Light, water, air, mineral nutrients, soil, and temperature are six essential requirements to grow grass. On the golf course, we can manipulate and manage five of these requirements to varying degrees. For example, irrigation systems supplement the lack of natural rainfall and fertilizer applications help maintain optimal levels of soil nutrients. Putting greens and tees can be constructed with sand-based root-zones to enhance drainage and compaction resistance. Various cultivation techniques can be utilized to ensure oxygen reaches the roots. Even temperature can be indirectly managed by using turf covers to warm the soil or oscillating fans to cool overheated turf. Some courses have even invested in subsurface heating and cooling systems to modify the soil temperature of their greens.

Unfortunately, golf course managers have little opportunity to increase natural sunlight. There are only so many hours of daylight, which varies considerably throughout the year, and you can’t wish clouds away. Installing a bank of high-intensity lamps over every shaded putting green simply isn’t feasible for courses. Ultimately, weather and the time of the year determine how much sunlight can possibly reach the turf. To complicate matters, nearly all golf courses have significant amounts of turf affected by tree shade that limits the amount of light energy that reaches the grass.

**SUNLIGHT — THE KEY TO LIFE FOR GREEN PLANTS**

Cool- and warm-season grasses require the energy provided by sunlight to convert water and carbon dioxide into carbohydrates and oxygen. This
process is called photosynthesis. Warm-season grasses have the ability to manufacture carbohydrates at higher temperatures than cool-season grasses, but the basic process and requirements for light, water, and carbon dioxide are similar.

Carbohydrates — i.e., sugars — are the food plants use to grow. The minerals in fertilizer provide essential building blocks required during photosynthesis to produce carbohydrates. Despite creative marketing calling many fertilizers “plant foods,” these products do not directly supply the energy plants need to grow. Granted, a lack of essential minerals in the soil can limit turf growth. However, liquid sunshine doesn’t exist, and fertilizer is never a substitute for adequate light if you desire healthy turf.

NEVER MADE IN THE SHADE
The detrimental effects of shade on turfgrass growth and development are well documented and obvious to any turf manager. Go no farther than your backyard to find weak, spindly grass in the shade of an oak or maple tree. Place the children’s swing set beneath the trees and you’ll be lucky to find more than a few patches of scraggly turf because heavily shaded grass cannot recover from wear.

Except for roughs, golf course turf is mowed much shorter than a home lawn, which magnifies problems associated with limited growth potential in shade. Turf growth of short grass is limited in the shade because shorter turf has minimal leaf area to intercept sunlight in the first place, which is why divots are so slow to recover on a heavily shaded tee. It should come as no surprise that putting greens suffer the most from shade since they possess little more than a thin veneer of leaf tissue mowed once or more each day at, or below, 0.125-inch.

Turf health and playability go hand in hand because superintendents manipulate the turf to provide a desired playing surface. Golfers then play on that surface, causing wear that everyone hopes will recover quickly; except sometimes turf doesn’t recover quickly. Obviously, the inability to rapidly recover from wear would affect the

Evergreens near putting greens are especially troublesome because they cast shade all year and increase the risk of winterkill by encouraging ice accumulation.

Buildings can cause considerable stress to nearby putting greens due to dense shade or reflected heat depending on sun location throughout the day.

Putting greens located in deep hollows receive shade from the topography and from the surrounding trees that are elevated above the putting surface.
popular, heavily played golf facilities
the most, but all courses are affected
by wear issues and the loss of turf
cover from time to time. Heavy play,
disease activity, excessive heat,
mechanical wear, and the stress
associated with too much or too little
water are factors that necessitate rapid
turf recovery — but rapid turf recovery
is impossible in the shade.

As mentioned above, putting greens
are particularly sensitive to shade and
they are, by far, the most important
playing surface on a golf course. The
following are examples of putting
green issues directly or indirectly
caus ed by tree shade:

● Winter injury caused by ice cover or
  low temperatures affects the weak
turf on shaded putting greens the
most. These greens also tend to
accumulate more ice and snow than
greens in sunny sites, and the ice
cover lasts longer during the transition
from winter to spring. Evergreen
trees cause the most winter injury
problems because they produce
dense shade all year.

● Shaded greens will experience the
  longest frost delays.

● Shaded turf that is weak entering
  winter has little chance to make
  and store the carbohydrates needed
  for rapid spring greenup. Any winter
  injury will also be extra slow to
  recover due to carbohydrate deple-
tion. Spring growth and winter injury
  recovery are also limited by low soil
  temperatures that persist longer in
  shaded sites.

● Diseases, such as dollar spot, that
  require long periods of leaf wetness
  are more prevalent in shaded sites
  since dew remains on the turf longer.

● Most greens that have severe tree
  shade issues will also have problems
  associated with poor air circulation
  and tree roots competing with turf for
  water and nutrients. The lack of air
  circulation can be especially detri-
  mental to turf health during extended
  periods of hot, humid weather.

● A thin, shaded putting surface will
  have a greater chance of developing
  moss encroachment problems than
dense turf in full sun.

● Recovery from cultural practices that
  thin out the stand of turf — such as
  aeration and deep vertical mowing —
  occurs more slowly on shaded turf
  than turf in full sun.

MINIMUM LIGHT REQUIREMENTS
Turf quality declines under shaded
conditions. Sometimes buildings
cause shade — for example, when the
practice putting green is conveniently
located immediately adjacent to the
clubhouse or golf shop. Sometimes
topography affects sunlight availability,
such as when a putting green is
located in a deep hollow. However,
trees are by far the most common
cause of shade problems on a golf
course, particularly when we are
talking about the closely mowed turf on
tees and putting greens. Increasing the
light reaching key playing surfaces
through selective tree removal can
pay huge dividends in turf health and
playing quality throughout the season.

In the past, agronomists and
superintendents had to make vague
estimates about the amount of sunlight needed to grow healthy putting green turf. For example, we assumed creeping bentgrass greens needed at least six hours of direct sunlight per day for healthy growth, but not all six-hour intervals of sunlight are equal. The amount of useful light energy, referred to as photosynthetically active radiation (PAR), that reaches the turf during six hours of full sunlight varies throughout the year based on the time of day and angle of the sun.

The amount of PAR that shines on a specific area of turf over a 24-hour period is called the daily light integral (DLI) and is expressed as moles of PAR per square meter per day. A study at Clemson University (Bunnell, 2005) determined that TifEagle bermudagrass maintained under putting green conditions needs a minimum DLI of 32.6 to provide acceptable turf quality.

Research at the University of Arkansas (Russell, 2019) determined that Tyee creeping bentgrass maintained under putting green conditions required a DLI of 30 to maintain acceptable quality throughout the season. Figure 1 provides useful information regarding the relative shade tolerance of various turfgrass species and DLI information.

Armed with these baselines and the relatively inexpensive equipment needed to measure DLI on a golf course, turf managers can clearly identify and quantify the potential for putting green shade problems. The USGA article “Made in the Shade or Mud in the Shade?” explains DLI in more detail, provides a practical method to measure shade, and explains how data can be utilized to make sound, fact-based tree management decisions.

**QUANTIFY, IDENTIFY, AND ACT**

Decision-makers are often reluctant to remove the “shady characters” from golf courses even when turf decline caused by insufficient sunlight is clearly evident. Documenting a shade problem with DLI data is a great start, but identifying which trees cause the most shade is also a key aspect of obtaining approval to harvest trees. Consider these options to support a case for removing trees that cause shade problems:

- Commercial companies, such as ArborCom Technologies, use proprietary computer modeling software that can determine what trees cause shade to a specific site and how shade problems will increase over time. A shade study can predict the impact of removing individual trees. The ability to predict the benefits of removing specific trees can mitigate concern about tree removal because only the trees that cause the most shade will be harvested.

- Inexpensive apps for smartphones and tablets, such as Sun Seeker® and Sun Surveyor, use the device’s camera to show the path of the sun from wherever the operator is standing. The software can illustrate which trees cause the most shade and help predict where trees will cause future problems. Also, the app is just as useful on a cloudy day as a sunny day. The date and time of day can be easily changed to demonstrate how shade patterns change throughout the season.

- If a picture is worth a thousand words, then a short video may be worth a million. An entire day’s shade pattern across a putting green can be condensed into a short 10- to 15-second video by using a time-lapse camera that may cost no more than $200. Mount the camera in a tree that provides a vantage point above the putting green and set the unit to start recording at sunrise and end at sunset. Obviously, a day with no cloud cover is ideal. Watching the shade travel across the putting surface throughout the day can make it easy to detect a clear correlation between dense shade and weak, thin turf.

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**Figure 1 — Relative Shade Tolerance of Common Turfgrasses**

In the U.S. from April to September, the DLI (Daily Light Integral) ranges from 25 to 50 mol/m²/day in most states while from October to March, DLI ranges from 5 to 25 mol/m²/day. These reference DLI ranges vary depending on location and season. Within each species, DLI requirements of individual cultivars vary widely.

<table>
<thead>
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<th>Poor</th>
<th>Fair</th>
<th>Good</th>
<th>Excellent</th>
</tr>
</thead>
<tbody>
<tr>
<td>DLI &gt; 30</td>
<td>DLI &gt; 20</td>
<td>DLI &gt; 15</td>
<td>DLI &lt; 15</td>
</tr>
</tbody>
</table>

Key:
- Kentucky bluegrass
- Perennial ryegrass
- Creeping bentgrass
- Common bermudagrass & Hybrid bermudagrass
- Centipedegrass
- Bahiagrass
- Seashore paspalum
- Zoyasia japonica
- St. Augustinegrass
- Zoysia matrella
- Annual bluegrass
- Colonial bentgrass
- Fine fescue & Tall fescue
- Rough bluegrass
- Ultradwarf bermudagrass (putting green types)
- Warm-season grasses
- Cool-season grasses

Adapted from Steir and Gardner, 2006; Turgeon, 2012; and Gardner and Goss, 2013.
Never discount the value of documenting the significant problems trees cause in addition to shade. Removing leaves, seeds, and other tree debris from putting surfaces and greenside bunkers throughout the season is costly, not to mention the annoyance the debris causes to golfers. Are tree roots increasing the risk of localized dry spots? Are trees next to putting greens impeding golfers’ ability to recover from an errant shot? Are trees adjacent to greenside bunkers an unnecessary double-hazard that does little more than slow the pace of play? What about tree-related moss encroachment, dollar spot, and inadequate air circulation during stressful weather? Leave no stone unturned when making your case for tree removal.

HAPPY HARVEST
After approval for tree removal is granted, then what? Don’t overestimate your ability to undertake in-house tree removal. Removing numerous large trees is a job for professionals. Obtain bids from reputable tree service companies that have an ISA-certified arborist on their staff and have experience working on golf courses. Winter is the best time to remove trees at northern golf courses. Frozen ground and deep snow can accommodate heavy equipment with minimal disruption to the playing surfaces. Furthermore, trees are not being removed in view of the golfers.

Helpful harvest hints include:

- Grind the stumps and repair the scars as soon as possible. To some golfers, stumps are the equivalent of tombstones and provide a nagging reminder of the loss. If tree removal is a winter project at a northern course, try to remove stumps before spring play.

- Avoid the temptation to plant replacement trees right after tree removal. Wait at least several years and then reassess playability, appearance, and turf health. More often than not, the harvested trees will never be missed.

- Do you have a large number of high-value trees targeted for removal? Some golf courses place little value...
on the trees they harvest, while others overestimate their worth. Most have no clue how much a given tree could be worth. Some golf courses have been able to offset the cost of removing numerous trees by partnering with local lumber mills that harvest and keep the timber. The pros, cons, and procedure for such an arrangement are worthy of a separate article, but this article from the USDA and U.S. Forest Service can provide valuable insight and advice on the topic: "What is My Timber Worth and How Do I Sell It?"

- Is someone associated with the golf course skilled in woodworking? If so, consider converting some of the harvested timber into tables, bar tops, benches, tee markers, and other wooden objects that can be used in the clubhouse or on the course. This is a great way to enjoy a tree without making the turf suffer.

**SATISFACTION GUARANTEED**

There is some truth in the old adage that turf doesn’t do anything quickly, except die. However, an exception may be how fast weak, shaded turf responds to more sunlight. Turf’s ability to increase density and recover rapidly from stress can be dramatic and occur within a few weeks after removing problem trees when growing conditions are favorable. In an era when everyone craves instant gratification, you’ll be surprised how quickly an aggressive program of removing “shady characters” can inject new life into tired, weak putting greens.

**REFERENCES**


BOB VAVREK is director of the USGA Green Section Central Region.

PATRICK O’BRIEN is an agronomist in the USGA Green Section Southeast Region.

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