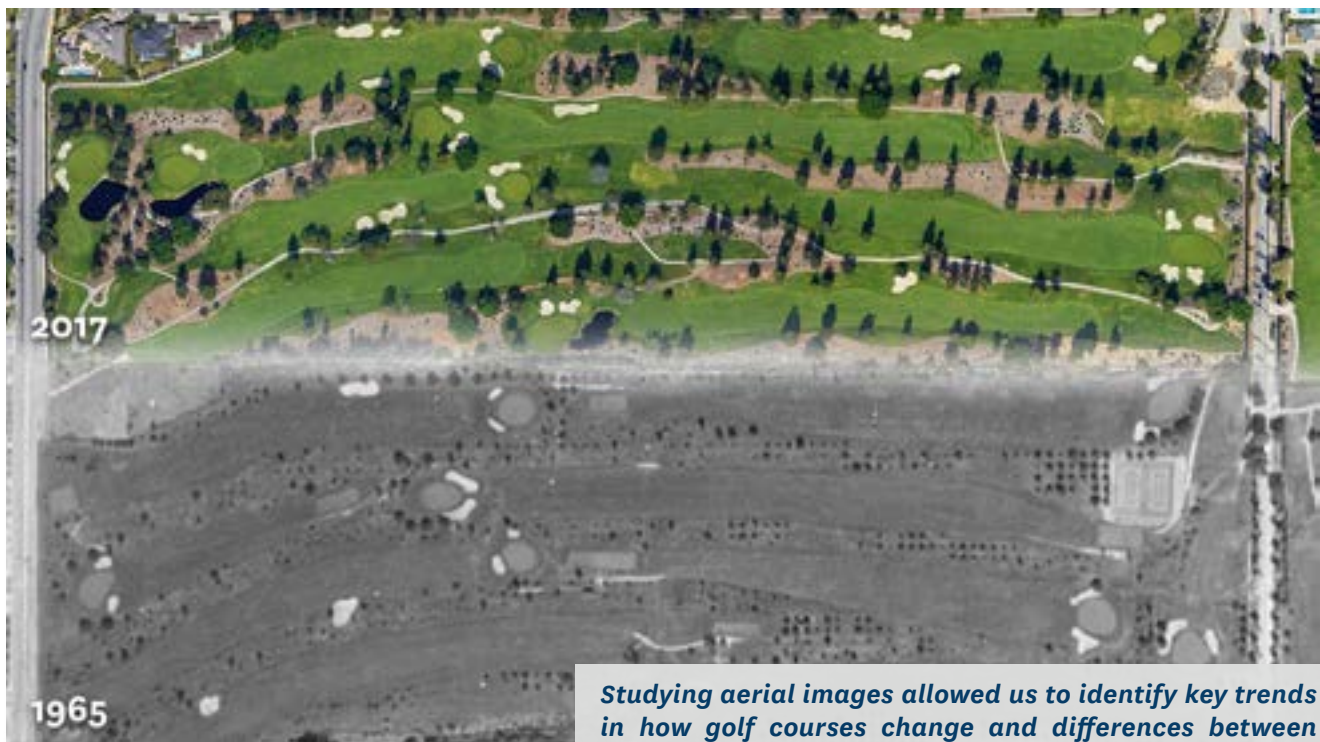
Courses Studied

The project included two key samples for study, an 80-course random sample of U.S. golf courses and a 15-course selection of courses that have recently hosted men’s professional golf events. In addition, non-randomized and limited samples of nine Japanese golf courses and nine Australian golf courses were included to provide an international context. This article will focus on results from the 80-course sample and the championship course group, information about the international course case studies can be found in the appendix of the full report.

The National Golf Foundation course list was used to develop the 80-course random sample with an even distribution of public and private courses, courses from different regions, and courses that opened in different decades from the 1920s through the 2010s. We chose this sampling approach in an effort to include courses with a wide range of budgets, customer groups, natural environments and adjacent land uses – essentially to better understand the “average” golf course.

A carefully selected case study of courses that had recently hosted men’s professional golf events was also included in the research because we recognized that these facilities face unique pressures with regard to hitting distance, and because these facilities typically have resources above and beyond what is available to most golf courses, so their patterns of change were likely to be different. The championship courses selected had a variety of opening dates and architects, and came from different regions.

For a course to be included in this research, there



Studying aerial images allowed us to identify key trends in how golf courses change and differences between older and newer courses.

had to be aerial images of sufficient quality available within approximately 20 years of the course's opening date and then on an interval of no longer than one image every 25 years through the 2010s. No more than one image per decade was analyzed, except in circumstances where a noteworthy change would have been missed otherwise. A few exceptions were made to these criteria if a course filled a key need in the sampling. All aerials were sourced from Google Earth or HistoricAerials.com. The full list of courses studied can be found in the tables at the end of this article.

Methods

AutoCAD was used to map and measure the images from each course. The work was performed by six mapping technicians, all with an extensive background in golf course architecture and expertise in CAD mapping. The key variables studied include:

1. Golf course footprint (acres)
2. Back tee yardage and footprint
3. Total fairway area (acres)
4. Size of practice areas (acres)
5. Distance to the end of the practice range (yards)
6. Practice area impact on footprint
7. Total putting green area (square feet)
8. Number and total area of teeing grounds (square feet)
9. The number and total area of bunkers (square feet)
10. Turn point – i.e., average distance from back tee to landing area hazards (yards)
11. Distance added by new tees or moved greens (yards)
12. The average distance between centerlines of holes (yards)

The shortest distance from a turn point to a course boundary (yards)

Obtaining exact measurements from aerial imagery is limited by factors such as image distortion, image resolution, and challenges identifying features through shadows or trees. While measurements down to the square foot cannot be made with certainty, analysis of aerial images provides an excellent objective estimate of feature sizes and a reliable picture of how a golf course changes over time. In an effort to limit issues related to image quality, the mapping of each course began with the most recent image because the quality was typically the best. We then worked backward through the decades with the baseline of the newest image as a guide for feature locations and sizes where image quality was more challenging on older images.

Sample size is also a limitation when analyzing the 15-course championship case study and the Australian and Japanese course case studies. Trends within the championship course case study are only discussed when there is a high level of confidence in the findings based on the expertise of the USGA Green Section staff.

Key Findings:

Modern courses have a larger footprint than older courses.

For the purposes of this study, footprint is defined as all playing areas of the golf course, all practice facilities, all native areas that are likely to require some maintenance, ponds and lakes, roads and paths, the maintenance facility, the clubhouse, and any dumping or staging areas that can clearly be attributed to the golf facility. Where a course had woodland borders, an approximation within the perimeter of the tree line was made to account for maintenance that likely occurs along and within the woodland margins.

In the 80-course sample, courses built during the three most recent decades had an average total footprint of 216.3 acres. Courses from the earliest three decades – the 1920s, 1930s and 1940s – had an average footprint of 152.3 acres, a difference of 64 acres. This pattern was also observed in the championship course case study, where the five most-recently opened courses had an average footprint 47 acres larger than the five oldest courses (260 acres versus 213 acres, respectively).

This trend can be partly attributed to increased hitting distance. Courses that opened most recently in both the 80-course sample and the championship course case study were longer and had larger footprints on average. In both the 80-course sample and the combined set of the 80-course sample and the championship course case study, there was a statistically significant correlation between longer back tee yardages and larger footprints. Of the 25 courses in the 80-course sample that had back tee yardages of 7,000 yards or more, the average footprint was 211.2 acres. Of the 53 courses that had back tee yardages less than 7,000 yards, the average footprint was 157.7, a difference of 53.5 acres.



On average, we found that modern courses had larger footprints, longer back tee yardages, and were in more remote locations. (Jon Cavalier/@LinksGems)

BACK TEE YARDAGE, FOOTPRINT AND FAIRWAY AREA (80-COURSE SAMPLE)

BACK TEE YARDAGE	COURSES IN YARDAGE RANGE	AVERAGE FOOTPRINT (ACRES)	AVERAGE FAIRWAY AREA (ACRES)
<6000	2	112.7	18.2
6000-6499	13	134.9	20.9
6500-6999	38	167.8	23.6
7000-7499	23	210.7	27.7
>7500	2	217.1	35.2

80 Course Sample: Back Tee Yardage, Footprint and Fairway Area.

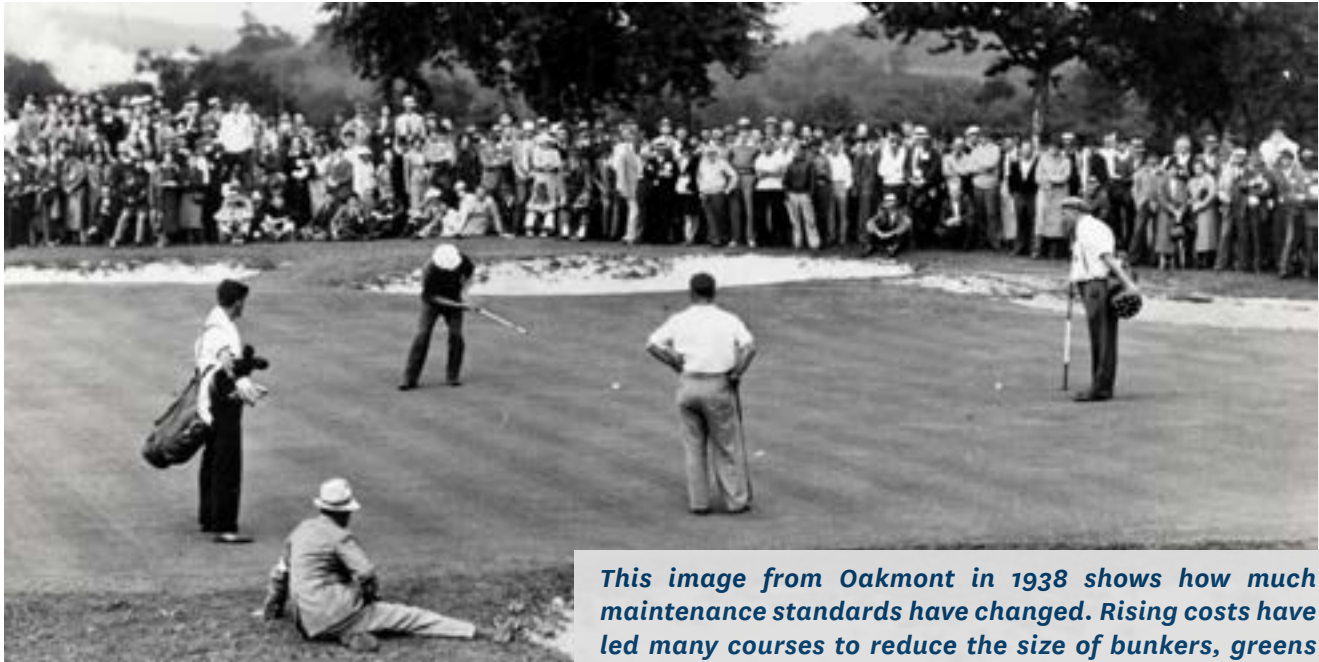
Along with distance, there are other likely contributors to the larger footprints of modern courses. Many modern courses were built far from population centers, where space is at less of a premium. There is also the influence of more-extensive practice facilities, maintenance facilities and other infrastructure that would be included in a modern construction.

The average area of fairways, greens and bunkers has decreased over time.

The average fairway area in the 80-course sample decreased by more than 9 acres from the earliest map year to the most recent map year. Courses in the championship course case study experienced an average reduction in fairway area of 6.1 acres from the earliest to most recent map year. The observed reductions in fairway area are likely the result of several factors including irrigation coverage, maintenance and fuel costs, equipment innovation and the proximity of trees. Overall maintenance cost is clearly a driving factor as expectations for fairway quality have increased significantly over time.

While fairway area decreased over time at most of the courses studied, it is important to note that longer courses are generally built with more fairway area at the outset. However, adding distance to existing courses did not lead to increases in fairway area on average.

The average total area of greens and bunkers also decreased over time. In the 80-course sample, the average total putting green area was 109,077 square feet for the earliest map year and 101,197 square feet for the last map year. The average total putting green area for the championship courses decreased from 125,642 square feet in the earliest map year to 115,755 square feet in the last map year. The average area of bunkers in



This image from Oakmont in 1938 shows how much maintenance standards have changed. Rising costs have led many courses to reduce the size of bunkers, greens and fairways.

the 80-course sample decreased from 82,573 square feet to 76,823 square feet. In the championship course case study, the decrease was even more pronounced, with a drop from an average of 243,971 square feet of bunker area in the earliest map year to 156,033 square feet in the most recent map year.

The increasing cost of maintenance for greens and bunkers is certainly a driving force in this trend. Interestingly, the average number of bunkers from the first map year to the last in both the 80-course sample and the championship course case study remained mostly unchanged – an increase of 3.2 and 0.4 bunkers respectively – so it would seem that reducing bunker size rather than the number of bunkers typically yielded the decreased sand area.

There were clear distance impacts on how courses evolve, and those impacts have become more pronounced in recent decades.

Measurements such as turn point distance and total distance added by new tees or moved greens increased on average in both the 80-course sample and the championship course case study. Courses in the 80-course sample averaged 126.1 yards of distance added by new tees or moved greens from the first map year to the last. Courses in the championship course case study averaged 300 yards in distance added by new tees or moved greens. The average number of tees also increased at courses in the 80-course sample and in the championship course case study. Not all tees added were back tees of course, many courses added forward tees, which could be partially considered a distance impact along with a growing effort to accommodate more players.

On average, golf courses within the championship course case study experienced much more significant distance impacts than courses in the 80-course sample. They experienced a greater increase in total number



Higher expectations for conditioning have been a motivating factor for courses to shrink the size of high-cost playing surfaces like greens, fairways and bunkers.

of tees, turn point, distance added by new tees or moved greens, and distance to the end of the driving range, all of which are directly related to increases in hitting distance. For example, championship courses averaged more than double the amount of distance added through new tees or moved greens than courses in the 80-course sample (300 yards of increase versus 126.1 yards), and almost five times the distance added by public courses within the 80-course sample (300 yards of increase versus 63.3 yards of increase).

“In both the 80-course sample and the championship course case study, alterations to golf courses with a clear distance component have increased from 1990 onward.”

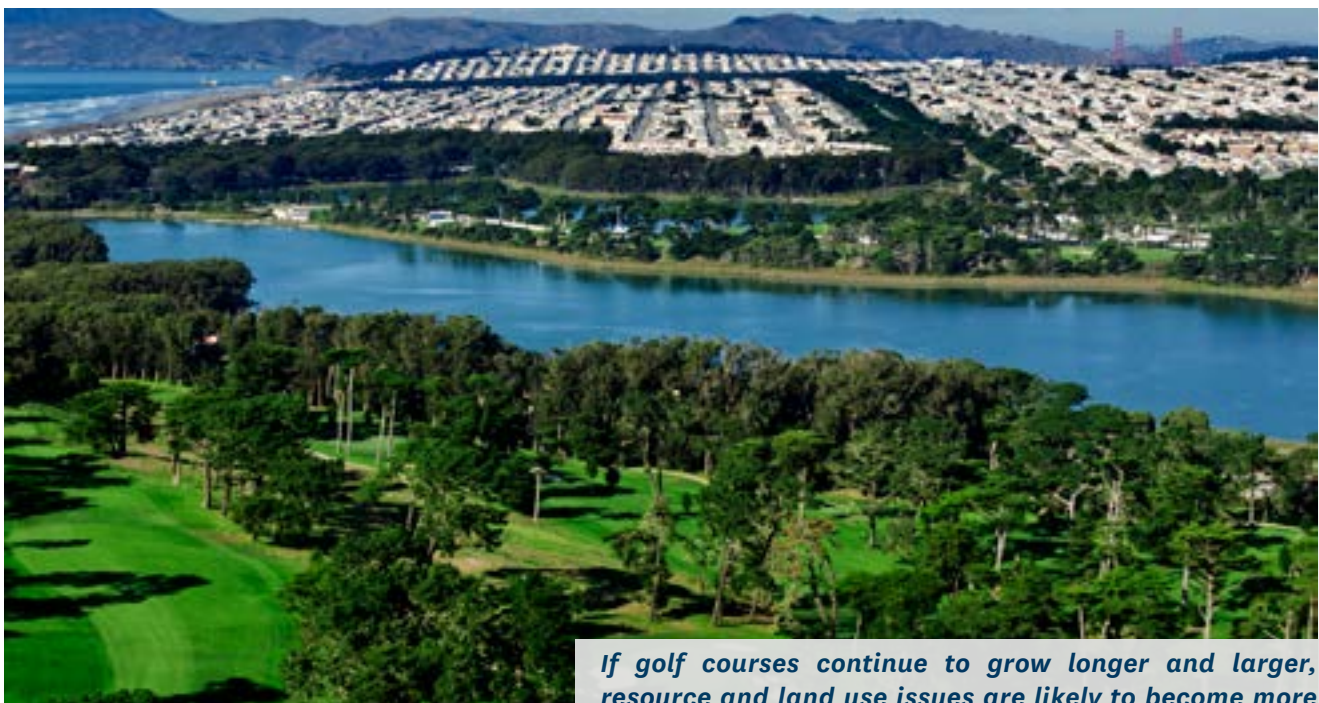
Courses that host men’s professional golf events are different than the average golf course.

Courses in the championship course case study showed clear differences from those in the 80-course sample in almost every measurement. For example, championship courses averaged a larger footprint (231.5 acres vs. 174.1 acres), a longer back tee yardage (7,397 yards vs. 6,774 yards), more area devoted to practice (13.6 acres vs. 9 acres), longer practice ranges (340.3 yards vs. 291.1 yards), more tees and more bunkers. These findings are not surprising given the additional resources available at championship facilities and the pressures they face as hosts of men’s professional golf events. While the trends observed in the championship course case study often mirrored the trends in the 80-course sample, they tended to be more extreme versions. These observations are important because championship courses receive more media attention and golfer focus than the average course, but the ability to draw conclusions about how average golf courses have changed, or will change in the future, from what is observed on championship courses can be problematic because of the fundamental differences.

Looking into the Future

The trends we observed in the evolution of golf courses have an impact on how we experience the game, what it costs to play, golf's footprint in our broader society and the long-term viability of the sport. Several key questions emerged from this research that should be of particular interest to the golf community:

- As rising maintenance costs motivate existing courses to reduce the size of fairways, greens, and bunkers, is the golf experience negatively affected? Are higher expectations for course conditioning making key components of strategy and enjoyable play less available to a broad range of courses?
- Has the low-hanging fruit been picked when it comes to adjusting for increased hitting distance? Have most of the practical design changes already been used in keeping up to this point? Courses showed limited ability to expand their footprint in our research, so will future efforts to add distance become increasingly expensive, awkward, or detrimental to the golf experience? Will we see architecture and safety increasingly compromised as courses implement less-practical solutions?
- Distance impacts were most pronounced on championship courses and private courses. Does this suggest that public courses are less affected by distance pressures or less able to adjust? If courses cannot make distance adjustments due to space or resource constraints, do they risk losing customers and negatively impacting their viability?
- Modern courses are generally longer, larger, and farther removed from population centers. What does this mean for the future stock of new golf courses? We found a direct connection between back tee yardage, footprint and fairway area – does that mean developers must look for larger and larger sites if hitting distance continues to increase? If those sites can only be found in remote locations, will that prevent most golfers from accessing new courses? Does the larger footprint of modern courses impact the game significantly since there are relatively few new golf courses being built?



If golf courses continue to grow longer and larger, resource and land use issues are likely to become more problematic.

Our research doesn't provide the answers to these questions, but they will be important considerations moving forward. The trends observed in this study and their impact on the future of golf are driven largely by our choices, preferences and expectations as golfers. While there are certainly external forces involved in the evolution of golf courses, such as adjacent land values or a changing legal climate, there is no question that our desires have a significant impact on the courses we play. Thinking about what is truly important in a golf experience, for ourselves and for future players, can help guide the choices we make today and shape the golf courses of tomorrow.

Special thanks to the team of mapping technicians – James Cervone, Keith Cutten, Ryan Farrow, Christine Fraser, and Shane Witcombe. Their technical skill and expert knowledge of golf course architecture were invaluable to this research.

USGA AERIAL MAPPING STUDY: CASE STUDIES

CHAMPIONSHIP COURSE CASE STUDY

BAY HILL CLUB - CHAMPIONSHIP COURSE (FL)
 BELLERIVE COUNTRY CLUB (MO)
 ERIN HILLS (WI)
 LIBERTY NATIONAL GOLF CLUB (NJ)
 MERION GOLF CLUB (PA)
 MURFIELD VILLAGE GOLF CLUB (OH)
 OAKMONT COUNTRY CLUB (PA)
 QUAIL HOLLOW CLUB (NC)
 ROYAL ST GEORGE'S GOLF CLUB (UK)
 SHINNECOCK HILLS GOLF CLUB (NY)
 THE OCEAN COURSE AT KAWAH ISLAND (SC)
 THE OLYMPIC CLUB - LAKE COURSE (CA)
 TPC BOSTON (MA)
 TPC SAWGRASS - STADIUM COURSE (FL)
 TPC SCOTTSDALE - STADIUM COURSE (AZ)

AUSTRALIAN COURSE CASE STUDY

BRINDGO GOLF CLUB
 GREEN ACRES GOLF CLUB
 HEIDELBERG GOLF CLUB
 KEW GOLF CLUB
 KINGSTON HEATH GOLF CLUB
 LATROBE GOLF CLUB
 RIVERSDALE GOLF CLUB
 VICTORIA GOLF CLUB
 WARRAGUL COUNTRY CLUB

JAPANESE COURSE CASE STUDY

ARIKO GOLF CLUB
 FUJIIA HOTEL GOLF COURSE (SENGOKU)
 HODOSAYA COUNTRY CLUB
 ISARAKI COUNTRY CLUB (EAST)
 NARIUS GOLF CLUB
 TAKARAZUKA GOLF CLUB - OLD
 TARUMI GOLF CLUB
 KASUMIGASEKI COUNTRY CLUB (EAST)
 NISHINOMIYA COUNTRY CLUB

USGA AERIAL MAPPING STUDY: 80-COURSE SAMPLE

AWKATUCKER COUNTRY CLUB (AZ)
 ALLING MEMORIAL GOLF COURSE (CT)
 ARIZONA COUNTRY CLUB (AZ)
 BILTMORE GOLF COURSE (FL)
 BIRNDOG GOLF COURSE (VA)
 BLACKSTONE GOLF COURSE (FL)
 BOWDEN MUNICIPAL GOLF COURSE (GA)
 BROAD BAY COUNTRY CLUB (WA)
 CAROLINA COLOURS GOLF CLUB (NC)
 CHERRY VALLEY COUNTRY CLUB (NJ)
 COFFIN GOLF CLUB (IN)
 CORAL CREEK GOLF COURSE (HI)
 COUNTRY CLUB OF ROSWELL (GA)
 COYOTE CROSSING GOLF COURSE (IN)
 COYOTE DEL MALPAS GOLF COURSE (NM)
 DEBORDELLO COUNTRY CLUB (SC)
 DERRYFIELD COUNTRY CLUB (NH)
 FRANKS GOLF COURSE (IA)
 FIREKEEPER GOLF COURSE (KS)
 FOREST HILLS COUNTRY CLUB (IL)
 FORDGATE COUNTRY CLUB - EAST (NJ)
 FOX RUN GOLF CLUB (MO)
 GANNON MUNICIPAL GOLF COURSE (MA)
 GEORGE WRIGHT GOLF COURSE (MA)
 GLENDORA COUNTRY CLUB (CA)
 GRAND FALLS CASINO AND RESORT (IA)
 GRANDE DAKS GOLF CLUB (FL)

GREEN ACRES GOLF COURSE (MI)
 HAMILTON FARM GOLF CLUB (NJ)
 HAWK POINTE GOLF COURSE (NJ)
 HIANATHA GOLF COURSE (MN)
 HIGHLAND COUNTRY CLUB (NC)
 HOBBS CREEK GOLF COURSE (UT)
 HUNTSMAN SPRINGS GOLF CLUB (CO)
 INGERSOLL GOLF COURSE (IL)
 KILLINGTON GOLF COURSE (VT)
 KNOWLEDGE CLUB (IL)
 LAKE FOREST GOLF AND COUNTRY CLUB (MO)
 LAKEWOOD COUNTRY CLUB (MD)
 LAUGHLIN RANCH GOLF CLUB (AZ)
 MACGREGOR DOWNS COUNTRY CLUB (ND)
 MALLARD CREEK GOLF AND RV RESORT (OR)
 MEADOW BROOK GOLF COURSE (PA)
 MENTAL MEMORIAL GOLF COURSE (OH)
 MIDLAND TRAIL GOLF CLUB (KY)
 MILL RIVER CLUB (NY)
 MINT VALLEY GOLF COURSE (WA)
 NORMANDY SHORES GOLF CLUB (FL)
 NORTHWOOD CLUB (TX)
 OAK RIDGE COUNTRY CLUB (MN)
 PEACHTREE GOLF CLUB (GA)
 PINNACLE PEAK COUNTRY CLUB (AZ)
 PLEASANT RIDGE GOLF COURSE (NC)
 RADNOR VALLEY COUNTRY CLUB (PA)

RANCHO PARI GOLF COURSE (CA)
 RANCHO VISTA GOLF COURSE (CA)
 SHANNONPIN COUNTRY CLUB (PA)
 SOARING EAGLES GOLF COURSE (NY)
 SPRING VALLEY GOLF CLUB (PA)
 STANFORD UNIVERSITY GOLF COURSE (CA)
 STERLING NATIONAL COUNTRY CLUB (MA)
 SUMMIT CHASE COUNTRY CLUB (GA)
 THE BRIARWOOD (MT)
 THE BRIDGES AT RANCHO SANTA FE (CA)
 THE GOLF CLUB AT HARBOR SHORES (MI)
 THE GROVE (TN)
 THE LINKS AT AUDUBON (TN)
 TIMBERVIEW GOLF COURSE (OH)
 TRUMP NATIONAL GOLF CLUB - PHILADELPHIA (PA)
 TUSCARORA COUNTRY CLUB (VA)
 THRONE HILLS GOLF CLUB (MO)
 UNIVERSITY OF MICHIGAN GOLF COURSE (MI)
 WEE BURN COUNTRY CLUB (CT)
 WEST SHORE COUNTRY CLUB (PA)
 WICKENBURG RANCH GOLF COURSE (AZ)
 WILLOW CREEK COUNTRY CLUB (UT)
 WINDSOR GOLF CLUB (CA)
 WOODED VIEW GOLF COURSE (OH)
 WOODSIDE ACRES GOLF AND COUNTRY CLUB (NY)
 YUMA GOLF AND COUNTRY CLUB (AZ)