STMA's Guide to International Soccer Pitch Maintenance

Developed November 2012 by the STMA International Committee

Sports Turf Managers Association (STMA) is the not-for-profit, professional association for the men and women who manage sports fields worldwide. Since 1981, the association and its local chapters have been providing education, information, and sharing practical knowledge in the art and science of sports field management. Its more than 2,600 members oversee sports fields and facilities at schools, colleges and universities, parks and recreational facilities, and professional sports stadiums. The mission of STMA is to be the recognized leader in strengthening the sports turf industry and enhancing members' competence and acknowledgement of their professionalism. For more information, log on to www.STMA.org.

STMA has created this manual to provide guidance for achieving a healthy and safe soccer pitch through use of key cultural practices. Whether you are just starting out as a sports turf manager or have been managing soccer pitches for years, the following information can assist in improving your soccer pitch to reach the standards required to satisfy user needs.

Turfgrass growth and health is influenced by the atmosphere above and immediately surrounding the turfgrass aerial shoots, the soil environment, cultural practices, pest organisms, and humans. The atmospheric conditions affecting turfgrass plants result from seasonal and daily fluctuations in the weather, which includes temperature, moisture, light, and wind. The amount of light received by turfgrasses is influenced by many factors in the environment such as clouds, buildings, and trees. Low light intensities can cause thinner, longer leaves, reduced density and tillering, shallow rooting, and lower food reserves within the plants. Shaded turf exhibits poor germination and growth, poor recuperative potential, and is less tolerant of wear, disease, and environmental stress. Maximize the amount of light turfgrasses on the pitch receive by pruning trees, installing artificial lighting, or changing pitch orientation. Turfgrass species have adapted to various atmospheric environments based on climate and weather conditions. Each pitch is unique and the atmospheric environment should be considered when selecting a turfgrass species and to optimize maintenance practices.

The soil environment also influences turfgrass growth and health. Soil texture, structure, moisture, aeration, temperature, and chemistry are some of the elements to be considered when managing a soccer pitch. While the soil environment is not discussed at length in this bulletin, consult the STMA website (www.stma.org) for more information regarding turfgrass rootzones.

Cultural practices, pest organisms, and humans make up the biotic environment that influences turfgrass growth and health. The biotic environment consists of the use and culture of turf by humans. This bulletin is directed at

mitigating the effects of pest organisms and human impacts through the use of cultural practices. The cultural practices discussed include mowing, fertilization, irrigation, aeration, overseeding, pest management, and use of plant growth regulators. In addition, recommendations for goal mouth renovation are provided to help successfully manage these high wear areas.

Mowing

Mowing is important in turfgrass management because it maintains uniform top growth within specified limits, helps control undesirable vegetation that is intolerant to mowing, encourages dense turfgrass growth, and provides a high presentational value.

In order to maintain healthy turf, it is important to mow at the correct height and frequency with the correct type of mowing equipment. Each turfgrass species has a mowing tolerance range, which indicates the lowest and highest heights tolerated by a species. Mowing outside of the tolerance range can put stress on the plant and lead to weak turf that does not reach the required or desired standard to form a satisfactory playing surface. Mowing a turfgrass species below the tolerated mowing height can result in thinning, invasion of weeds and undesirable grass species, and scalping. Scalping is the excessive removal of green shoot tissue resulting in the exposure of unsightly shoot stubble or bare earth. Mowing a turfgrass species above the tolerated mowing height can result in puffy, limp, or decumbent turf.

Recommended Mowing Heights

(taken from Sports Fields: A Manual for Design, Construction, and Maintenance, by Jim Puhalla, Jeff Krans, and Mike Goatley)

Cool Season Turfgrasses

Type of Grass	*Lowest to Highest Heights Tolerated*
Kentucky bluegrass (*Poa pratensis*)	38 mm – 76 mm 1.5 in – 3 in
Perennial ryegrass (*Lolium perenne*)	13 mm - 38 mm 0.5 in – 1.5 in
Tall fescue (*Festuca arundinacea*)	38 mm – 76 mm 1.5 in – 3 in
Creeping bentgrass (*Agrostis palustris, A. stolonifera*)	3 mm - 6 mm 0.1 in – 0.25 in

Warm Season Turfgrasses

Type of Grass	*Lowest to Highest Heights Tolerated*
Bermudagrass (*Cynodon dactylon*)	13mm – 51 mm 0.5 in – 2 in
Zoysiagrass (*Zoysia japonica*)	13 mm - 38 mm 0.5 in – 1.5 in

Note: The mowing heights provided are recommendations within turfgrass tolerance ranges. On highly maintained soccer pitches, the ball is expected to roll fast over the turfgrass surface. Higher mowing heights impede ball roll and slow ball speed. Therefore, turfgrass managers will maintain the pitch at a lower mowing height (23-28 mm or 1 in) to achieve a fast ball roll. Ball speed may not be an issue on lower maintenance soccer pitches. Be sure to

determine user needs when selecting turfgrass species for soccer pitches. Match the most appropriate turfgrass to your climate, as well as user and maintenance needs.

Jerad Minnick

Mowing frequency is the number of mowings per unit of time. Mowing frequency depends on turfgrass growth and type, level of maintenance, climatic conditions, and the standard required. Turfgrass growth influences mowing frequency because if grasses are actively growing, it must be cut more frequently. A standard rule in the industry for moderately to intensively maintained turfgrass is to never remove more than 1/3 (or up to a maximum of 5 mm) of leaf blade of the grass blade in a single mowing. Removing more than 1/3 can result in poor plant health and growth due to increased stress levels.

The level of maintenance a turfgrass area receives also determines mowing frequency. Higher levels of maintenance usually mean more frequent mowing due to aesthetic requirements, nutrient applications, and recreational needs. Lower maintenance areas often require less frequent mowings.

Climatic conditions also influence how quickly turfgrass grows. Cool-season turfgrasses are actively growing in the spring and fall and may require more frequent mowings during this period. Most cool season grasses are not well adapted to hot, dry weather usually experienced in summer. Therefore, summer mowing frequency may be less due to a reduction in plant growth. Warm season turfgrasses are actively growing in summer months, which may increase mowing frequency on warm-season turfgrass surfaces. Mowing frequency for warm-season turfgrasses decreases during cooler temperatures due to a reduction in growth.

Daily weather conditions also influence mowing practices. Rain, frost, and extreme temperatures should all be taken into consideration when mowing turfgrass areas. In the event of excessive rain, mowing should be avoided to prevent rutting and compaction. Avoid mowing (and turf use in general) when there is early morning frost. Traffic on frosted turf ruptures leaf blades and the damage will likely be visible. During hot temperatures, avoid mowing in the middle of the day if temperatures exceed 32°C or 90°F as this may cause damage to the turf. Avoid mowing when leaf tissue is wet to prevent clumping of turfgrass clippings.

In most cases, turfgrass clippings will not need to be collected if the turf is being mowed on a regular basis using the '1/3rd rule.' Clippings are actually a source of plant nutrients and include large amounts of nitrogen and potassium that can be returned to the turfgrass environment if left on the surface. However, variables such as weather conditions, season of the year, soil fertility, moisture conditions, growth rate of the turfgrass, and the surface playing characteristics of the sport sometimes require clipping collection. Collect clippings if they are so long and excessive that they negatively impact surface playability and/or turf health (i.e. blocking sunlight, increasing disease activity under the piles, etc.). Depending on the level of maintenance expected for the pitch, clippings may need to be collected to keep the surface free of debris. Excess clippings have the potential to make the turfgrass surface slippery for athletes.

An additional consideration for mowing turfgrasses is mowing direction. Changing direction each time the pitch is mowed promotes upright growth and can reduce wear from equipment continually following the same pattern. On higher cut turf, mowing the same direction creates 'grain' and the wave-like ridges have potential to affect

the speed and direction of ball roll. A low height of cut maintained on most professional soccer pitches does not influence speed and direction of ball roll.

There are three different types of mowers available to cut turfgrass: reel or cylinder mowers, rotary mowers, and flail mowers.

Reel or cylinder mowers can be trailed, ride-on, or pedestrian (walk behind). These mowers consist of a rotating reel cylinder equipped with multiple blades and a stationary bedknife. The reel blades guide leaves toward the bedknife, where they are cut by a shearing-type scissor action. Mowing quality is, in part, a function of the sharpness of the cutting edges and proper adjustment of the bedknife against the reel blades. Dull cutting surfaces or poor adjustment may result in tearing and bruising of the leaves. Reel mowers provide the highest quality cut when properly maintained and operated. Reel mowers are commonly used on soccer pitches to create patterns. The heavy rollers on the reel mowers are also useful for smoothing out the soil surface.

Rotary mowers are the most common and affordable way to cut grass. Like the reel mowers, they can be trailed, ride-on, or pedestrian. Horizontally mounted blades rotate on a vertical shaft to cut grass blades. Rotary mowers cut by sheer impact of a spinning blade hitting the grass leaves. For the best quality cut, a sharp blade and high blade speed is necessary. A dull blade can result in shredding of leaf blade tips giving a brown cast to the playing surface. Similar to the reel mower, the rollers on rotary mowers can be used to create patterns on the soccer pitch.

Similar to the rotary mower, a flail mower also cuts by sheer impact. The mowing component consists of numerous small L-shaped knives hinged to a horizontal shaft. When the shaft rotates, the knives are held out by centrifugal force. Due to the small clearance between the knives and the mower housing, cut debris is recut until it is small enough to clear the housing. An advantage of this type of mower lies in its ability to reduce tall vegetation to a finely ground mulch. The free-swinging knives will fold away upon striking a rock or other hard obstruction. As with other mowers, sharpness of cutting edges is an important determinant of mowing quality. Flail mowers are used primarily on utility turfs where mowing is performed infrequently.

Fertilization

PSU

Fertilization is important for supplying supplemental nutrients to keep turf healthy. In order to determine exactly which nutrients the plants need, a soil test, and sometimes a tissue test, should be performed. Soil tests should be conducted on a routine basis – every one year for sand-based pitches and every three years for native soil pitches, or when you are considering a fertilizer program change. A soil test will analyze nutrient requirements, pH, phosphorus and potassium levels, and will provide the best guide to fertilization to maintain or achieve a healthy pitch. Tissue tests are a great diagnostic tool in that they provide a snapshot of nutrients present in the plant at the time the sample was taken. Their real value is realized if conducted simultaneously with a soil test since only the soil report can provide clues as to why a nutrient deficiency or toxicity is occurring. Follow the recommendations in your soil test report to provide your turf with the recommended amounts of nutrients. By applying only what the plants need, you are not only being environmentally responsible, but you are also saving money.

The primary macronutrients required for turfgrass growth include nitrogen (N), phosphorus (P), and potassium

(K). Nitrogen is important for plant growth because it enhances green color, increases overall growth of leaves, shoots, roots, stolons, and rhizomes, increases turfgrass density, improves tolerance to weather conditions, improves wear tolerance, reduces susceptibility to some diseases, insects, and the invasion of weeds, and provides better recuperative potential. Soil tests do not test for nitrogen because it is highly mobile in the soil. Nitrogen is often applied to turfgrass areas on a routine schedule to ensure the grass is receiving the nutrition it needs.

PSU

Phosphorus transfers and stores energy needed for survival, aids seedling development and establishment, and aids root growth. Many times turfgrass managers will make fertilizer applications without taking a soil test and end up having an overabundance of phosphorus in the soil. Phosphorus is under a lot of scrutiny due to its potential negative impacts on the environment, which reinforces why soil testing is so important. If your soil test indicates there is sufficient phosphorus, you do not need to add more. Research indicates that soil test results should indicate available phosphorus to be between 90-135 kg/ha (80-120 lbs per acre).

Potassium assists with photosynthesis, manages water inside the plant, improves tolerance to poor/stressful weather conditions, improves wear tolerance, and reduces susceptibility to diseases, insects, and the invasion of weeds. Research indicates that soil test results should indicate available potassium between 336-560 kg/ha (300-500 lbs per acre).

In addition to the primary macronutrients, there are also secondary macronutrients. These include calcium (Ca), magnesium (Mg), and sulfur (S). Calcium aids in cell wall structure and new cell formation, as well as stimulates root and leaf development. Low levels of calcium are designated as less than 560 kg/ha (500 lbs per acre) on soil test results. Magnesium is involved in formation of proteins, improves phosphorus uptake from the soil, and aids in plant respiration. Low levels of magnesium are designated as less than 45 kg/ha (40 lbs per acre) on soil test results. Sulfur is involved with formation of proteins, and assists with turf growth, green color, shoot growth and density, root growth, carbohydrate reserves, and disease susceptibility. An acceptable level of sulfur in the soil is designated as 17-56 kg/ha (15-50 lbs per acre) on soil test results.

James Brosnan, Ph.D.

Micronutrients required for turfgrass growth include iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), boron (B), molybdenum (Mb), chlorine (Cl), and nickel (Ni). Adequate amounts of micronutrients are usually present in the soil as long as pH is appropriate. However, turfgrass managers may choose to make supplemental applications of iron (Fe) to green up grass without the extra growth nitrogen provides. Excess amounts of micronutrients are more commonly seen than deficiencies. Deficiencies are much more likely in sand-based soils than heavier textured native soils. If provided on the soil test results, follow the recommendations if additions of micronutrients are necessary.

Lime should only be applied in accordance with what is recommended on soil test results. Correct liming is as important as fertilization. Liming involves applying an agent to reduce soil acidity (raise pH) and make soils more favorable for turfgrass growth. Properly managed soil pH regulates nutrient availability and creates a soil environment not only desirable for turf, but also for healthy soil microorganisms.

Fertilization frequency is dependent on a number of factors: turfgrass species, level of maintenance, weather conditions, frequency of pitch use, and expected quality of the pitch. Generally, turfgrasses require 226-453 g of N per 93 m2 per month, or approximately 2.4-5 g of N per m2 per month of active growth (0.5 – 1.0 lb N per 1000 square feet). This ensures continuous feeding and healthy plants that are able to withstand environmental pressure.

Fertilizers can be quick or slow-release. Quick release products are water soluble and cause a turfgrass response usually within a week or less. These products are generally inexpensive, but have increased leaching and leaf burn potential if used improperly. Application of quick release fertilizers should always either be planned before a rain event or followed with irrigation to prevent turf burn. Slow release products are water insoluble and provide a gradual, sustained growth response over a period of 3-10 weeks or more. Slow release products normally require sufficient moisture, optimal temperatures (above 13°C or 55°F) and/or microbial activity to release the intended nutrient or active ingredient. Time of year in which these products are applied can be critical for their success. These products are generally more expensive per kg / bag (or per 1b / bag), but rarely burn leaf blades. Application of fertilizers should always be correctly calibrated to ensure the correct amount of nutrient is being applied to the correct surface area. Not only does correct calibration make the fertilization process efficient and effective, but it also reduces waste and maintains turfgrass plant health. Correct fertilizer application can be achieved using rotary or drop spreaders that can be trailed, tractor mounted, or pedestrian walk-behind.

Irrigation

Turfgrass plants need water to survive. Therefore, to supplement rainfall, irrigation is applied. Irrigation ensures an adequate supply of moisture for turfgrass growth, maintains sufficient surface moisture to promote germination of turfgrass seed, and modifies turfgrass tissue temperatures on hot days. Irrigation also provides increased safety and traction due to surface hardness.

Photo courtesy of Jerad Minnick

Irrigation should occur on an as needed basis, but typically, turfgrasses need 25-30 mm (1-1.5 in) of water (whether it be by irrigation or precipitation) per week. The amount of water needed by a plant is the sum of the amount lost through the evaporation of moisture at the soil surface and the transpiration of water through the plant. This loss of water is also known as evapotranspiration. Cool-season turfgrasses typically lose more than 10 mm (0.4 in) of water per day to evapotranspiration, and warm-season grasses lose about 6-7 mm (0.25-0.28 in) of water per day. If turfgrass managers monitor evapotranspiration (ET) rates on a daily or weekly basis, then the minimum amount of irrigation recommended is 70% ET. The daily ET rate for a specific area should be available from local educators or the weather service. It can also be determined using the chart below, which indicates approximate potential ET rates for various climates.

Potential Evapotranspiration Rates for Various Climates

(taken from Sports Fields: A Manual for Design, Construction, and Maintenance, by Jim Puhalla, Jeff Krans, and Mike Goatley)

Climate Type	Daily Loss
Cool humid (average high temperature in midsummer <21ºC (70°F); relative humidity is >50% in midsummer)	2.5-4 mm 0.1-0.15 in
Cool dry (average high temperature in midsummer <21ºC (70°F); relative humidity is <50% in midsummer)	4-5 mm 0.15-0.2 in
Warm humid (average high temperature in midsummer between 21-32ºC (70-90°F); relative humidity is >50% in midsummer)	4-5 mm 0.15-0.2 in
Warm dry (average high temperature in midsummer between 21-32ºC (70-90°F); relative humidity is <50% in midsummer)	5-6 mm 0.2-0.25 in
Hot humid (average high temperature in midsummer >32ºC (90°F); relative humidity is >50% in midsummer)	5-7.5 mm 0.2-0.3 in
Hot dry (average high temperature in midsummer >32ºC (90°F); relative humidity is <50% in midsummer)	7.5-10 mm 0.3-0.4 in

Photo courtesy of Jerad Minnick

The correct amount of water to apply at any one time is dependent on the turfgrass rootzone, grass species, and weather conditions. Soil physical properties such as soil texture, compaction, infiltration, and percolation influence irrigation amounts. Native soil rootzones containing high amounts of clay and/or silt typically have high water holding capacity with a low infiltration rate. Sand-based rootzones have little water holding capacity and may percolate water very quickly. The makeup of the rootzone may require more or less frequent irrigation of the turfgrass area. Some turfgrass species are more drought tolerant than others. For example, fine fescues and tall fescue withstand drought conditions better than perennial ryegrass or Kentucky bluegrass. Bermudagrass withstands drought conditions better than other warm season turfgrasses. Another consideration when determining irrigation amounts are weather conditions. In hot, dry, windy, and sunny conditions, more frequent irrigation is needed to make up for water lost to evapotranspiration. Turfgrasses should always be watered at the first sign of wilt. Wilt is characterized by folded or curled leaves, blue-green to gray color, and visible footprints left after walking on the surface. Wilted turfgrass recovers quickly if it is taken care of immediately. Traffic should not be allowed on wilted areas or recently recovered wilted grasses.

The best time to irrigate turfgrasses is in the early morning between 4:00 a.m. and 9:00 a.m. Early morning is an ideal time because there is a reduction in disease potential and water lost to evaporation due to lower temperatures, less sunlight, and lower wind velocity. Midday irrigation is not an efficient time to irrigate because water lost to evaporation is at its greatest potential (up to 50%). However, midday syringing is effective if the goal is to cool

plant temperatures and reduce heat stress. Syringing is a very light application of water applied to the turfgrass leaf surface that cools the turf so it can get through the hottest part of the day. Syringing does not restore soil moisture.

To promote the healthiest turfgrasses, deep, infrequent irrigation that wets the entire rootzone (generally 100 mm or 4 inches in depth) should take place. Deep, infrequent watering encourages development of deep, strong root systems that can extract water from a large volume of soil. When applying water to turfgrass areas, the irrigation rate should not exceed the infiltration rate of the soil. Once the rootzone is wet, additional irrigation is considered excess and will be removed by drainage. Overwatering can lead to poor turfgrass health, increased weed, disease, and insect problems, runoff and/or leaching of nutrients and pesticides, standing water, and compaction.

Light and frequent irrigation is not recommended for established turfgrass areas. It leads to weak, unhealthy plants and a shallow root system. Light and frequent irrigation is only acceptable when establishing grass from seed or sod. When establishing turf, because seedlings are very susceptible to drying out, the seedbed should not be allowed to dry. Once germinated seedlings reach 51 mm (2 in) in height, begin shifting the irrigation strategy to deep and infrequent watering to promote root growth.

If an area is experiencing drought conditions and an athletic pitch does not have access to irrigation or is facing water restrictions, allow turfgrass to go dormant. Dormant turfgrass should be watered once every four weeks during a drought. Turfgrass plants will recover from dormancy as long as wear and usage levels are kept at a minimum level.

Aeration

Aeration refers to mechanical methods of selective tillage that modify physical characteristics of turfgrass areas. Aeration is one of the most important cultural practices for maintaining turfgrasses. Benefits of soil aeration include improvement of air, water, and nutrient movement within the rootzone, correction or alleviation of soil compaction, and a reduction in thatch accumulation. If a pitch does not receive mechanical aeration regularly, chances are it will be extremely unhealthy with poor turfgrass growth and compacted soils.

Hollow Tine Aeration

Different methods of aeration include hollow tine aeration, solid tine aeration, shatter coring, water jet coring, slicing, vertical mowing, spiking, deep tine, and deep drill/drill and fill. Hollow tine aeration is the most popular type of aeration and is considered essential for a turfgrass area to be successful. All of the mechanical aeration methods improve turfgrass areas by relieving compaction, managing thatch, and creating channels in the rootzone for air, water, and nutrients to penetrate and reach turfgrass roots. There are benefits and disadvantages associated with each aeration method. Be sure to assess site needs to determine which aeration method will provide the most benefit. The following provides an overview of each of the aeration methods:

Type of Aeration	Description
Hollow tine	Aerator pulls soil core (9mm-18mm or 0.35 in-0.7 inches in diameter) from a 50-150 mm or 2-6 in depth. Soil cores can be removed or reincorporated into the rootzone using a dragmat. This method should be done at least twice a year with high traffic areas receiving it 4-6 times per year
Solid tine	Solid tines penetrate through the rootzone with minimal surface disturbance An ideal tool to utilize during periods of intensive pitch use, but it does not substitute for overall benefits of core aeration
Shatter coring	Solid tines aggressively penetrate the soil and fracture belowground compaction zones at a depth up to 152 mm or 6 in Minimal disturbance to the surface and soil stability; does not substitute for overall benefits of core aeration
Water jet coring	Streams of pressurized water penetrate thatch and loosen soil Effective way to aerate stressed turf in unfavorable weather conditions Most effective on sand-based pitches Minimal disturbance to the surface; does not substitute for overall benefits of core aeration
Slicing	V-shaped knives mounted on disks attached to a slowly rotating steel shaft cut into the turf Effective alternative to aggressive aeration during extreme temperatures but does not substitute for overall benefits of core aeration
Vertical mowing	Knives that cut into the turf are attached to a rapidly spinning horizontal shaft. Depending on height adjustment, can be used to relieve grain, dethatch, or aerate; does not substitute for overall benefits of core aeration
Spiking	Similar to a vertical mower, only blades are pointed rather than broad and flat. Blades are attached to a slowly turning horizontal shaft.
Deep tine	Tines penetrate the soil to a depth of 150-450 mm or 6-18 in Tines range in diameter up to 38 mm or 1.5 in If using hollow tines, holes can be back filled with a soil amendment Solid tines are beneficial when aerating heavily compacted clay or gravelly soil Minimal disturbance to the surface with use of solid tines Core aeration results in significant surface disruption and a concentrated effort to manage the cores and/or topdress with new soil material or amendments
Deep drill/drill and fill	Drills penetrate the soil to a depth of 150-450 mm or 6-18 in Attachments are available that will inject sand or amendments immediately into the drilled holes

To sustain turf at a desired level of quality, aeration practices should take place only when turfgrasses are actively growing. Aeration should not take place during periods of stress or limited growth. Cool-season grasses should not be aerated during hot, dry periods as this can cause extreme stress to plants and inhibit recovery. Cool-season grasses are in a semi dormant state during the summer and do not have the recovery potential of actively growing plants. Avoid aeration of warm-season grasses during cooler temperatures when the plants are not actively growing. Doing so can cause injury to bermudagrass that will not allow plants to successfully recover.

Chad Price, CSFM

To keep pitches in top playing condition, mechanical aeration should take place once a month during periods of active turfgrass growth. Playing schedules often make it difficult for aeration to take place at this frequency. Therefore, turfgrass managers should aim to core aerate at least once in the spring and twice in the fall - once before the sports season begins and again after the last game. Monthly or more frequent aeration will benefit turfgrasses, especially in heavy wear areas, as long as the pitch is not under too much stress and temperatures are favoring growth.

Seeding, Sprigging, and Sodding

Seeding, sprigging, and sodding become necessary to establish new turfgrass areas, repair bare or thin areas, as well as transition from one turfgrass species to another. Turfgrass breeding has developed high performing turfgrass cultivars for various athletic uses. A cultivar is a variety or subdivision of a plant species that, because of similar morphological and performance characteristics, can be distinguished from other plants within that species. A hybrid is a cultivar created by crossing varieties of dissimilar genetic constitution to ultimately achieve a better performing plant. Selection of turfgrass species and cultivars depends on pitch and athletic requirements as well as climate.

Simon Gumbrill

In warm season areas, sports turf is generally dominated by bermudagrass and zoysiagrass cultivars. These cultivars flourish in the hot summers and mild winters, and can withstand occasional summer dryness without damage. The ideal time to seed and sprig bermudagrass or zoysiagrass is from midspring to midsummer. Planting in mid to late spring will give the plants adequate time for establishment so the pitch can withstand traffic in the fall. Ideal planting conditions are when soil temperatures reach 18ºC (65°F). Planting midspring to midsummer reduces the risk of cold temperature injury on warm season grasses. It also increases potential for achieving desired coverage and density before cold temperatures arrive. The following provides recommended seeding and sprigging rates for warm season turfgrasses:

Turfgrass Species	Recommended Seeding or Sprigging Rate
Bermudagrass (seed)	5 g/m2 1 lb / 1000 sq ft
Bermudagrass (sprigs)	5-15 bushels / 93 m2 (higher planting rates may require 25+ bushels / 93 m2) 5-15 bushels / 1000 sq ft (higher planting rates may require 25+ bushels / 1000 sq ft
Zoysiagrass (seed)	5-10 g/m2 1-2 lb / 1000 sq ft
Zoysiagrass (sprigs)	8-10 bushels / 93 m2 8-10 bushels / 1000 sq ft

Sod of either of these species can be installed at any time as long as the soil is not frozen, but consider that sodding during warmer temperatures will better ensure root development and a stable playing surface.

In cool season areas, Kentucky bluegrass and perennial ryegrass predominate, and a mixture of those species is probably the most popular sports turf. Both types tolerate cold winters adequately, and can withstand warm

summers. Seeding of cool season turfgrasses can take place just about any time the soil can be worked. Seeding throughout the year helps to maintain turfgrass density. The optimum time for cool season turfgrass establishment is late summer to early fall. At this time, soil temperatures are near optimum for germination, there is less weed competition then in the spring, and water requirements are lower. This time period allows for sufficient establishment before the onset of freezing temperatures.

The following provides recommended seeding rates for cool season turfgrasses:

Ryan Bjorn, Julie Adamski

Turfgrass Species	Recommended Seeding Rate
Kentucky bluegrass	10-15 g/m2 2-3 lb / 1000 sq ft
Perennial ryegrass	20-30 g/m2 4-6 lb / 1000 sq ft
Tall fescue	25-40 g/m2 5-8 lb / 1000 sq ft
Creeping bentgrass	5-7.5 g/m2 1-1.5 lb / 1000 sq ft

When seeding to repair high wear areas on the pitch, higher seeding rates at more frequent intervals may be needed to maintain turfgrass density and increase the likelihood of growth and establishment. Seeding rates of 50-100 g/m2 (10-20 lbs / 1000 sq ft) can help in the rapid recovery of bare spots on pitches. Seeding following core aeration is an effective practice to encourage germination and growth. University research has also shown that athlete's cleats assist in incorporating the seed into the soil.

Chad Price, CSFM

Sod of any of these species can be installed at any time as long as the soil is not frozen, but consider that sodding during the spring and warmer parts of the fall will better ensure root development and a stable playing surface.

The transition zone is characterized by cold winters and hot summers. It is an approximate location where cool season and warm season turfgrasses encounter the limits of their southern and northern adaptation. Turfgrasses most tolerant to transition zone temperatures include tall fescue, cold resistant cultivars of bermudagrass, and some zoysiagrasses. If a pitch is planted with warm season turfgrass, the grass will go dormant at the onset of cooler temperatures. Warm season turfgrass growth usually ends in mid fall and goes dormant after the first killing frost. It remains dormant until soil temperatures reach 15ºC (60°F) consistently the next spring. Depending on pitch maintenance expectations and user expectations, the pitch may require overseeding to maintain its green color and playability. The best time to overseed is early fall during a period when warm season turfgrass growth is slowing and soil temperatures are optimal for ryegrass seed germination. If pitches are overseeded too early, actively growing warm season grasses will outcompete the ryegrass. If pitches are overseeded too late, cold temperatures may prevent sufficient establishment of ryegrass.

For a smooth transition and uniformly overseeded pitch, ryegrass seeds must have good seed to soil contact. This can be achieved by dethatching, core aeration, close mowing, collecting clippings, topdressing, sweeping, and dragging the pitch. However, aggressive aeration and/or vertical mowing so late in the season can be very detrimental to warm season turfgrass survival. Conduct aggressive aeration programs during active periods of growth whenever possible.

Following are recommended seeding rates when overseeding warm season turfgrass pitches:

Turfgrass Species	Recommended Rate
Perennial ryegrass	50-75 g/m2 10-15 lb / 1000 sq ft
Annual ryegrass	50-100 g/m2 10-20 lb / 1000 sq ft
Intermediate ryegrass	50-100 g/m2 10-20 lb / 1000 sq ft

Overseeding is not a required practice for warm season turfgrass pitches. Dormant, brown bermudagrass or zoysiagrass is not dead and can still provide a quality playing surface if it is maintained properly up until dormancy. Once it goes dormant, the pitch can withstand traffic, as long as it is not excessive. Overseeding success is dependent on how bermudagrass and zoysiagrass are prepared for overseeding and the management provided as ryegrass seeds germinate and plants develop. As part of a seasonal management plan, consider how overseeding fits the sport and site's needs. If the pitch is only used in the fall, winter overseeding might not establish quickly enough to be justified for this use. However, for spring play, winter overseeding of a heavily trafficked turf might be the best way to provide a safe, quality playing surface.

When overseeding or establishing turfgrass, an effective management plan can ensure healthy germination of seedlings. Minimize traffic on overseeded pitches as much as possible while seeds are germinating. Lightly irrigate the pitch 3-4 times per day. Do not overirrigate. Irrigation should be just enough to keep the seedlings moist throughout the day. As seedlings establish, irrigation can gradually decrease until it is on an as needed basis. Fertilize with low levels of quick release nitrogen every two weeks. Seedlings can begin to be mowed when they reach about 50 mm (2 in) in height. Once the seedlings are established, pitches can be mowed at the recommended height. Use caution when using preemergent weed control as some products may inhibit seedling germination. Always read the label before applying any type of chemical to the turfgrass surface.

Pest Management

Healthy, dense stands of turfgrass are the best way to prevent disease, weed, or insect infestations. Following proper cultural practices throughout the year, including fertilization, irrigation, mowing, seeding, and soil aeration, can minimize and sometimes eliminate pest problems. The goal of turf management is to produce healthy turf while limiting reliance on pesticides. Many managers follow Integrated Pest Management (IPM) practices. IPM does not completely eliminate pests, but maintains the population at a tolerable level. It is important to routinely check and inspect pitches and identify pest problems in the early stages so a

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decision can be made whether pest effects need to be controlled culturally, biologically, or chemically. Pesticides are often a part of IPM programs, but they are selected and applied responsibly to avoid health risks to other living organisms than those targeted. Pesticide label recommendations should always be followed for personal and environmental safety and to comply with legislation. The label also provides important information for correct handling and application of pesticides. Not following the label is a violation of the law. Turfgrass managers in certain parts of the world may not have access to pesticides or are unable to use pesticides depending on laws. Following sound cultural practices throughout the year to maintain healthy turf will be the best defense against insect, disease, and weed infestations.

Weeds

The best way to defend against weeds is by increasing density and vigor of turfgrasses to discourage weed competition. Weeds are opportunistic and fill voids in the turfgrass canopy. These voids can be avoided with proper selection and establishment of turfgrasses, adequate liming and fertilization per recommendations from soil tests, proper mowing heights, and watering deeply and infrequently.

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If control methods must be implemented to eliminate weeds, cultural or chemical controls can be utilized. Cultural control methods include hand picking the weeds. If herbicides are necessary to control weeds, preemergence and postemergence products are available to control winter annual, summer annual, and perennial broadleaf weeds, grasses, and sedges. Preemergence products will control weeds prior to germination. Always read the label when applying preemergence herbicides, as some can be detrimental to the growth of new turfgrass seedlings. If using postemergence herbicides, weeds should be actively growing and young for the most effective control. Herbicides are also classified as selective and non-selective. Selective herbicides target specific weeds with minimal effects to desirable plants. Non-selective herbicides kill all plants contacted.

Spring is the best time for weed control because most weed germination occurs in the spring. Applying weed control products at the correct time can often provide effective control that lasts for most of the growing season. If weed infestations are a significant problem on the pitch, stopping the problem before it starts can eliminate additional herbicide applications. Preemergence products are effective for early spring applications to prevent weed germination. Postemergence products are effective for late spring and supplemental applications to control broadleaf weeds. Depending on weed prevalence, spot treating weeds may be a more desirable method of control as opposed to broadcast applications over the entire turf surface.

Herbicides should never be applied when turfgrass plants are drought or heat stressed. Herbicides should only be applied when turfgrass is actively growing, temperatures are less than 29ºC (85°F), and soil moisture is adequate.

Insects

Weak turfgrasses are more susceptible to insect infestations; therefore, correct maintenance and management of turfgrass areas can help discourage insect infestations and damage. Suitable mowing heights, adequate liming and fertilization per recommendations from soil tests, watering deeply to a depth of 100 mm (4 in) and infrequently, and soil aeration are all essential to maintaining healthy turfgrass that can withstand moderate insect damage.

Most insect damage occurs in the summer, but turfgrass managers should always monitor for populations and treat accordingly. Cultural, biological, and chemical control methods provide options for dealing with insect pests. Cultural control methods include planting insect tolerant turfgrass species, monitoring fertility and irrigation

programs, and controlling thatch accumulation. Biological control methods include predators, parasites, and diseases. If insect populations have reached the determined threshold, chemical control may be the only option. When applying insecticides, always be sure to read the label. Different insecticides treat for different life stages of the insect. Be sure to make applications during the appropriate time in the pest's lifecycle. Some insecticides will need to be watered in for below ground insects and others will not for surface feeding insects.

Diseases

Turfgrass diseases develop in the presence of optimal environmental conditions, susceptible plant hosts, and a disease pathogen. An optimal environment is determined by weather conditions and cultural practices. Diseases can occur during all weather conditions. Knowing the weather conditions that favor certain diseases can help when monitoring turfgrass areas. Cultural practices such as fertilization, irrigation, mowing height, and compaction and thatch management can also influence disease development. Diseases can develop under high nitrogen or low nitrogen conditions, wet or dry conditions, and high or low mowing heights. Diseases also need a susceptible plant host. Turfgrass plants may be a host for pathogens when conditions are favorable. There are certain diseases that favor specific grass types and there are other diseases that can infect all turfgrasses. The disease pathogen is almost always present in the soil and not causing problems. However, if environmental conditions become optimal and a susceptible host is available, the pathogen can attack the turfgrass plants. Diseases cannot occur unless all three factors are present in optimal conditions.

Cultural control methods for diseases include maintaining a healthy dense pitch through proper mowing, irrigation, fertilization, and aeration. Healthy, actively growing turfgrass areas can usually withstand moderate disease infestations.

Diseases can often become a severe problem on highly maintained turfgrass areas. Therefore, chemical control may be necessary. There are two types of fungicide applications – curative and preventative. Curative applications are made when the disease has already appeared. Preventative applications are made before the disease has appeared to prevent it from becoming a problem. The determination to use preventative applications is usually based upon history of the site and takes into consideration turf type, temperature, and humidity.

Diseases can pose a severe threat to turfgrass areas. Turfgrass managers must be able to identify diseases and understand conditions for their development. To assist in disease identification, managers may choose to send a sample to a lab for correct identification of the pathogen. Turfgrass managers can monitor disease development by keeping a pitch diagram and marking the areas where disease develops. Over time, a pattern may emerge and managers will be better able to predict disease onset and take necessary control measures. Once the disease is identified, managers can start selecting turfgrass varieties for overseeding that are resistant or more tolerant to the pathogen. If pesticides are an option, specific fungicides can be applied preventatively to control disease development.

Plant Growth Regulators

Plant growth regulators (PGRs) or inhibitors are used to suppress seedheads and vegetative growth of desirable turfgrasses, enhance turfgrass quality, and manage annual bluegrass (Poa annua) growth and development. Depending on the turfgrass situation, PGRs may reduce mowing costs by reducing clippings, prevent scalping, and increase turfgrass density. Additional benefits of PGR use include suppression of vertical top growth of desirable turfgrass, increased lateral growth, and improved recuperative potential.

Some disadvantages associated with the use of PGRs are phytotoxicity, cost, and what is known as the rebound effect. Many PGRs cause discoloration to the turf. The discoloration is only temporary and may be hidden through

supplemental nitrogen or iron applications. PGR products are expensive; however, the benefits provided by application may outweigh the costs. If a PGR is applied to a turfgrass surface, once the plants reach to end of the time period that PGRs are active, there is a surge of growth, known as the rebound effect. While this may be considered a disadvantage to some turf managers, others may consider it an advantage. If the rebound effect is timed appropriately, the surge of growth may help recovery on wear areas.

There are three distinct groups of PGRs classified by the way they inhibit turfgrass growth.

1. Cell division inhibitors inhibit cell division and differentiation in meristematic regions. They inhibit both vegetative growth and seedhead development. Phytotoxicity may be a problem, but cell division inhibitors are useful for reducing mowing frequency.
2. Herbicides can be used at low rates to suppress growth or seedhead development of turfgrasses. Depending upon the chemical, herbicides inhibit turfgrass growth and development through interruption of important plant processes. Use of herbicides can be used to reduce mowing and control weeds.
3. Gibberellin biosynthesis inhibitors inhibit gibberellin production. Gibberellin is a plant-produced hormone that is needed for cell elongation and normal growth and development. When production is inhibited, plant cells do not elongate, internodes become shortened and overall plant growth is reduced. Use of gibberellin inhibitors promote lateral turfgrass growth, which encourages denser growth.

For best results with PGRs, always consult the label for application information. Be conscious of the grass species for which it is labeled. PGRs are recommended for use only on certain turfgrass species. Additionally, the use of a PGR is often determined by the type of turfgrass area and level of maintenance. Understand how the product affects the plant, how the product enters the plant, and if water is necessary following application. Never apply PGRs to grass that is under stress.

Goal Mouth Repairs and Renovation

Photo courtesy of Dr. A. J. Powell Jr.

Much of the wear that occurs on soccer pitches is concentrated in the goal mouth area. The poorest surface conditions are most often found where the best conditions are required. Goal mouth areas need to provide a firm, stable surface that is safe for use and provides the quality required. They cannot be hard and compacted with little grass cover. Goal mouth areas require attention prior, during, and after the playing season. Prior to the playing season, the goal mouth should have healthy, actively growing grass, a firm, level, playing surface, and healthy soil physical properties. During the playing season, turfgrass managers should maintain the goal mouth area by seeding and/or plugging bare areas, topdressing, and aerating on an as needed basis to relieve compaction and fill divots. Correct irrigation will be essential to the success of the repairs and renovation and will need to be carefully planned to coincide with low usage levels. Post season, full renovation, including soil aeration, topdressing, and seeding, sprigging, and/or sodding, can take place to restore healthy turfgrass cover and soil properties.

Mowing

Determining the correct mowing height must be balanced with the amount of use the pitch receives, climatic conditions, turfgrass species, and the overall maintenance program. Many turfgrass managers will raise the mowing height on the pitch during summer or winter months to improve turfgrass stress tolerance to heat, cold, drought, and other extreme weather conditions. While this is an effective practice, decreasing mowing height at the start of the playing season may cause unneeded stress on the grass plants as they adapt to the lower cutting

height. Therefore, if the pitch is to be mowed at various heights throughout the year, reductions in mowing height must be conducted slowly to allow the plants to acclimate. Another option is to mow the pitch at the same height throughout the year. Maintaining the pitch at one height throughout the year will promote healthy, dense turfgrass growth.

Goal mouth areas may have different mowing requirements depending on their condition. If the turfgrass in goal mouth areas is healthy and actively growing, the area can be mowed at the same height and frequency as the rest of the pitch. If the goal mouth is being reestablished with seed, sprigs, or sod, the mowing height should be increased and mowing frequency decreased to accommodate the plants until they are properly established.

Seeding, Sprigging, Plugging, and/or Sodding

Goal mouth areas need to have grass cover to cushion falls, protect the soil structure, stabilize the soil surface, and provide a truer roll and bounce of the soccer ball. Grass cover can be achieved with seed, sprigs, plugs, and/or sod. The strategy for goal mouth areas is to avoid complete failure of turf cover and exposure of bare soil. Therefore, grass may need to be established or reestablished amidst a continuous pitch use schedule. Research conducted by Iowa State University found that by seeding often and at higher than normal seeding rates is an effective strategy for maintaining grass cover. Research at Iowa State also found that most cool-season grasses can be pregerminated to speed establishment and recovery on athletic pitches. Perennial ryegrass, Kentucky bluegrass, and tall fescue can be pregerminated and used in a divot mix composed of seed and amounts of organic matter to hasten seedling establishment. Pregerminated seeds have been shown to fill in areas twice as fast as seeding without pregermination.

Sprigging, plugging, and/or sodding may also need to take place to maintain turfgrass cover. If replacing the goal mouth with sod, the most effective procedure would be to use sod grown onsite versus purchasing sod. This can be achieved by dedicating a portion of the grounds to a turfgrass nursery which can be utilized for pitch repairs. When applying sod, be sure the sod's soil texture matches the existing soil texture on the pitch. Thick cut sod may be ideal for the goal mouth as it is less likely to shift during play if it has not had a chance to grow roots into the existing rootzone. During cooler temperatures, germination blankets may be used to speed turfgrass germination and growth. Post season seeding, sprigging, or sodding can take place to restore grass to the goal mouth area.

Aeration

Soil aeration is one of the most important practices, and often the most under-utilized tool for goal mouth maintenance. Aeration corrects or alleviates soil compaction common to high traffic areas. High traffic areas may require soil aeration 8 or more times per year, including during the playing season. Frequent soil aeration relieves compaction, allows turfgrass roots to grow deeply, and allows air, water, and nutrients to penetrate the soil and reach turfgrass roots.

Topdressing

Topdressing is important to maintain a level surface for true ball roll, maintain firmness and stability, maintain drainage characteristics, dilute and reduce thatch, and fill aeration holes. When applying topdressing, the material should always match the soil texture of the existing rootzone where possible. If it does not, problems such as layering can occur.

Layering is a result of introducing different particle sizes into the rootzone and can impede root growth as well as water and nutrient availability. When leveling the surface, simply dumping topdressing material on the surface and leveling it out is not a smart solution. It only masks the underlying problem of compaction and loss of grass cover and does not provide a firm, stable surface on which to play. When applying topdressing when there is still grass cover, apply in combination with hollow tine aeration. Approximately 3-6 mm (0.1-0.25 in) of topdressing material can be broadcast as a dusting over the turf surface. More topdressing may be needed in low areas to level the playing surface. Overseeding or sprigging with the topdressing application can also improve recovery and health of the goal mouth. Research has shown that topdressing can improve the wear tolerance of the turf and reduce the rate of grass cover loss.

Irrigation

Goal mouth areas are prone to compaction. Compaction decreases infiltration of water into the soil and may cause puddles after irrigation or precipitation. If aeration practices are conducted on a frequent basis, compaction can be reduced and standing water may not be a problem. When applying seed, sprigs, plugs, and/or sod, the goal mouth must receive light and frequent irrigation to help germination and establishment. As the seed, sprigs, plugs, and/or sod matures, irrigation programs can gradually be converted to deep and infrequent watering.

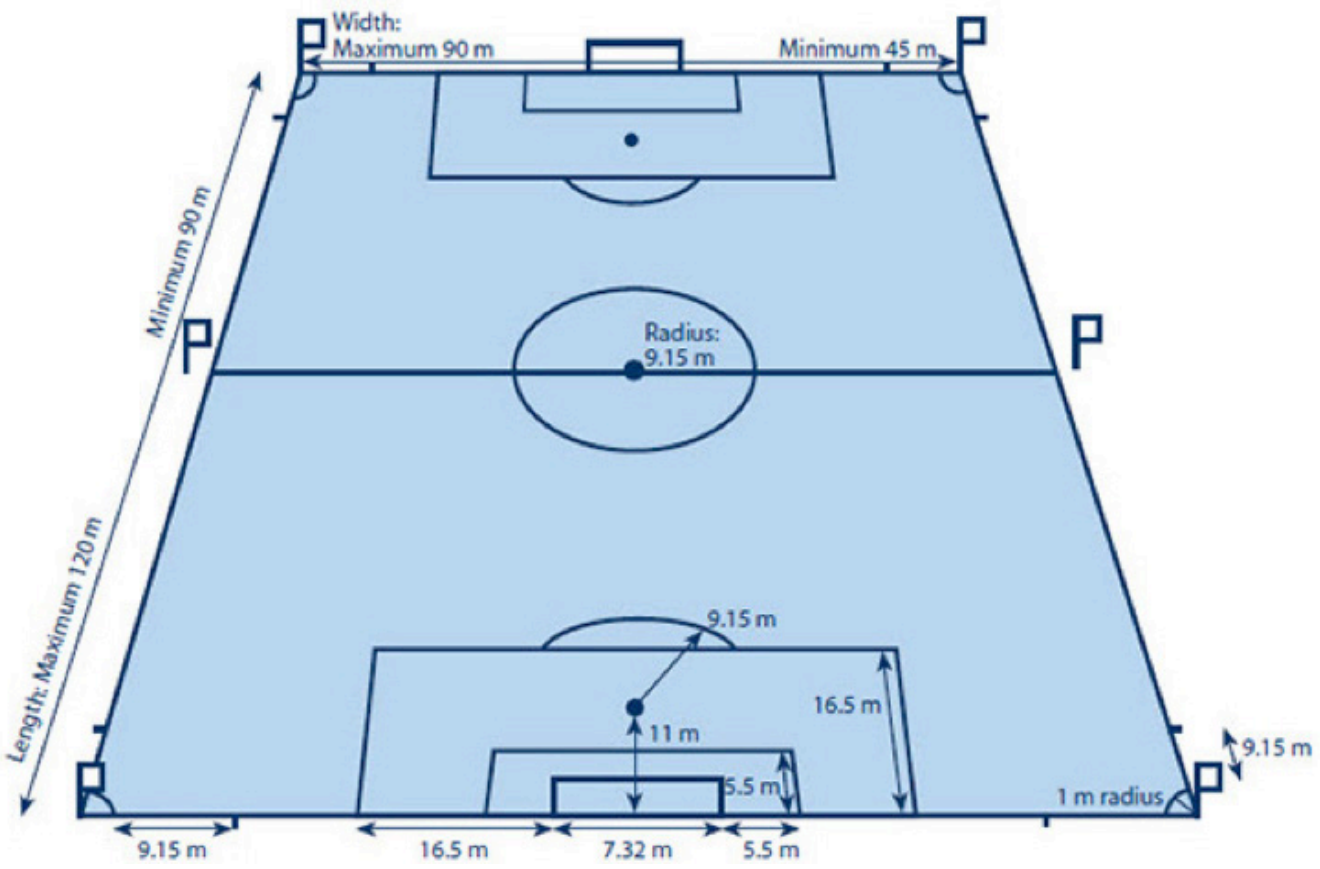
Fertilization

Vigorous turfgrass growth is detrimental to the goal mouth area on soccer pitches. Excessive nitrogen leads to excessive, fast growth. Although faster growth may be seen as essential to plant recovery time, faster growth actually weakens the plant. Therefore, nitrogen should be provided to plants in consistent, low levels.

In addition to proper cultural practices, the following practices can be implemented to reduce wear in goal mouths:
Where space and play allow, shift the pitch 90 degrees or laterally from one season to the next. Use a pitch for half of a season, and then relocate the pitch for the second half of the season.
Do not allow any type of practice to take place in the goal mouth area. Reserve these areas for game use only.
Use lightweight, mobile goal posts so the areas of wear can be rotated around to different areas of the pitch.
Goalkeepers often dig marks into the turfgrass as reference points if they cannot see painted lines. Painting fresh lines on the pitch prior to the game can sometimes eliminate unnecessary turfgrass damage.

Communication

It is important that the end users and supervisors understand the necessity for reducing damage to goal areas. By providing education on better playing conditions, they will often respond in a positive manner and collaborate in efforts to keep pitches safe, healthy, and playable.

Pitch Layout

To assist with soccer pitch layout, the following diagram provides measurements. The pitch dimensions found optimal by FIFA are 100-110 m (100-120 yards) long by 64-75 m (55-75 yards) wide. For World Cup and Confederation games, the pitch should be 105 m by 68 m (115 by 75 yards). For international and national games, the pitch should be between 100-110 m (100-120 yards) long and 64-75 m (55-75 yards) wide. The pitch can be between 90-120 m (98-130 yards) long and 45-95 m (50-104 yards) wide for other events. It is recommended to have a free area behind the goal of 8.5 m (10 yards) and next to the sidelines of 10 m (11 yards).