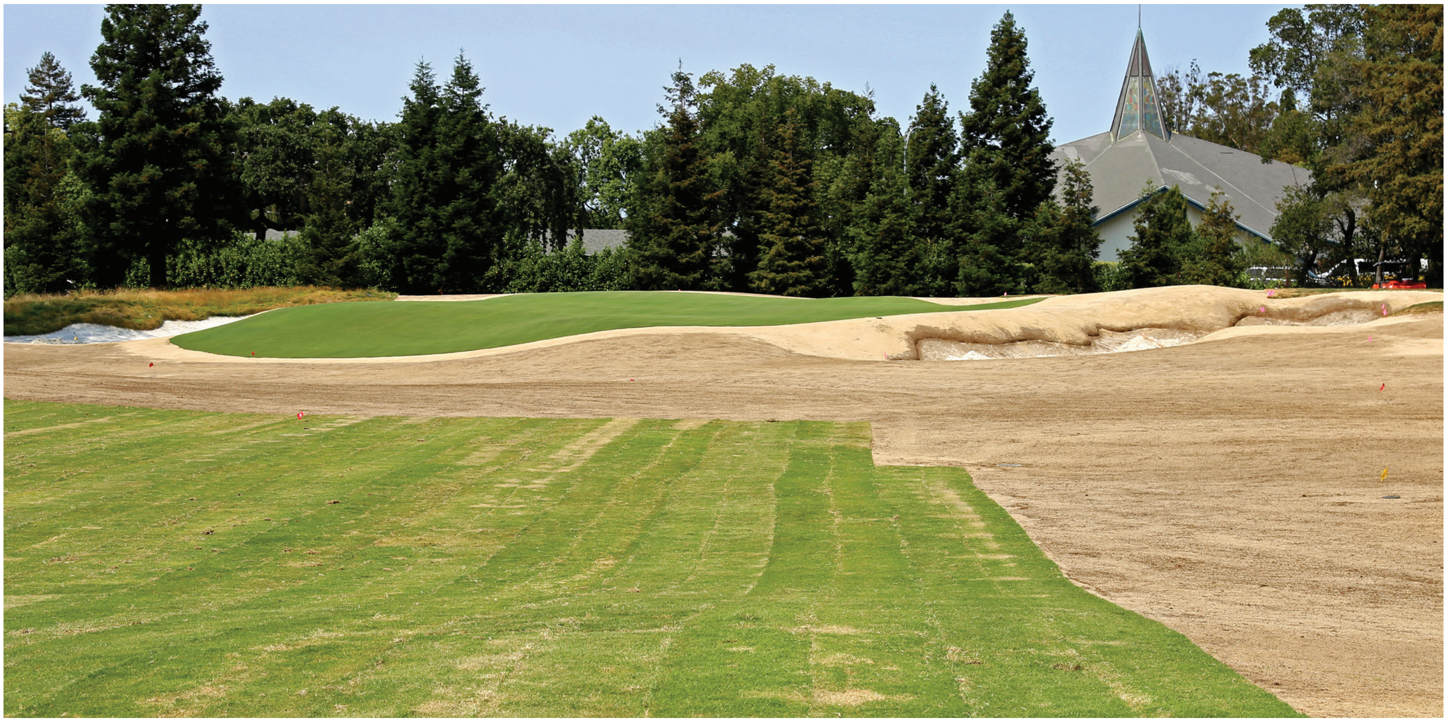
ADVANCED IRRIGATION TECHNIQUES AND CONSERVATION STRATEGIES

# Grassing Strategies for Golf Course Water Conservation



Turfgrass conversion has helped many golf courses save water, but there are a lot of variables to consider and patience is necessary to achieve the desired results.

## SNAPSHOT

*This strategy deals with establishing turfgrasses that use less water and reducing winter overseeding. It is a high-impact, high-cost strategy applicable to many golf courses, especially where warm-season grasses are well-adapted but not in use.*

| | |
|---|---|
| Expected cost | $25K to $80K per acre |
| Ease of implementation | Large capital project |
| Potential water savings for affected area | 10% to 30% |
| Highest potential impact areas | Western and southern U.S., and throughout the transition zone |

## OVERVIEW

Grass selection is a fundamental part of successful golf course management. Different grass species – and even different cultivars of the same species – can have a significant impact on the maintenance requirements, aesthetics and playability of a golf course. The availability of improved turfgrass cultivars, changing weather patterns, and shifting priorities in playing conditions have led many courses to make grassing changes in recent years. Increased use of warm-season grasses in dry and transitional climates is a great example. Water conservation is a primary driver of this trend, but better playing conditions for more of the year is also a key factor.

When it comes to saving water through grassing changes, rough and fairway areas offer the greatest opportunity simply because of how large they are. Renovation costs can be high and there will be downtime when play is not possible, but converting from cool-season to warm-season grasses routinely yields at least a 25% reduction in water use in converted areas. Where water is expensive, the investment in turf conversion typically pays off in seven to eight years. There also may be an opportunity to reduce water use where warm-season grasses not specifically developed for low-water-use characteristics are already in use, and the relative benefit will vary regionally and based on irrigation strategies.

Winter overseeding of warm-season grasses should be avoided whenever possible, as it dramatically increases annual water use and impairs playing conditions outside of the overseeded period.

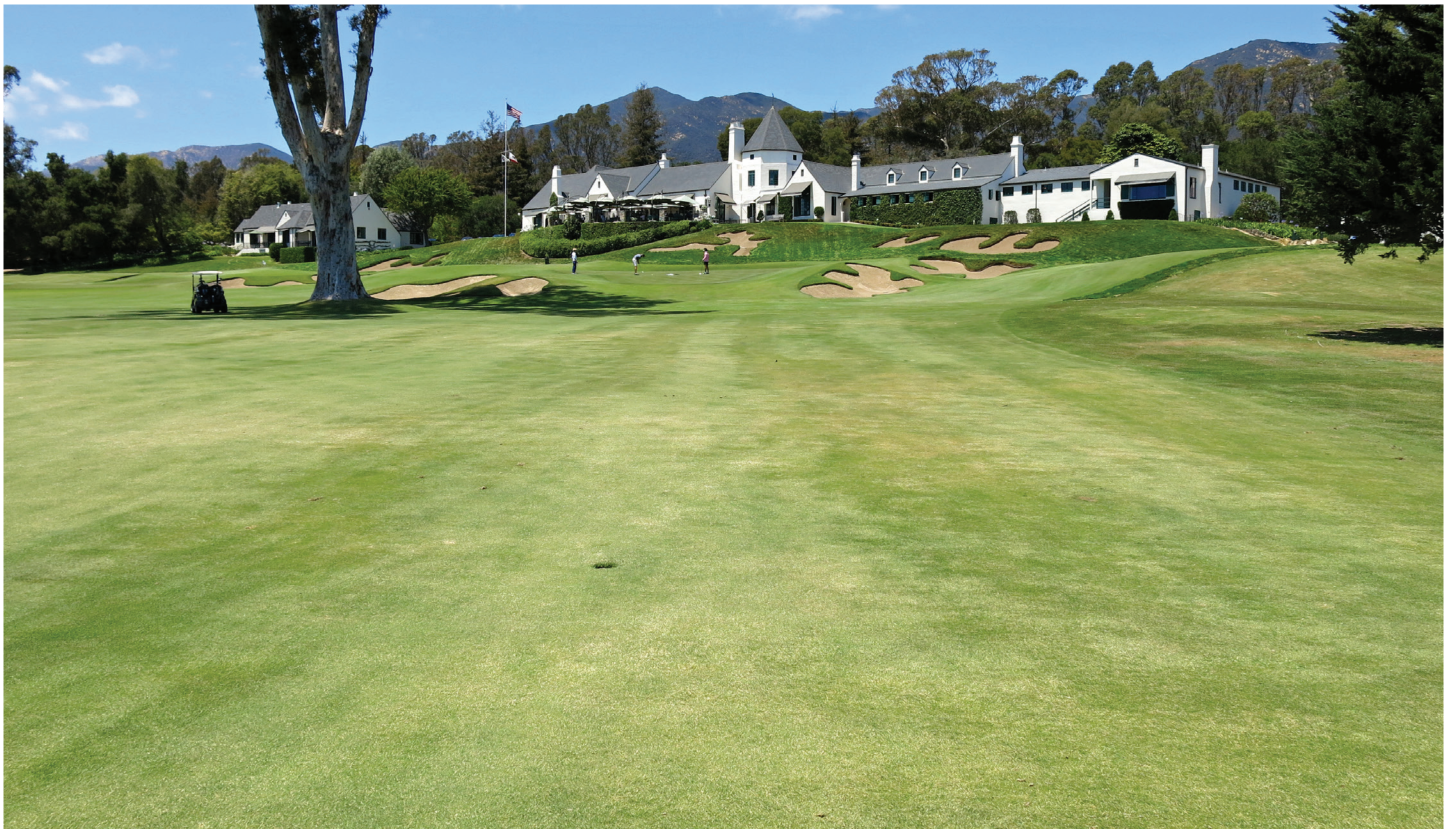
The potential water savings that comes with converting from one cool-season turfgrass to another is lower than converting from cool-season to warm-season grasses, but there is still significant value in considering the water-conservation benefits of newer and improved cool-season cultivars (Braun et al., 2022b). Even without substantial water savings, establishing drought-resistant cool-season cultivars in areas such as bunker faces can improve irrigation and maintenance efficiency by reducing the need for time-consuming hand watering and deliver better turf conditions. Other benefits include better heat, drought and disease resistance, which all mean better turf conditions throughout the primary playing season, and potentially significant savings through reduced pesticide applications that can pay for the cost of the project within several years.

## SCENARIOS FOR USE

### Where Is the Strategy Typically Used?

Converting to improved or better-adapted turfgrass cultivars is an effective strategy for golf courses seeking to reduce water use, improve playing quality, or both. Turfgrass cultivars are available to enhance the drought resistance of any playing surface. However, fairways are a common target for conversion because they have a larger footprint than putting greens or tees and a relatively higher expectation for management than rough.

Warm-season grasses are more drought-resistant, have lower water requirements than cool-season grasses and are well suited for warmer climates, making them a viable option for regions with hot summers or prolonged dry periods if winters aren't too cold. Newer cool-season grasses with improved disease and drought resistance can reduce pesticide and water use, while also improving playability. Growth habits impact how a specific turfgrass deals with drought and is an important consideration. When irrigation is unavailable, turfgrasses like bermudagrass or Kentucky bluegrass that spread via rhizomes and/or stolons recover better from dormancy after prolonged drought. Turfgrasses also respond differently to deficit irrigation, a common strategy to reduce water use.



Golf courses in warm and dry climates have saved considerable amounts of water by converting large areas like fairways and roughs from cool-season to warm-season grasses.

## Opportunities to Expand Use

While some golf courses have adopted newer drought-resistant grasses, there are many more courses that can still benefit. Opportunities exist to expand the use of improved warm-season grasses to more regions, especially as breeding efforts continue to improve the cold-tolerance of these grasses. There are also many areas in the southern U.S. where bermudagrass cultivars from the 1950s and 1960s continue to prevail. Newer bermudagrasses have lower water-use rates than these older industry standards. Where warm-season grasses are not plausible, but water conservation is required or desired, thoughtful selection of drought-resistant cool-season grasses is critical.

The biggest impediment to courses saving water through turf conversion is not a lack of grassing options, it is the understandable reluctance to incur the cost and extended disruption associated with making the conversion. Optimizing regrassing processes and educating courses about the potential return on investment are both important aspects of helping more courses save water through turf conversion.

# BENEFITS

## Expected Water and Cost Savings

Converting from a cool-season to warm-season turfgrass will achieve the most-significant water savings. At least a 25% or more reduction in water use can be expected in converted areas (Whitlark, 2022; Whitlark et al., 2023). Comparatively, savings of 10% to 20% can be expected from establishing a drought-resistant cool-season grass, or similarly, replacing an older warm-season grass with an improved, drought-resistant cultivar (Amgain et al., 2018; Ketchum et al., 2023; Minor et al., 2020; Serena et al., 2023). Actual savings will vary depending on differential water use between existing and new cultivars and various site conditions.

For courses with high water costs, such as in the southwestern U.S., the savings associated with using a cultivar that requires less irrigation can help the project pay for itself in a relatively short period of time. Many conversions can pay for themselves in just a few years (Minor et al., 2020), and even multimillion-dollar projects can break even in less than eight years, especially when considering other cost savings from improved cultivars such as reduced fertilizer and pesticide use (Whitlark, 2022). Turfgrass conversion projects have a range of costs and the ultimate payback period for any project will mostly vary depending on grassing method, management costs of the old and newly established grass and lost revenue during the project. In unique situations, some golf courses have creatively limited course closure during regrassing, reducing their payback period to less than two years (Jacobs & Gross, 2019).

***Converting from a cool-season to warm-season turfgrass will achieve the most-significant water savings.***

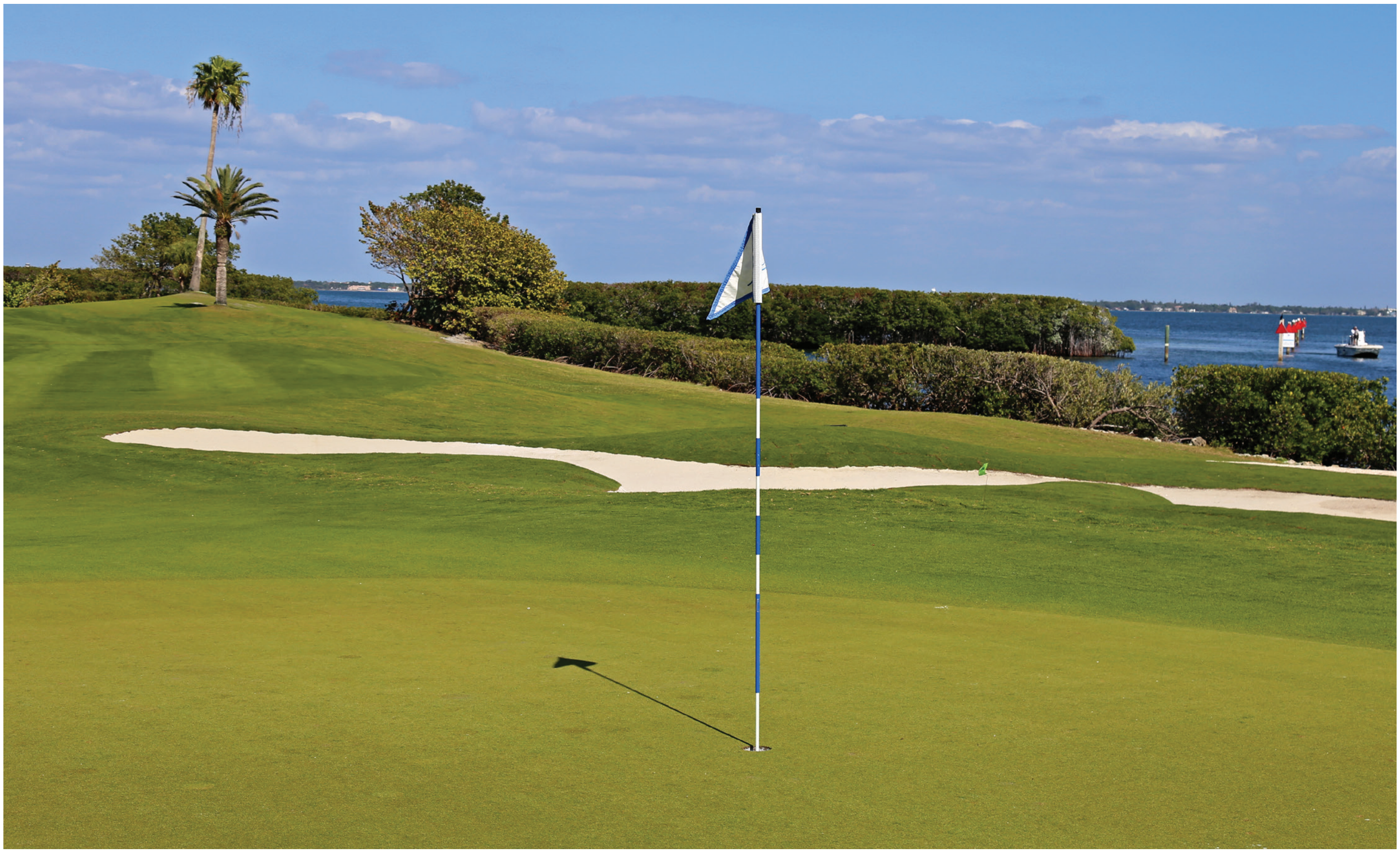
## Better Playing Conditions

One of the biggest motivations for converting to grasses that use less water is the prospect of better playing conditions. Using cool-season grasses in areas with hot summers often means there will be higher water use and softer conditions through some of the primary playing season. Converting to grasses that use less water and are more drought-resistant means playing surfaces can be kept firmer and healthier during these times. The risk of disease and turf loss is also higher with frequent irrigation and when grasses are otherwise stressed, so converting to improved cultivars usually means better consistency.

Courses that have an evolved mix of various grasses on a particular playing surface will also realize improved playing conditions with a uniform stand in converted areas. Aside from potential differences in growth rate or habit, each of the different grasses in mixed stands tend to struggle the most during different seasons, leading to ongoing inconsistency throughout the year. Mixes of cool-season and warm-season grasses are especially challenging and can also complicate general turfgrass management considerations.

## Addressing Salinity Problems

One of the most difficult challenges in turfgrass management is dealing with soil and water that are high in salts. Water quality problems are common in the arid and semiarid regions of the U.S., but also appear in humid areas like Florida. Further, coastal areas and anywhere recycled wastewater or an impaired well is used for irrigation will likely deal with water quality issues at some level. Competition for potable, non-potable and recycled water resources has changed turfgrass management and irrigation practices in many areas.



Using grasses like seashore paspalum (pictured here) has allowed courses in some areas to utilize lower-quality water sources that may be less expensive or more available than other options.

As a result, salt tolerance has become a more important consideration for turfgrass selection. Warm-season turfgrasses are generally more tolerant of lower-quality irrigation water sources. Therefore, in addition to simply requiring less water, converting from cool-season to warm-season grasses can help a course reduce total water use and improve maintenance efficiency by making better use of lower-quality water sources. This could mean using recycled irrigation water when it would have previously been difficult, or it could mean less need for leaching irrigation events to mitigate salt accumulation. Within warm-season grasses, there are species such as seashore paspalum, that better tolerate higher salt content in irrigation water. Similarly, salt tolerance can differ greatly among cultivars within species and care should be taken to review relevant research if salinity is a consideration during a regrassing project.

# CONSIDERATIONS

## Selecting the Right Turfgrass

When selecting a turfgrass, the intended playing surface, local climate and soil conditions as well as irrigation needs and resources are most important to consider. Several resources are available to help identify the turfgrass species and cultivars best suited for a situation. The USGA Green Section, university extension programs, the National Turfgrass Evaluation Program (NTEP), the Turfgrass Water Conservation Alliance (TWCA), or the Alliance for Low Input Sustainable Turf (A-LIST) provide extensive research results for all major turfgrass species.

Identifying which grass options will perform best and establishing an in-house trial on the course with several cultivars is an excellent way to make a final decision. This also allows golfers, decision-makers and others at the facility to inspect the quality of each grass so there are no surprises after the renovation. Again, focusing on larger areas such as fairways and roughs achieves the most-significant reduction in irrigation.

Establish the test plots in the turfgrass nursery area, on the driving range, or in the fairway or rough areas of the course. Some superintendents locate trials in problem areas where existing turfgrass fails annually or in areas that will receive limited irrigation in the future. Most land-grant universities have replicated turfgrass trials that can be observed by appointment or during field days.

The National Turfgrass Evaluation Program (NTEP) is a valuable resource for research-based information about which grasses can potentially save the most water at your course.

## Understanding Drought Resistance

The overall ability for plants to survive drought is termed "drought resistance." Turfgrasses increase their drought resistance with different inherent morphological and physiological mechanisms that are essential to understand when selecting the turfgrass best suited to a particular environment. Drought-resistance mechanisms include drought avoidance, tolerance and escape. In simple terms, drought avoidance means that a turfgrass will maintain growth and quality longer during drought stress by conserving or accessing more water, whereas turfgrasses exhibiting tolerance or escape mechanisms will not.

**Drought avoidance** specifically refers to the ability of a turfgrass to maintain a higher plant water status by reducing water lost through transpiration or by increasing water uptake to meet transpirational demands. Turfgrasses primarily achieve this through deeper rooting but can also directly reduce transpiration through various mechanisms. Tall fescue is unique among cool-season grasses for its excellent drought avoidance characteristics. All warm-season grasses generally exhibit strong drought avoidance, but bermudagrass, buffalograss and seashore paspalum are species of interest to golf that are exceptional at avoiding drought stress (Fry & Huang, 2004).

**Drought tolerance** is the ability of a turfgrass to endure drought and survive. Dormancy is commonly associated with drought tolerance, but a turf must successfully recover from dormancy to exhibit strong drought tolerance. Drought-tolerant turfgrasses typically have low transpiration rates and are able to avoid dehydration of cells during severe drought, especially in meristem tissues, by accumulating solutes that attract water – a phenomenon called osmotic adjustment. When irrigation or precipitation occurs following drought, the ability to spread via stolons and/or rhizomes is an important characteristic of drought-tolerant grasses. The fine fescues and Kentucky bluegrass are unique to cool-season grasses because of their exceptional drought tolerance traits. Buffalograss, zoysiagrass, and bermudagrass are most noted for drought tolerance among warm-season grasses (Fry & Huang, 2004).

**Drought escape** means a plant completes its life cycle (from germination to seed setting) before succumbing to drought stress. Escape is exhibited by annual plants and weeds.

## Determining Water Requirements for Turfgrasses Using Evapotranspiration

Since the 1980s, scientists have documented the water used by turfgrass species in terms of evapotranspiration (ET). Evapotranspiration estimates the amount of water a turfgrass species uses over a given period of time and combines evaporation from soil and leaves with plant transpiration. Reference ET ($ET_o$) is typically the starting point for understanding the irrigation requirements for a particular location and is commonly estimated using environmental data for a hypothetical grass field that is well-watered and mowed at approximately 5 inches (Allen et al., 1998). This hypothetical grass field obviously differs from most turfgrass areas, especially golf course turfgrass areas, and years of controlled research have helped estimate actual turfgrass ET ($ET_a$) by developing multipliers, referred to as crop coefficients ($K_c$), that appropriately reduce $ET_o$.

Generally, warm-season turfgrasses have a $K_c$ value of 0.6, while the $K_c$ value for cool-season grasses is 0.8. This difference translates to an expected 20% to 30% reduction in water use by warm-season grasses compared to cool-season grasses. A range of more specific $K_c$ values exist for major turfgrass species and cultivars, which have been used to classify turfgrass species by relative ET efficiency (Table 1). High-density, low-growing turfgrasses like bermudagrass, zoysiagrass and buffalograss have the lowest water-use rates. The fine-leafed fescues rank medium for cool-season species, while Kentucky bluegrass, annual bluegrass and creeping bentgrass typically exhibit very high water-use rates. Researchers continually refine $K_c$ values with new methods, in new locations, and as new grasses are released. There have been incremental changes in how we understand the range of ET rates for specific species, and newer estimates typically fall within or very near the ranges presented in Table 1 and the general warm-season and cool-season $K_c$ values above remain valid starting points for grass selection (Braun et al., 2022a; Colmer & Barton, 2017).

**Table 1. Summary of mean rates of turfgrass evapotranspiration.**

| Cool-Season Grasses | Warm-Season Grasses | Mean Summer ET Rate (Inches Per Week) | Relative Ranking (ET Rate) |
|---|---|---|---|
| | Buffalograss | 1.4-1.9 | |
| | Bermudagrass hybrids | 0.9-1.9 | |
| | Centipedegrass | 1.0-2.5 | Low |
| | Common bermudagrass | 0.8-2.5 | |
| | Zoysiagrass | 1.0-2.2 | |
| Hard fescue | | 1.9-2.3 | |
| Chewings fescue | | 1.9-2.3 | |
| Red fescue | | 1.9-2.3 | Medium |
| | Bahiagrass | 1.7-2.3 | |
| | Seashore paspalum | 1.7-2.3 | |
| | St. Augustinegrass | 0.9-1.9 | |
| Perennial ryegrass | | 1.8-3.1 | |
| | Carpetgrass | 2.4-2.8 | |
| | Kikuyugrass | 2.3-2.8 | |
| Tall fescue | | 1.0-3.5 | High |
| Creeping bentgrass | | 1.4-2.8 | |
| Annual bluegrass | | >2.8 | |
| Kentucky bluegrass | | 1.1- >2.8 | |
| Italian ryegrass | | >2.8 | |

This table is based on summaries and reviews of numerous published articles. Sources: Balogh & Walker, 1992; Beard & Kenna, 2008.

It's important to remember that these generalizations do not fully reflect the drought-resistance potential of various turfgrass species or especially cultivars. Relative ET rates should be considered along with a grass' ability to avoid or tolerate drought, the nature of expected drought periods and golfer expectations during and following drought.

A common way to approach this challenge has been to determine turfgrass performance and ET rates under different levels of deficit irrigation, and the NTEP has coordinated several nationwide trials with various deficit-irrigation strategies. Turfgrass ET rates obviously decline under deficit irrigation and warm-season grasses consistently perform best. Bermudagrass stands out among warm-season grasses under limited irrigation in these trials, and tall fescue tends to require less water than other cool-season grasses. For example, the best bermudagrass cultivars in a recent NTEP trial required 0.14 inches of irrigation per week to maintain acceptable quality, whereas the best zoysiagrass and buffalograss cultivars required 0.28 inches of irrigation per week (NTEP, 2022; Serena et al., 2023). When comparing Kentucky bluegrass and tall fescue cultivars in a different trial, the average water requirement to maintain acceptable turf quality among 15 Kentucky bluegrass cultivars ranged from 0.56 to 0.77 inches of irrigation per week. In contrast, the irrigation required by 18 tall fescue cultivars ranged from 0.49 to 0.56 inches (NTEP, 2020).

Developing better estimates for $ET_a$ can be done in two ways. First, $ET_o$ estimates are readily available at a daily scale and should be at least seasonally adjusted for irrigation programming. Estimates can be further improved by making site-specific adjustments to account for the microclimates of individual irrigation zones. Second, $K_c$ values can be improved by considering specific cultivar(s) and how a cultivar performs in a specific location and season. Ultimately, $ET_o$ and $K_c$ values are a valuable starting point for understanding irrigation requirements during grass selection, and superintendents can adjust as needed for estimating actual water requirements for irrigation. Research is ongoing to refine $K_c$ estimates for different grass species and cultivars under different irrigation regimes and in different regions of the U.S.

## Climate Zones and Turfgrass Adaptation

Climate is the prevailing combination of weather conditions over time – including light, temperature, precipitation and wind. All of these factors influence the growth and development of turfgrasses. Temperature extremes and precipitation patterns are key environmental factors that affect the range of turfgrass adaptation. Cool-season turfgrasses grow best at air temperatures between 60 and 75 F. In contrast, warm-season turfgrasses grow best at air temperatures between 75 and 95 F. Apart from temperature extremes or water supply challenges that may fundamentally limit the use of a grass in a particular climate zone, these optimal ranges help define the expected growing season for grasses that will allow recovery from damage or provide expected aesthetics.

## Managing Adjacent Surfaces

A challenging aspect of converting some playing areas to drought-resistant grasses is how to manage adjacent areas with different water requirements. This is a common issue when converting cool-season fairways to warm-season turf, but not the adjacent rough. Unless the irrigation system already can (or is redesigned to) irrigate fairways and rough separately, the rough will likely experience regular drought stress and other associated issues under an irrigation regime designed for the warm-season fairways. If this is not acceptable, the rough may also have to be converted to fully realize potential water savings and optimize conditions in both areas.

Another issue with having different turfgrasses adjacent to one another is the potential for encroachment and contamination. This can happen with warm-season fairways creeping into cool-season greens or roughs, or it can happen with older warm-season grasses contaminating a new stand of an improved warm-season cultivar. There are various ways to create buffers and manage regrowth and encroachment, but there will likely be a constant struggle any time different grasses are located next to each other. Converting more area to improved cultivars will limit this potential challenge.

## BRIEF DESCRIPTIONS AND CONSIDERATIONS FOR DIFFERENT GRASSES

The following is an overview of cool-season and warm-season grasses commonly used on golf courses in the U.S. Together with the information presented above, this material can help golf courses select grasses to optimize water use at their facility.

### Cool-Season Turfgrasses

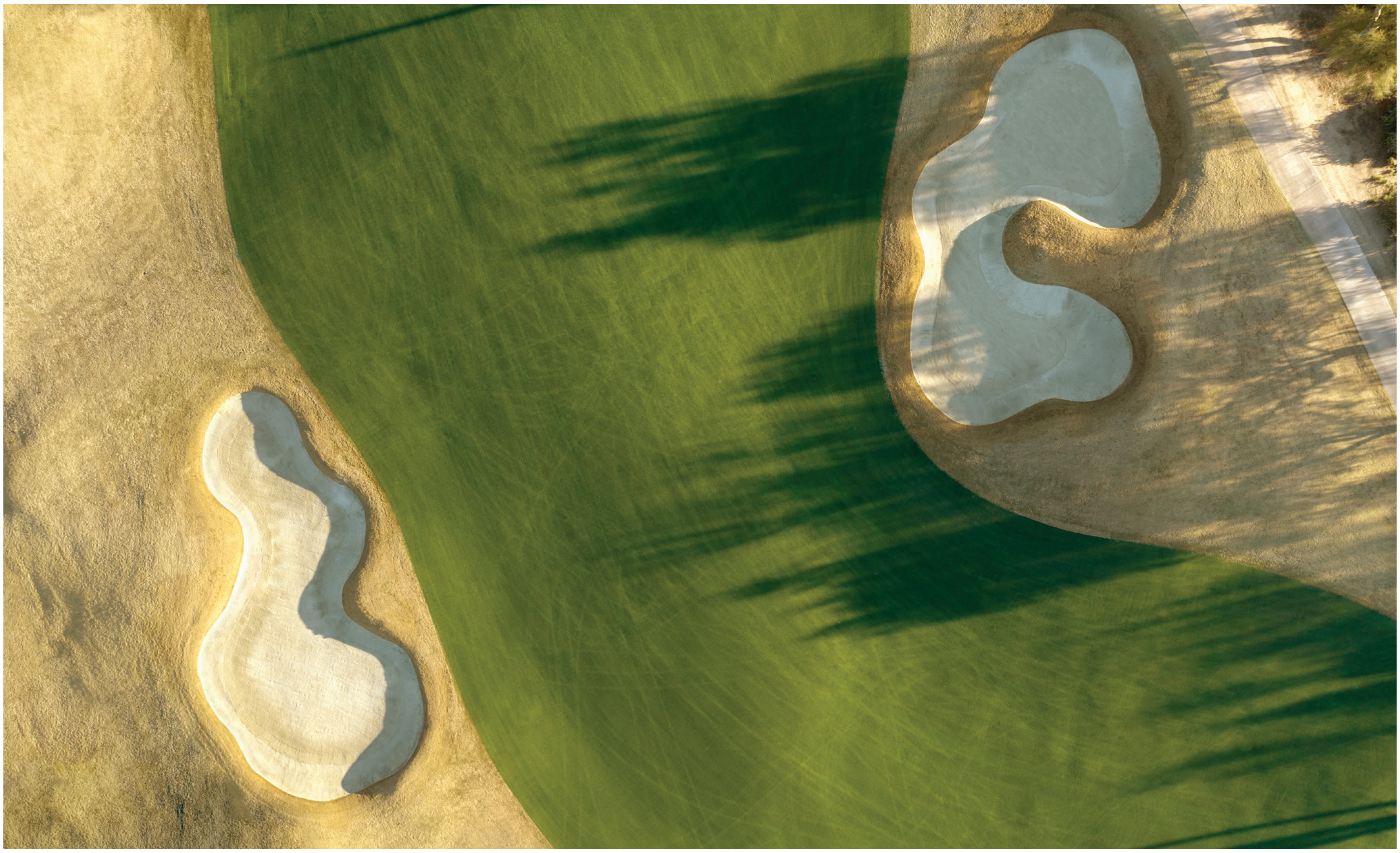
#### Kentucky bluegrass

A multipurpose turfgrass commonly used for golf course roughs and fairways, Kentucky bluegrass is a long-lived perennial widely adapted throughout cool-season growing areas. It also can be used in cool, semiarid and arid regions if irrigated. Kentucky bluegrass has exceptional drought tolerance and can survive drought, initiate new shoot growth, and spread via rhizomes when moisture conditions improve. The ability to spread by rhizomes also allows the species to recuperate from traffic and divots. Summer dormancy may occur from drought or heat stress, with the aboveground foliage becoming brown. Although comparable to most cool-season grasses for drought avoidance, attempting to maintain Kentucky bluegrass quality during severe drought will require more water than tall fescue. Conversely, Kentucky bluegrass or a fine fescue would better survive and recover from an extended period without precipitation or irrigation.

#### Perennial ryegrass

Perennial ryegrass is generally short-lived, but it can persist indefinitely if not subjected to extremes in temperature or high disease pressure. Typically, perennial ryegrass survives under cold winter conditions when protected by consistent snow cover. Ryegrass is generally considered a high water user, with ET requirements of 1.8 to 3.1 inches per week, and has no distinguishing drought-resistance characteristics.

Perennial ryegrass has two primary uses. In cooler climates, it is frequently used alone or in combination with Kentucky bluegrass in sunny locations for tees, fairways and roughs. Perennial ryegrass monostands are commonly overseeded annually to maintain coverage and density. When mixed with Kentucky bluegrass, perennial ryegrass is intended to provide quick establishment and is largely replaced by Kentucky bluegrass as the stand matures. In parts of the southern and western U.S., perennial ryegrass is the main overseeding grass for tees, fairways and roughs. Seeded in late August and early September, it remains green until late spring, when temperatures warm and it dies as the underlying bermudagrass breaks dormancy. Golf courses with water conservation goals should generally avoid winter overseeding since it can increase irrigation requirements by 20% or more due to the establishment and maintenance irrigation of the ryegrass (B. Whitlark, personal communication, August 27, 2024). Alternatives to overseeding are discussed later.



Overseeded ryegrass can provide high-quality aesthetics and playing conditions in areas where bermudagrass goes dormant during winter, but at the cost of increased annual irrigation and damage to the understory bermudagrass.

## Fine fescue

Fine fescues are long-lived perennials widely distributed throughout the cooler climates of the U.S. that are used primarily for golf course roughs and naturalized or native areas, with limited use on fairways and putting greens in the U.S. Poor heat tolerance limits the geographic distribution of fine fescue compared to Kentucky bluegrass. Creeping red fescue is distinguished from other fine fescues because it spreads through a creeping growth habit, although somewhat less vigorously than Kentucky bluegrass. Chewings and hard fescue have bunch-type growth habits.

All the fine fescues have narrow, upright leaves. They are superior to other cool-season grasses for shade adaptation, and their water-use rate is lower than Kentucky bluegrass and perennial ryegrass. Fine fescues exhibit exceptional drought tolerance and can be a persistent and low-maintenance stand in suitable climates and enhance water conservation. The species also has better salt tolerance than other cool-season grasses.

## Turf-type tall fescue

Turf-type tall fescue is a long-lived perennial grown in the transition zone between cool, humid and warm regions. It persists as far north as the Great Lakes and as far south as Atlanta and Dallas. Tall fescue is fairly heat tolerant compared to other cool-season species because of its deep rooting characteristics that also confer exceptional drought avoidance relative to other cool-season species. The drought tolerance of tall fescue is inferior to that of Kentucky bluegrass and the fine fescues as it does not as readily recuperate from extended periods without water. Tall fescue also can suffer winter injury in the coldest areas of the northern United States.

Tall fescue is exceptionally drought- and wear-tolerant among cool-season species and is underutilized on golf courses in the transition zone that cannot utilize warm-season grasses to acquire these traits. It is superior to Kentucky bluegrass and perennial ryegrass in shade tolerance but inferior to fine fescues in the shade. Tall fescue use on golf courses is typically restricted to rough. Newer cultivars have finer texture and tolerate lower mowing and make reasonably good low-maintenance fairways or tees, but this is not a common use. Tall fescue has limited recuperative capacity and is commonly mixed with Kentucky bluegrass for this reason.

## Bentgrasses

Generally not known for drought resistance, creeping bentgrass is primarily grown as a turfgrass for golf course putting greens, tees and fairways. It has vigorous creeping stolons that develop at the ground surface, forming a fine-textured turf with superior shoot density, uniformity and turfgrass quality when closely mowed. Several creeping bentgrass cultivars have improved heat tolerance for high soil and air temperatures and have improved dollar spot resistance. Developing improved varieties of creeping bentgrass has long been the focus of many university-based turfgrass breeding programs. Creeping bentgrass is more tolerant of heat and drought than annual bluegrass but typically is not a species sought out to advance water conservation goals.

Colonial bentgrass differs from creeping bentgrass because it has less spreading capability through rhizomes or stolons. Colonial bentgrass exhibits dormancy and rapid recovery with drought stress. Velvet bentgrass has an extremely fine texture, forming a very dense turf. Its rate of spread by stolons is greater than colonial bentgrass but less than creeping bentgrass. Velvet bentgrass also exhibits better drought tolerance than creeping bentgrass.

## Annual bluegrass (*Poa annua*)

Although a desirable and high-quality turf on many golf courses, annual bluegrass is often considered a weed that is usually managed rather than controlled. More-perennial biotypes may become a significant or dominant component of intensively managed golf course fairways, tees and greens. Its fundamental

*Poa annua* is less tolerant of drought and heat than other cool-season grasses used on golf courses. If water conservation is a priority, converting *Poa annua* playing surfaces to grasses that require less water should be considered.

limitation is that it is more susceptible to cold, heat, disease, insect, ice and drought stresses than most cool-season species. Although annual bluegrass is less tolerant of heat and drought than other cool-season golf course grasses, it remains a popular choice for putting greens due to its density and overall putting quality. However, if water conservation is a priority, consider replacing annual bluegrass playing surfaces with other species like creeping bentgrass.

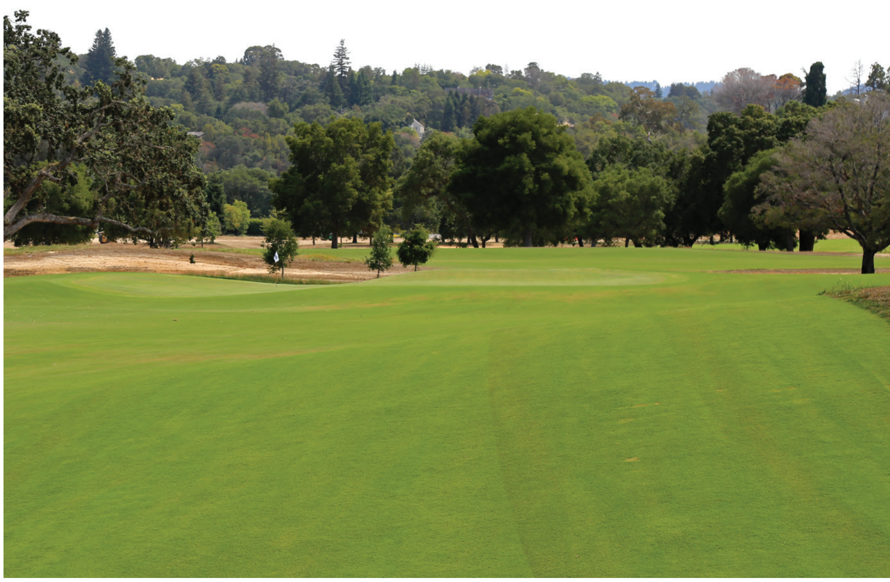
## Warm-Season Turfgrasses

### Bermudagrass

Bermudagrass is a fast-growing turfgrass species that spreads by stolons and rhizomes. It has excellent drought avoidance and tolerance. Extremely heat tolerant but intolerant of shade, bermudagrass is the dominant golf course grass in the South, as well as the hot-summer climates of the western U.S. Bermudagrass is versatile and can be used on all golf course playing surfaces. Where growing conditions are suitable, improved bermudagrass cultivars have the best potential to help golf courses conserve water, whether they are converting from cool-season turf or older warm-season cultivars.

Changing weather patterns and the development of bermudagrass cultivars with improved cold tolerance is expanding the useful range of this grass, especially on fairways and tees. Golf courses as far north as Pennsylvania and New Jersey are using bermudagrass on various surfaces, as are golf courses north of the San Francisco Bay Area along the west coast. This allows these courses to provide better playing conditions during the hot summer months and to use less water throughout the year when compared to cool-season species. One trade-off with this expanded range is a shorter growing season and the increased risk of winter injury. Courses that are thinking about converting from cool-season grasses to bermudagrass (or any warm-season grass) have to evaluate whether a shorter growing season is acceptable and consider the benefits of saving water and having better summer playing conditions in most years against the risk of potential freeze damage in an unlucky year.

While seeded cultivars are becoming more available, the best-performing bermudagrasses used on golf courses today are exclusively established by using sprigs or sod. This means the establishment period will be longer or more expensive than what is possible with seeded cool-season grasses. The time required to establish from sprigs, or the expense involved in grassing with sod, is an obstacle that limits conversion to improved bermudagrasses.



Where growing conditions are suitable, converting cool-season fairways and rough to bermudagrass can decrease water use in those areas by 25% or more. The development of bermudagrasses with improved cold-tolerance is making this conversion an option for a growing number of golf courses.

### Zoysiagrass

This perennial, slow-growing grass is widely adapted across the warm-season growing area of the U.S. It forms a uniform, dense, low-growing and high-quality turf that spreads by stolons and rhizomes. Although zoysiagrass does best in full sun, it can tolerate shade conditions better than many other warm-season species. Winter color retention and the playing surface quality of dormant zoysiagrass are other potential benefits. Even though it typically uses more water than bermudagrass, better dormant quality may eliminate the need for overseeding, which could lead to less water consumption throughout the year in some environments.

Traditionally, zoysiagrasses have been planted vegetatively by sprigs, plugs or sod and are slow to establish compared to bermudagrass, which has been a significant limitation in their use for larger areas on golf courses. However, a few seeded cultivars are available, and more will be available in the future. Plant breeders have also developed several zoysiagrass cultivars with faster sod production characteristics and better adaptation to a broader range of environmental conditions. If the winter qualities of zoysiagrass allow golf courses to avoid overseeding or using cool-season grasses in warm climates, the water saving opportunities are significant.

### Seashore paspalum

Seashore paspalum is known for its ability to survive high levels of salt in irrigation water and soil, making it a popular option in areas with poor water quality and locations where inundation with seawater is a risk. This turfgrass is found on golf courses in coastal regions of the U.S. from Texas to the Carolinas, and on the islands of Hawaii. It is a popular grass in Puerto Rico and throughout the Caribbean. Seashore paspalum spreads by rhizomes and stolons, and breeding efforts continue to improve cold tolerance, density, resistance to pests and other characteristics. Most improved cultivars for golf courses are established vegetatively by sod or sprigs. Seeded cultivars like ‘Pure Dynasty’ provide options for less-expensive establishment or in situations where importing vegetation is prohibited. As a water-conservation strategy, seashore paspalum provides the most value for its tolerance of poor-quality or recycled water high in salts.

## Native Grasses

Native grasses have the greatest potential in regions where water availability, water quality, poor soils or a challenging climate are limiting factors in providing quality turfgrass. However, the domestication of native species into viable golf course turfgrasses is not a simple task. Alkaligrass, blue grama, wheatgrasses, buffalograss and inland saltgrass are a few species that have potential as turfgrasses for the arid west or when irrigating with saline water. Of these, buffalograss and inland saltgrass have been the subject of considerable research in terms of their golf course feasibility and plant breeders have worked on developing improved cultivars that could be suitable for low-maintenance fairway and rough applications.

### Buffalograss

This cold-tolerant, stoloniferous, native prairie grass can be used for low-maintenance fairways, tees and rough. Seeded cultivars of relatively high quality are available, but because of its reputation as a low-maintenance grass, buffalograss has not been widely adopted on golf courses. It is fairly common in lawns or other general-use turfgrass areas compared to other native grasses and can make an exceptional low-maintenance rough where adapted. It greens up earlier than bermudagrass in the spring and turns brown after the first fall freeze. Buffalograss does not have the same density as traditional turfgrasses, especially under lower mowing heights, and therefore cannot provide the same aesthetics and playability as other warm-season grasses. It has exceptional overall drought resistance and is best suited to advance water conservation in areas that will receive little to no irrigation after establishment.

### Inland saltgrass

This grass is native to western North America and exhibits very high salt tolerance. Its aspect and growth habit are similar to other warm-season grasses with the presence of stolons and rhizomes. Currently, the use of inland saltgrass is limited on golf courses. However, plant selection, breeding efforts and research have been conducted for the past 40 years to bring this grass into the golf industry. It can make an exceptional, well-adapted grass for naturalized and low-maintenance areas where water and resources are limited. Saltgrass use is limited by lack of awareness, the commercial availability of improved cultivars and the availability of management information. Research is promising and ongoing.

# IMPLEMENTATION

## Converting to Warm-Season Grasses

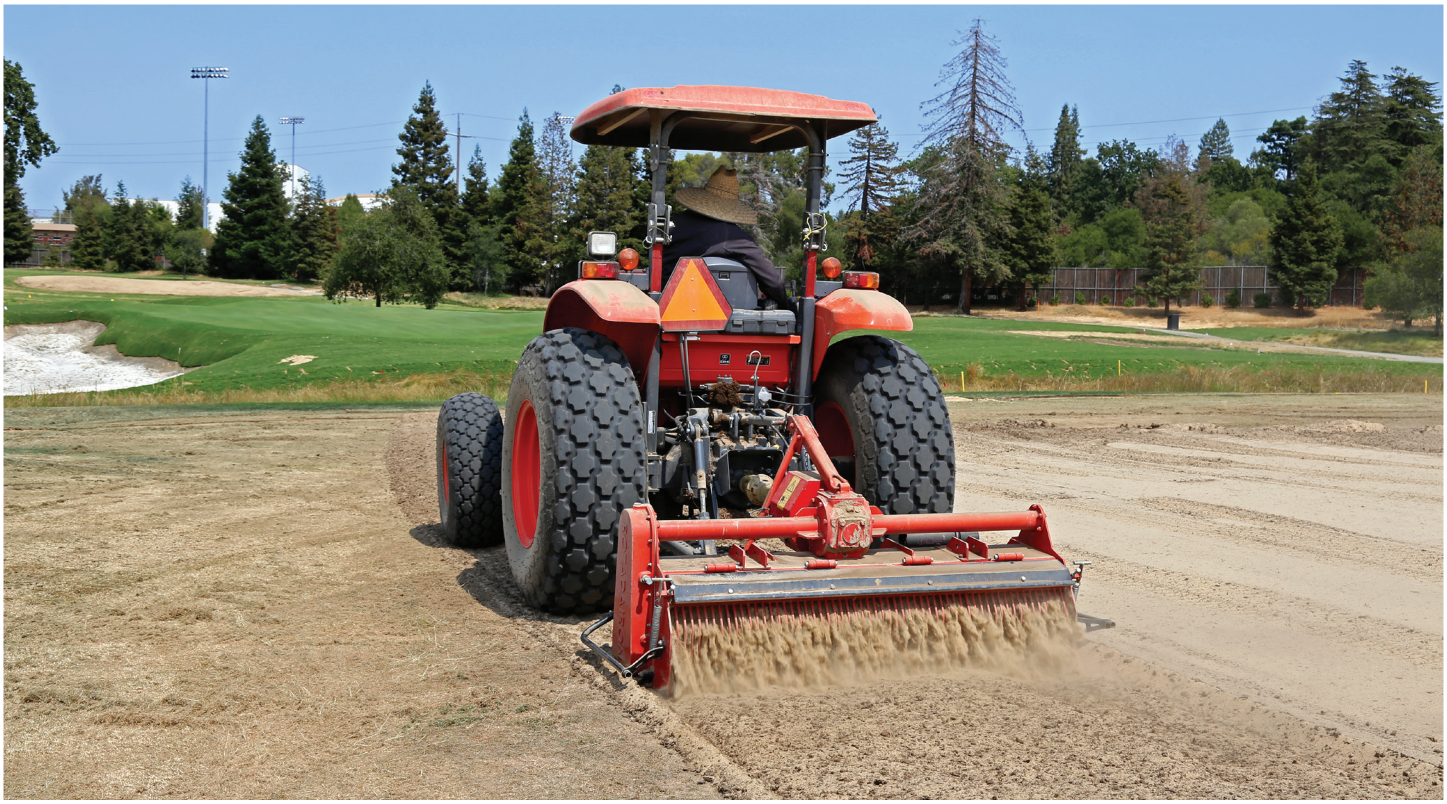
Transitioning from established cool-season or warm-season grasses to a new warm-season grass that uses less water involves completely renovating the turf area. Consult fellow turfgrass professionals familiar with your region to develop a plan for a successful transition and with help choosing the most-suitable warm-season grass cultivars based on your particular needs and site conditions. For more information, please see the USGA Green Section Record article "Converting to Bermudagrass Fairways."

### Step 1: Control existing grasses

Effective control of existing grasses takes time and patience. Begin treating existing turf with multiple applications of glyphosate in early spring when temperatures are above 50 F. Allow regrowth in between applications, which will require 14-21 days. For cool-season grasses, at least two applications should be made, but three or more may be required. For bermudagrass and other warm-season grasses, make three to five applications of glyphosate, also allowing time for regrowth in between applications. Tank-mixing fluazifop will improve control of bermudagrass over glyphosate alone. Do not mow for seven days before or after applications. Maintaining soil moisture to allow existing turf to recover between applications is critical to achieve the necessary control of existing grasses. For bermudagrass, apply one pound of nitrogen per 1,000 square feet one week after the first herbicide application to promote regrowth. Disturbing the soil between herbicide applications is also beneficial. Manage surface organic matter by fraise mowing, core aerating, vertical mowing or dragging with a metal-tine rake. Do not plant within seven days of the final herbicide application unless you remove the fluazifop from the last application. If seeding, up to a 30-day delay may be needed following the last herbicide application.

## Step 2: Prepare the soil

Use vertical mowing, aeration and mower scalping to remove as much of the material left on the surface as possible. The no-till method works best when establishing the new turfgrass by sod. If you prefer to till the soil prior to planting, three common methods (once herbicide applications are complete) are using an asphalt grinder, a Blecavator or a RotaDairon. These methods will improve soil characteristics, but they require sprinkler removal before tilling and finish grading prior to planting to smooth out the surface.



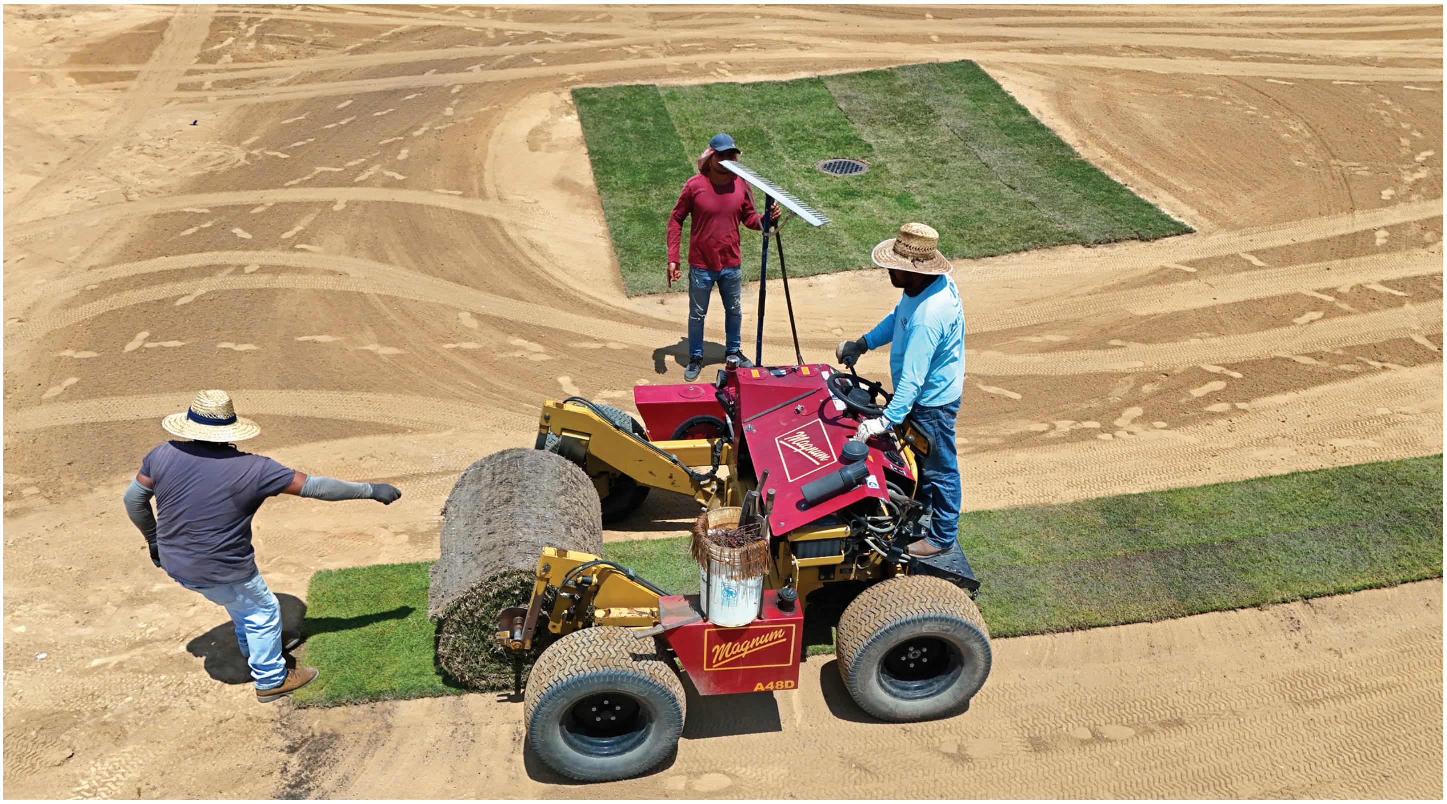
Tilling the soil before planting may be desirable, especially when planting sprigs. However, steps must be taken to protect irrigation system components and finish grading will be necessary to smooth out the surface.

## Step 3: Planting

Choosing to sprig the new grass means the materials and planting process are cheaper than sodding. Still, the cost difference may not be significant when factoring in lost revenue from the additional course closure time required to establish sprigs. After planting sod in an area, it could reopen for play in as little as two or three weeks, whereas sprigging will require a minimum of eight to 10 weeks for establishment. Planting sprigs also has the advantage of not introducing foreign soil like sodding does. If planting into a sand-capped fairway, this consideration is particularly important.

When converting from one bermudagrass to another, it is better to plant sod primarily for improved control of the existing turf and weeds. Sodding increases the success rate of establishing a dominant stand with fewer inputs such as water, fertilizer and pesticides. Sodding also ensures full turfgrass cover and, if laid between spring and the end of July, will allow the new turf to establish healthy rhizomes before winter.

When sprigging, if you have not tilled the soil you should soften it with aggressive aeration and irrigation to effectively cut the sprigs in. Plant 400 to 800 bushels of sprigs per acre in the morning and water immediately. Roll fairways with a 2- to 6-ton asphalt roller to push sprigs into the ground and produce a smoother, firmer playing surface. The sprigged area should be closed during this time. Finally, depending on the species being established, consider whether specialty herbicide applications can help control weeds and improve establishment.




Sodding is more expensive than sprigging or seeding in terms of materials and cost to install, but quicker establishment with sod means less disruption to the golf calendar, better weed control and potentially a better finished product.

## What if Warm-Season Grasses Aren't Possible?

Converting from cool-season grass to warm-season grass is the scenario that will save the most water in terms of grassing strategies. However, freezing temperatures and the risk of winter injury limit the use of warm-season grasses in colder climates, even arid ones. While cool-season grasses are not inherently as drought-resistant as warm-season grasses, some species and cultivars exhibit better drought tolerance than others.

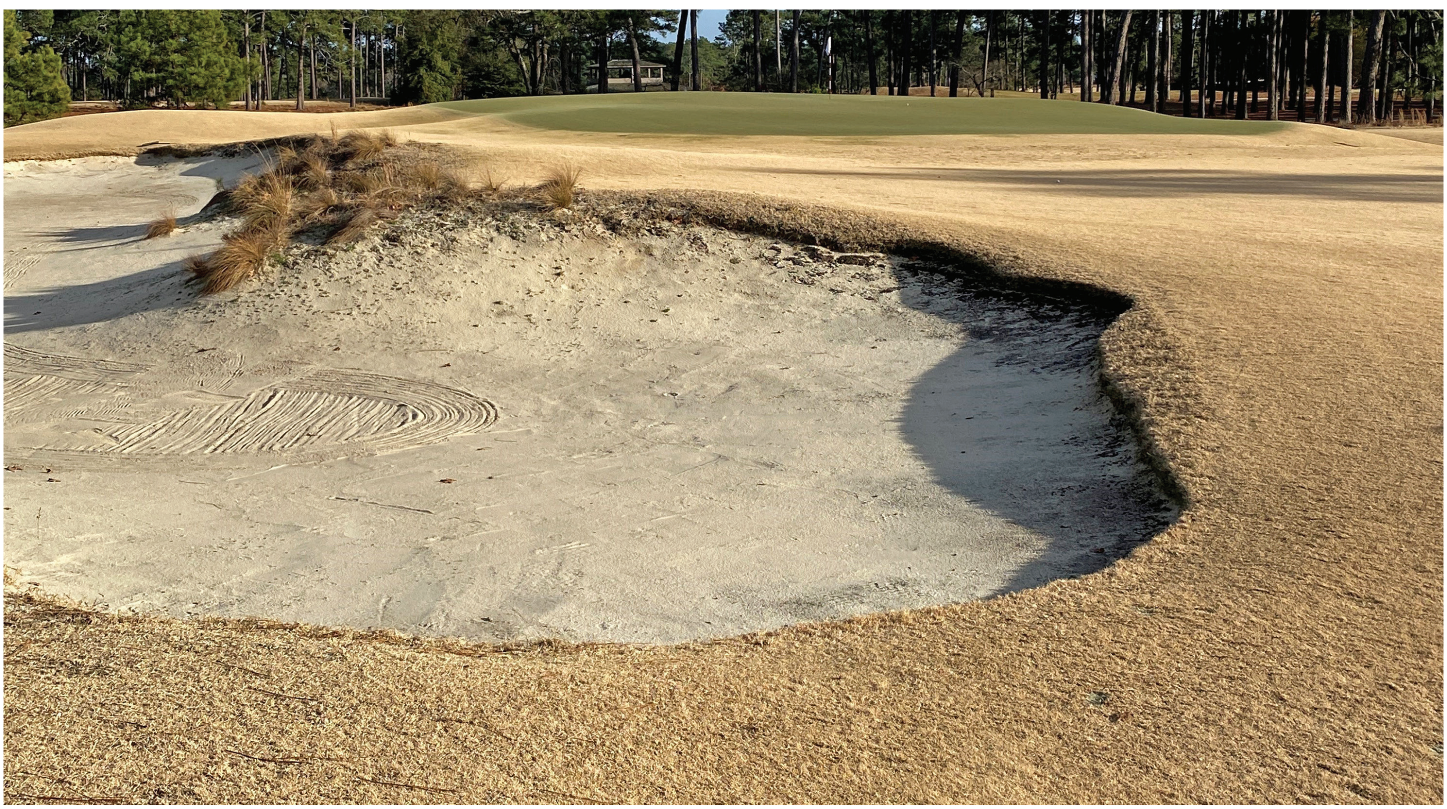
Selecting the best cool-season grass cultivar to help your course use less water will depend on several factors including your location, climate, soil type, maintenance practices and preferences. More information on drought-resistant cultivars can be found in TWCA, A-LIST and NTEP reports. As always, it is strongly recommended to select several cultivars that have promising research and field results and test them at your course under your unique site conditions and maintenance program before making a final decision.

The seasonal timing for establishing a cool-season grass will be different than for warm-season grasses. Late summer is generally the preferred time to seed or sod cool-season grasses. Therefore, initiating the control of existing grasses can be delayed into summer to align with the preferred seeding or sodding date and reduce the period of disruption to the golf course.

## Eliminate Winter Overseeding to Save Water During Dormancy

Eliminating overseeding of warm-season grasses and playing on dormant turf can significantly reduce water use. Although dormant turfgrass does not provide any recovery from traffic or divots, non-overseeded bermudagrass, if well maintained, can provide an excellent playing surface. Some golf courses are experimenting with zoysiagrass to obtain better winter playing conditions without overseeding. Generally, the quality of dormant zoysiagrass is slightly better than dormant bermudagrass, especially over longer periods of dormancy. Zoysiagrass also offers a firmer and denser surface, which is more resistant to divot and traffic injury. For both species, using pigments or colorants to maintain a green appearance can help enhance aesthetics during dormancy without requiring active growth.

Estimates from Arizona indicate that an acre of non-overseeded bermudagrass requires around 4.5 acre-feet (1.47 million gallons) of water per year. Overseeding an acre of bermudagrass increases annual water use to 6.2 acre-feet (2.02 million gallons). The 2020 median fairway acreage for a golf course in the Southwest was 29.3 acres (Shaddox et al., 2023). Overseeding that area with cool-season grass would require nearly 50 more acre-feet (or more than 16 million gallons) of water per year – for only one golf course.



An increasing number of golf courses – including Pinehurst No. 2 pictured here – that used to overseed in the winter have discontinued the practice to improve year-round playing conditions and conserve resources like water and fuel.

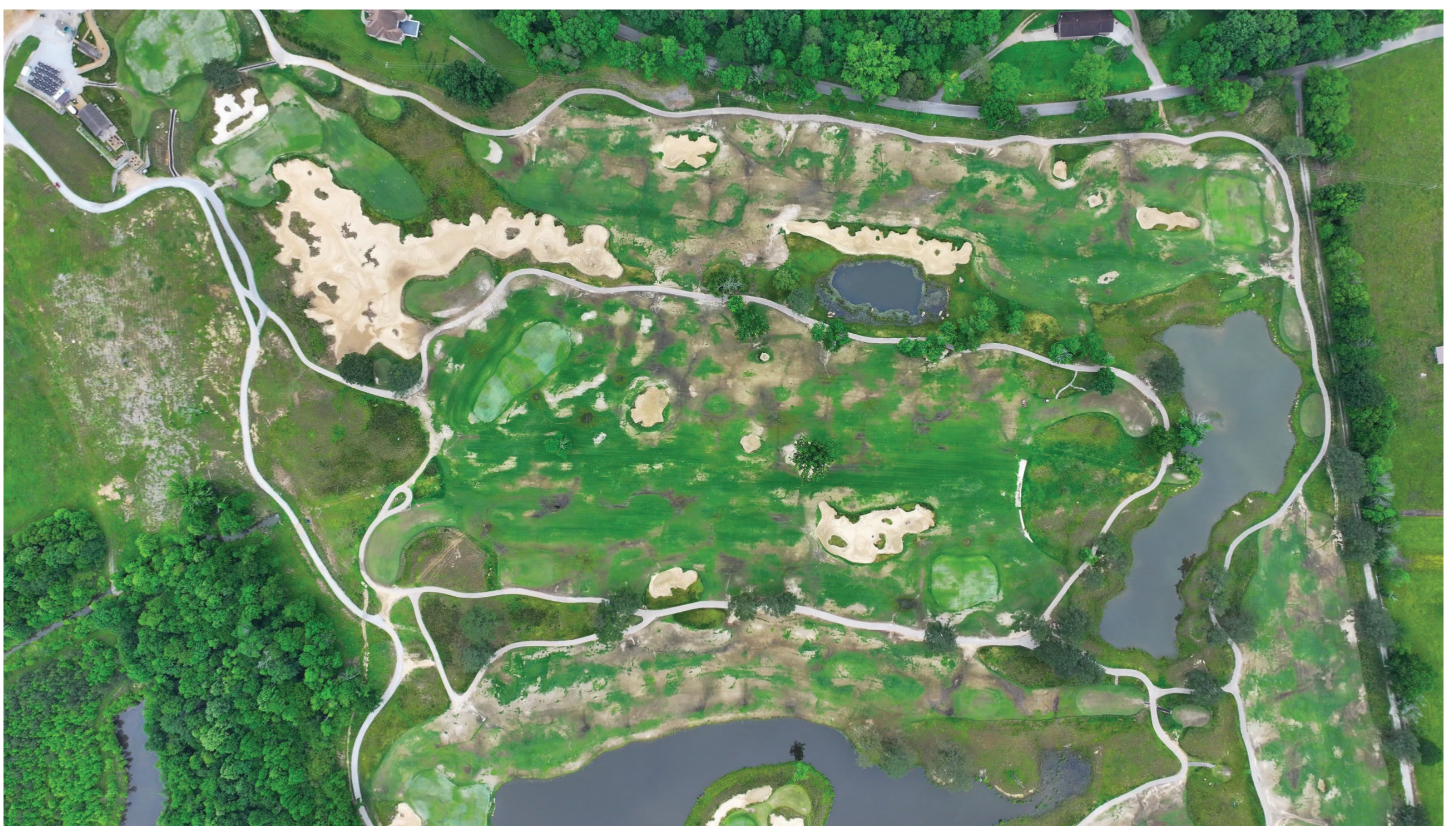
# TIPS FOR SUCCESS

## Measure your current water use and establish a target.

The first step in successful water conservation on a golf course is to accurately measure current water use to establish a baseline. Once this is done, set a target for water reduction. If turf conversion is part of your water conservation plan, this baseline information will help you choose a species or cultivar that helps meet your goals. It is important to have realistic expectations and to recognize that water savings will not be at their full potential in the early years of establishing new grasses.

## Recognize that warm-season grasses have limitations.

Converting from cool-season to warm-season grasses offers enticing water savings, but it is important to recognize that even improved warm-season grasses have limitations. Before transitioning to a warm-season grass, assess the environmental challenges in your region, especially the risk of extremely cold temperatures. Additionally, consider golfer expectations for playability and aesthetics throughout the year, particularly in regions with colder winters where warm-season grasses may go dormant for several months. Balancing these factors will help ensure that the chosen grasses provide a high-quality playing surface while meeting water conservation goals.



While the functional range for using warm-season grasses is shifting into cooler climates, all it takes is a few days of extreme cold to create lasting damage like we see on this golf course in Tennessee. The benefits and limitations of any grassing option must be carefully weighed.

## Use unbiased data when selecting grasses.

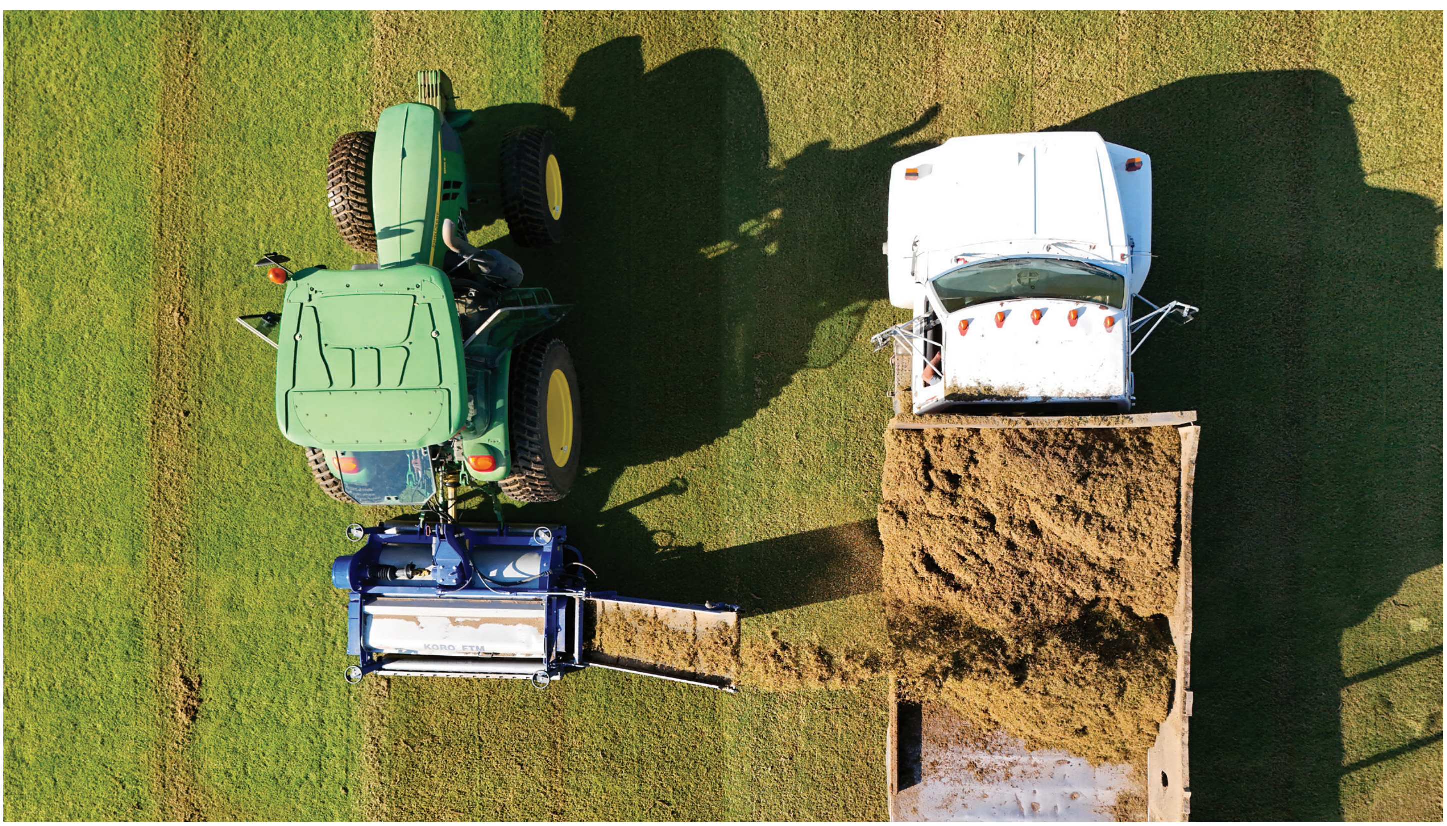
Selecting the right grass for your course should be based on reliable and unbiased data. Use resources from NTEP, TWCA and A-LIST, as well as university research, to compare the performance of different grass species and cultivars in your climate. These trials provide objective data on drought resistance, water-use efficiency and overall turfgrass quality, helping you make informed decisions that align with both environmental sustainability and golfer needs.

## Establish test areas at your course.

Establishing small-scale test areas in challenging parts of the course, such as high-traffic zones or areas prone to drought stress, allows you to test the performance of different turfgrass species. Manage these plots according to best practices and observe their performance over two to three years. During this period, gather feedback from stakeholders, including course staff and golfers, to assess playability and overall satisfaction with the grassing options.

## There are pros and cons to every regrassing method.

It can be difficult to decide between sodding for immediate cover or seeding/sprigging, which both require longer times for establishment but cost less in materials and installation. There are agronomic benefits to seeding or sprigging, but those can be outweighed by timing considerations. Whatever grassing method you choose, try to allow more than enough time to eliminate the existing grasses, prepare the soil and establish the new turf. Too many



Visit the production fields that you are considering purchasing seed, sod or sprigs from. This is an opportunity to make sure everything meets your standards before issues like weeds or pests arrive at your course.

courses struggle with turf conversions simply because they did not allow enough time to do the job properly with the many unpredictable variables involved.

### Do your homework when sourcing plant material.

Once you've chosen the appropriate turfgrass cultivar based on regional suitability and performance data, work with a reputable sod, seed or sprig producer. Visit the production fields to inspect the quality of the turf and ensure that it meets your specifications before purchase. Quality checks are essential to avoid introducing any pests, diseases or weeds that could affect the health or playing conditions of your new turf. Courses establishing bermudagrass will want to be on the lookout for "off-types" that may be present in the fields and could be introduced onto your course. Dealing with undesirable grasses or weeds can be very challenging after establishment

### Soil testing before planting will help you create the best possible growing environment.

Prior to planting, conduct soil tests to identify nutrient deficiencies, pH imbalances or issues with soil texture. These tests guide decisions on soil amendments such as adding sand, fertilizers or organic matter to create an optimal growing environment for the new grass. Regrassing projects are inherently disruptive and require some time where the course is closed. While this has many negative aspects, one benefit of this disruption is that it provides an opportunity to make soil improvements that are difficult or impossible while the course is open.

### Be patient and adjust management practices to realize benefits.

After planting, allow sufficient time for the turf to become fully established before subjecting it to regular play. Once the grass is established, management practices – particularly irrigation – must be reviewed and adjusted to reflect the needs of the new turf. This might involve reducing water input, adjusting mowing heights and applying fertilizers appropriately to promote deep rooting and sustained health. Patience during this period is critical for long-term success. The peak playing conditions and full water conservation potential of a new grass will not be realized likely for several years after planting. While this may not be what golfers and decision-makers want to hear, it is the reality of a long-term investment in a better and more-sustainable turfgrass.

## BMP CASE STUDIES

### Birnam Wood Golf Club, Santa Barbara, California

Birnam Wood Golf Club historically maintained a mixed stand of cool-season turfgrasses, sometimes called the "California turf surprise." This turf composition produces acceptable playing conditions but never delivers a premier golf experience, and the water demand is higher than it would be for warm-season turf. Historically, Birnam Wood budgeted for about 185 acre-feet of water use annually (approximately 60 million gallons), costing nearly $200,000 per year.

The golf course's leadership recognized an opportunity to improve the consistency of playing conditions and reduce resource inputs, most notably irrigation water, by converting the cool-season turf to bermudagrass. In 2015 and 2016, the golf course converted 31 acres of fairway to 'Santa Ana' bermudagrass and the roughs to 'Tifway 419' bermudagrass. In addition, they replaced 7.2 acres of irrigated turf with low-water-use landscaping.

After the renovation, the golf course water budget is about 135 acre-feet annually, a 25% reduction in annual water inputs. The course's water cost per unit has increased by over 500% in the past decade, and water costs today are nearly $11.00 per hundred cubic feet. The 25% water reduction saves the facility over $100,000 annually at current prices. The conversion has also saved approximately $100,000 annually in fertilizer, seed and pesticides. The cost of the project, which included minimal soil preparation and sodded bermudagrass, was about $1.25 million. Within seven years, the project paid for itself.

## Menlo Country Club, Redwood City, California

Menlo Country Club in the San Francisco Bay Area converted the fairway on their sixth hole from perennial ryegrass to 'Santa Ana' bermudagrass in 2018 to see whether water savings and improved playability would justify converting all the fairways. Golf course superintendent Chris Eckstrom documented significant water savings on this fairway – noting that 25% savings over cool-season grasses is very realistic. Based on this success, in 2021, the golf course converted the remaining 33 acres of perennial ryegrass fairways to 'Santa Ana' bermudagrass and replaced 2.4 acres of turf with naturalized grasses.

The golf course realized a 20% water savings during the first year alone, while the fairway turf was still immature. Future water savings should be even more significant. With a water budget of nearly $1 million annually and water costs increasing 5% to 8% yearly, the $2.6 million project – including Blecavating the soil in fairways and sodding the bermudagrass – will pay for itself in less than eight years. Menlo Country Club realized additional economic savings by reducing the use of pesticides, and golfers are pleased with the improved quality and consistency of the new bermudagrass fairways.

USGA Green Section Podcast: Chris Eckstrom on Regrassing Cool-Season Fairways With Hybrid Bermudagrass

## "Using Turf Colorants Instead of Overseeding"

*USGA Green Section Record,* 2017.

Maintaining a resort golf course in the transition zone can be challenging. At Brunswick Plantation and Golf Resort in Calabash, North Carolina, one of the major challenges was managing the transitions into and out of winter overseeding. The overseeding process restricted golf carts to paths and impaired playing conditions for a month each fall. In spring, competition between bermudagrass and ryegrass caused further playability issues. The result was very poor fairway playing quality during some of the best golfing weather. By converting from overseeding to using colorants the course was able to reduce water use by 30%, maintain the desired green color, and eliminate the diminished playing conditions during the fall planting and spring transition.

## REFERENCES

Allen, R.G., Pereira, L.S., Raes, D., & Smith, M. (1998). FAO Irrigation and drainage paper No. 56. *Rome: Food and Agriculture Organization of the United Nations,* 56(97), e156.

Amgain, N.R., Harris, D.K., Thapa, S.B., Martin, D.L., Wu, Y., & Moss, J.Q. (2018). Evapotranspiration rates of turf bermudagrasses under nonlimiting soil moisture conditions in Oklahoma. *Crop Science,* 58(3), 1409-1415. https://doi.org/10.2135/cropsci2017.08.0493

Balogh, J.C., & Walker, W.J. (1992). *Golf course management & construction: Environmental issues.* CRC Press.

Beard, J.B. (2002). Environmental protection and beneficial contributions of golf course turfs. In *Science and Golf II* (pp. 478-488). Taylor & Francis.

Beard, J.B., & Kenna, M.P. (2008). Water quality and quantity issues for turfgrasses in urban landscapes. In *Workshop on water quality and quantity issues for turfgrasses in urban landscapes (2006: Las Vegas, Nevada).* Council for Agricultural Science and Technology.

Braun, R.C., Bremer, D.J., Ebdon, J.S., Fry, J.D., & Patton, A.J. (2022a). Review of cool-season turfgrass water use and requirements: I. Evapotranspiration and responses to deficit irrigation. *Crop Science,* 62(5), 1661-1684. https://doi.org/10.1002/csc2.20791

Braun, R.C., Bremer, D.J., Ebdon, J.S., Fry, J.D., & Patton, A.J. (2022b). Review of cool-season turfgrass water use and requirements: II. Responses to drought stress. *Crop Science,* 62(5), 1685-1701. https://doi.org/10.1002/csc2.20790

Colmer, T.D., & Barton, L. (2017). A review of warm-season turfgrass evapotranspiration, responses to deficit irrigation, and drought resistance. *Crop science*, 57(S1), S-98.

Fry, J., & Huang, B. (2004). Applied turfgrass science and physiology. John Wiley & Sons, Inc.

Harivandi, A.M., Butler, J.D., & Wu, L. (1992). Salinity and turfgrass culture. *Turfgrass,* 32, 207-229.

Jacobs, P., & Gross, P. (2019). Fairway regrassing – Can you afford not to? *USGA Green Section Record,* 57(17).

Ketchum, C., Miller, G., & Pinnix, G. (2023). Stress coefficients for hybrid bermudagrass in the transition zone. *Crop, Forage & Turfgrass Management,* 9, e20212. https://doi.org/10.1002/cft2.20212

Minor, J., Campbell, B., Waltz, C., & Berning, J. (2020). Water savings and return on investment of a new drought resistant turfgrass. *Journal of Environmental Horticulture,* 38(2), 56-62. https://doi.org/10.24266/0738-2898-38.2.56

National Turfgrass Evaluation Program. (2020). *2016 National Cool-Season Water Use/Drought Tolerance Test.* NTEP 2020 data. https://ntep.org/data/cs16w/cs16w_21-8/cs16w_21-8.pdf

National Turfgrass Evaluation Program. (2022). *2018 National Warm-Season Water Use/Drought Tolerance Test*. NTEP 2022 data. https://ntep.org/data/ws18w/ws18w_23-8/ws18w_23-8.pdf

Serena, M., Morris, K., & Petrovsky, J. (2023). Measuring and comparing the water requirements of warm-season grasses. *USGA Green Section Record,* 61(15).

Shaddox, T.W., Unruh, J.B., Johnson, M.E., Brown, C.D., & Stacey, G. (2023). *Turfgrass use on US golf courses. HortTechnology,* 33(4), 367-376. https://doi.org/10.21273/HORTTECH05238-23

Whitlark, B. (2022). Converting to bermudagrass fairways. *USGA Green Section Record,* 60(14).

Whitlark, B., Umeda, K., Leinauer, B.R., & Serena, M. (2023). Considerations with water for turfgrass in arid environments. In M. Fidanza (Ed.), *Achieving Sustainable Turfgrass Management.* Burleigh Dodds Science Publishing. http://dx.doi.org/10.19103/AS.2022.0110.21