USGA
Green Section Record
FEATURED
May 1, 2020

Soil layering begins from the moment turf is planted, making adequate cultivation and sand topdressing critical.

Don't Layer It On

Soil layers are simply differences in soil texture – intentionally or unintentionally created – that slow water flow through the soil profile.

BY ADDISON BARDEN, AGRONOMIST, SOUTHEAST REGION

Manufactured and modified sand-based soil profiles on golf courses have one main objective in common: good soil drainage that yields healthy turf and firm playing conditions. Uniform soils without layering are key to good drainage as they allow the free flow of water via gravity and water cohesion and adhesion to soil. . However, from the moment turf is planted and the first sand topdressing application is made, soil layering begins. In severe cases of soil layering, mitigating the negative impacts can be a daunting task that requires aggressive and disruptive cultivation.

So, what exactly are we talking about when we refer to soil layering? Soil layers are simply differences in soil texture – intentionally or unintentionally created – that slow water flow through the soil profile. Layering can occur at varying depths in the soil, but for the purpose of this article we will focus on soil layering in the upper

©2020 United States Golf Association. All rights reserved. Please see Policies for the Reuse of USGA Green Section Publications.

rootzone portion of a putting green.

Even the smallest layer can create turf health and playability issues. While there are several negative impacts of soil layering, the common cause of these issues is slower infiltration due to the varying adhesion forces of differing soil textures. More often than not, layering results in excess soil moisture at the surface that causes shallow rooting, increased disease incidence and severity, and soft playing conditions.

Water Flow Dynamics

In order to understand how soil layering negatively impacts turf health and how to address layering issues, we must understand how water moves through soils. The primary forces influencing water movement in the soil are gravity and water cohesion and adhesion.

The role played by gravity is fairly straightforward – it's the force that drives water flow downward. However, adhesion and cohesion are more complex. Soil moisture overcomes the force of gravity and can move laterally and vertically due to cohesion and adhesion. Water cohesion is the property that attracts water molecules to one another, and adhesion is its attraction to other surfaces, such as soil particles and organic matter (Gardner, 1988).

Soil particles with greater surface area have greater adhesion forces than soils with less surface area. The three soil texture classes are sand, silt and clay – which are the largest to smallest particles, respectively. Clay particles, being the smallest, have the greatest surface area in a given volume of soil and the greatest adhesion force. Sand particles are the largest and have the least surface area in a given volume of soil, which gives them the lowest adhesion strength. This is why sands drain well and are the most desirable soil for golf courses.

Organic matter also plays a significant role in water flow as it directly and indirectly holds soil moisture. In some cases, such as when a soil is at field capacity, organic matter has a higher water-holding capacity than mineral soils of a similar volume (USDA NRCS, 2008). Organic matter's ability to hold water depends on the exact source but it is high relative to sand (Bigelow, et al., 2000).

More uniform soils allow water to flow more freely. Obviously, the rate of flow is highest in sand and slows in silt and clay, but the absence of soil layers maximizes flow for a given soil type. When soil layers are present, water flow is slowed due to the differing adhesion forces of varying soil textures. It isn't until enough pressure builds above a change in texture – or water cohesion forces exceed adhesion forces – that soil water can flow through the layer. This principle is utilized to create the perched water table in USGA putting greens. However, when soil layers occur in the upper rootzone, agronomic and playability problems occur.

The dynamics of water flow in a variety of soils is described and displayed in great detail in the video "Water Movement in Soils" by the late Dr. Walter Gardner from Washington State University.

©2020 United States Golf Association. All rights reserved. Please see Policies for the Reuse of USGA Green Section Publications.

Well-blended putting green soil profiles – USGA (left) and amended push-up (right) – promote healthy root systems and good playing conditions by allowing water to move freely.

Impact On Turf Health And Playing Conditions

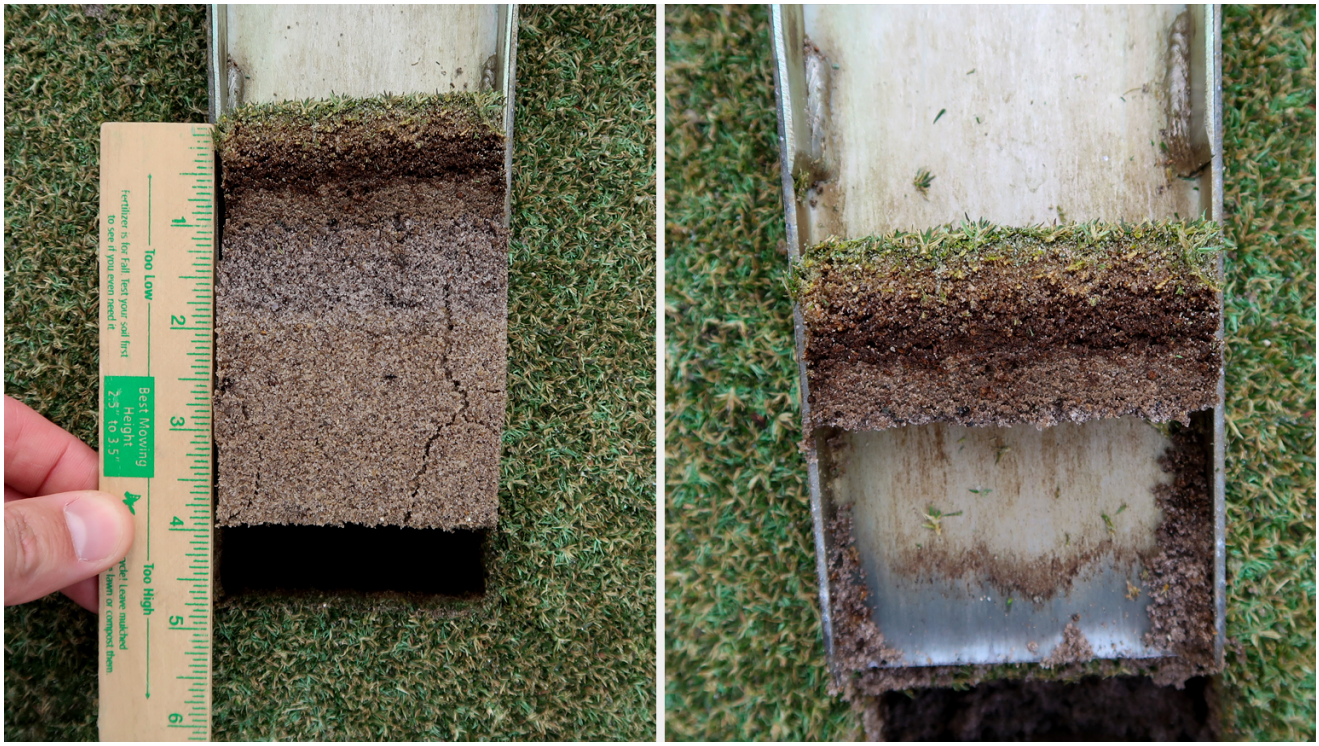
A healthy root system is the foundation for good playing surfaces. Without it, playing conditions suffer and inputs required to maintain healthy turf increase. The major concern with soil layering is that decreased drainage leads to abiotic and biotic stresses in the rootzone and a variety of playability problems. The following are common issues related to soil layering:

- Soft putting surfaces prone to ball marks
- Reduced traffic tolerance due to saturated soils
- Increased soil compaction due to saturated soils
- Poor rooting and plants that are less drought tolerant
- Increased disease incidence and severity due to saturated soil conditions
- Poor infiltration leading to greater likelihood and susceptibility to salt toxicity
- Greater lateral surface movement of plant protectants due to saturated soils, which can lower efficacy of products requiring root uptake

For information on the USGA's Course Consulting Service Contact the Green Section Staff.

Learn More

©2020 United States Golf Association. All rights reserved. Please see Policies for the Reuse of USGA Green Section Publications.



As seen in this soil profile, layers of differing soil texture impede water movement through the soil, resulting in a shallow root system.

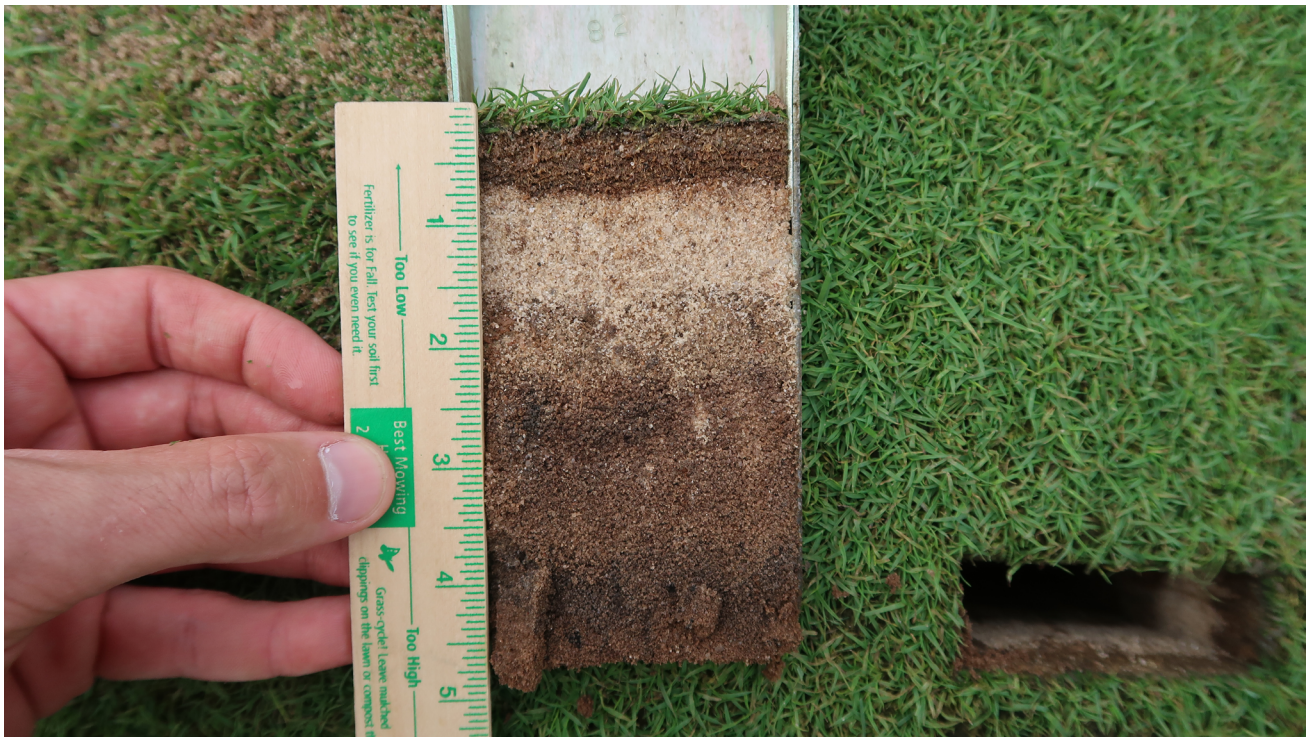
Formation Of Soil Layers

Soil layering occurs the moment turf is planted on any soil surface because of the organic matter production that comes with turf growth. This is why adequate sand topdressing and cultivation is so important. However, the most difficult layering issues to resolve occur when differing soil textures are introduced into the soil profile.

A common form of soil layering occurs when infrequent, heavy sand topdressing applications are made to any turf surface. Infrequent sand topdressing applications are usually made because of labor shortages, a desire to reduce impact on playing conditions, and reduce cost. The layering pattern that often arises under this management program resembles the growth rings on a tree. You will see layers of organic matter that accumulate between topdressings followed by layers of heavy sand topdressing that come from applications usually made during a cultivation event. The lack of light-and-frequent sand topdressing applications, or excessive turf growth between applications, results in layering.

Infrequent, heavy sand topdressing applications result in soil layering when organic matter is repeatedly buried by sand instead of diluted.

©2020 United States Golf Association. All rights reserved. Please see Policies for the Reuse of USGA Green Section Publications.



Sand mixes are often used as fill during putting green repairs or renovations. When the sand does not match the underlying soil – or the soil the sod was grown on – layers are created.

Another common layering issue occurs when sodding a turf surface. The soil texture of sod grown at other locations rarely matches the soil at the golf course it is planted on. The differences in soil texture from the sod farm to the golf course result in an immediate soil layer formation.

Similar to the introduced layers that come from sodding, layers can be created when soil is added as fill to level a surface prior to planting. Even if the fill matches the existing soil, the newly added material doesn't contain the accumulated organic matter that the existing surface soil contains. Burying a surface layer under added material can create issues deep within the soil profile that are difficult to resolve.

Flooding can also create significant layering issues within a soil profile by depositing sediment onto a putting green. This silt layer will impede drainage through the soil profile. If the flooding occurs regularly, there will likely be multiple layers of silt from each flooding event. These situations can be difficult to prevent because sediment is inherently hard to remove from the turf after a flood without doing more damage to the surface. The water and equipment needed to remove sediment from putting greens can also be unavailable after major storms.

The best cure for soil layering is preventing it from happening by using careful construction methods and a maintenance program that includes adequate cultivation and light-and-frequent sand topdressing.

©2020 United States Golf Association. All rights reserved. Please see Policies for the Reuse of USGA Green Section Publications.

Solving The Problem

The best cure for soil layering is preventing it from happening by using careful construction methods and a maintenance program that includes adequate cultivation and light-and-frequent sand topdressing. Core aeration can be used to remove material and incorporate sand into the rootzone to maintain acceptable levels of organic matter. Some superintendents are able to maintain appropriate organic matter levels – free of layers – with solid-tine aeration and sand topdressing, but these situations are mostly confined to turf species that do not produce much thatch, such as Poa annua. Regardless of the cultivation program needed at your course, light-and-frequent sand topdressing applications are critical to prevent layering in the rootzone.

There are many topdressing sand mixes used today. A two-sand system is being utilized by many superintendents for light-and-frequent topdressings to dilute accumulating organic matter while maintaining acceptable infiltration rates and playing conditions. Those addressing layering issues in sand-based greens with cultivation and sand backfilling should use the same sand for backfilling as was used in the putting green construction – without organic matter – to enhance drainage. For those with amended native soil putting greens, a sand that falls within the range detailed in the USGA Recommendations For Putting Green Construction should be used.

Unfortunately, if soil layering already exists one cannot topdress their way out of the issue.

Unfortunately, if soil layering already exists one cannot topdress their way out of the issue. Topdressing will only bury the layer and make it more difficult to resolve with cultivation. Cultivation is needed to address existing layering and, in most cases, cultivation that includes removing material will be needed. Ultimately, the right cultivation program to remediate the issue depends on the depth and severity of soil layering.

Vertical mowing is a great practice for removing considerable material from the upper 0.75 inch of the soil profile. Vertical mowing is a relatively aggressive cultivation practice but one that is worthwhile for the amount of material removed. Applying sand topdressing after vertical mowing always helps to smooth the surface and speed recovery. In situations where layering is confined to a depth reachable by vertical mowing equipment, sand injection may not be needed but is helpful.

Hollow- or solid-tine aeration are the most common cultivation methods to remediate soil layering in the upper 3 inches of the soil profile. Hollow-tine aeration is often required to address layers because unwanted material must be removed and replaced with sand. Large-diameter solid tines – i.e., larger than 0.375 inch – can be used in conjunction with sand topdressing to increase gas exchange and water infiltration, but

©2020 United States Golf Association. All rights reserved. Please see Policies for the Reuse of USGA Green Section Publications.

this cultivation practice may not fully address layering. Using small-diameter solid tines during venting or spiking helps improve gas exchange and infiltration between cultivation events but doesn't replace more aggressive cultivation techniques. A good resource for information about traditional aeration practices is the USGA article "Managing Organic Matter in Putting Greens."

When a layer is shallow, core aeration and sand topdressing can be used to create sand channels to the original rootzone mix. However, a channel of sand with no connection to the surface causes more issues than benefits.

When soil layering is located more than 3 inches below the surface, or the depth that can be reached with traditional aeration equipment, deep-tine aeration equipment or services will be needed. Deep-tine core aeration is a labor-intensive and aggressive practice – especially on greens with shallow, weak roots – but this may be necessary to break up and remove deeper layers that are negatively impacting turf health. Testing intact soil samples can indicate whether deep-tine aeration should be performed with hollow or solid tines. Other cultivation equipment, such as sand injection machines, can incorporate sand deep within the profile to improve infiltration. However, if soil layers need to be removed, sand injection equipment should be used sparingly because this practice will not remove layers.

Creating continuous channels of sand from the surface into the soil is important to maximize infiltration. Channels that are disconnected from the surface will not improve drainage, but actually hinder water movement through the profile (Gardner, 1988). Therefore, if there are deep layers in the soil and hollow-

©2020 United States Golf Association. All rights reserved. Please see Policies for the Reuse of USGA Green Section Publications.

A continuous column of sand is important to allow water to flow freely past layers.

tine aeration and filling the channel with sand is not an option, reconstruction may be needed. Extensive soil testing should be performed before deciding to rebuild greens given the significant investment and disruption to play.

Communicating The Importance Of Preventative Maintenance

It is probably safe to assume that, if given the opportunity, many superintendents would sand topdress more than they currently do. Additionally, those with soil layering issues would like to implement a more aggressive cultivation program to remediate the problem. However, the reality is that resources and golf schedules place limits on these practices.

Regular soil testing to determine infiltration rates, organic matter concentrations at various depths, water holding capacity, particle size distribution and other key factors is a great way to understand and demonstrate how putting greens mature over time. The results from these tests can be used as an objective way to show decision-makers and stakeholders whether existing programs are maintaining acceptable conditions or if changes are needed.

It's best to submit intact soil cores for testing to track key performance metrics. Tracking how greens mature will enable you to proactively address issues before they become too severe. Furthermore, test results can be used to communicate cultivation or sand topdressing needs to golfers at your facility. In order to obtain a good representation of all putting greens at your course, submit at least three cores from a good, average and poorly performing putting green each year for testing. Also, make sure to submit cores before problems arise so baseline data is established. There are a number of accredited labs across the country that offer testing services, make sure to use the same lab for all testing to ensure valid comparisons. A USGA agronomist can help you interpret test results and develop a plan to prevent or address layering in your putting green soils.

Addison Barden is an agronomist in the Southeast Region.

©2020 United States Golf Association. All rights reserved. Please see Policies for the Reuse of USGA Green Section Publications.

Citations

Bigelow, C.A., D. Bowman, and K. Cassel. 2000. Sand-based rootzone modification with inorganic soil amendments and sphagnum peat moss. USGA Green Section Record. July/August. 38(4): 7-13.

Gardner, W.H. 1988. Water movement in soils. USGA Green Section Record. March/April. 26(2): 23-27.

Gardner, W.H. 1959. Water movement in soils. YouTube.com.

Moeller, A. and T. Lowe. 2016. Managing organic matter in putting greens. USGA Green Section Record. November 4. 54(21): 1-7.

USDA, NRCS. 2008. Soil quality indicators. NRCS.USDA.gov.

©2020 United States Golf Association. All rights reserved. Please see Policies for the Reuse of USGA Green Section Publications.