Study: Natural turf use levels

INJURIES ARE OF MAJOR CONCERN to parents, coaches and, of course athletes. Few studies have been conducted to relate actual field conditions as well as maintenance practices to reported injuries. We conducted a study in 2007 to determine the level of use that an athletic field will sustain before field conditions begin to affect the playability and safety of the field. Eleven sports turf managers from four New England states volunteered to take part in the study; they represented 12 varsity fields from nine high schools and three universities. Field use included football, soccer or both. Lacrosse was also played on two of the soccer fields.

The turf manager participants were given a form to record the date, event (game or practice) and hours/minutes of use. This provided the number of weeks the fields were in use for which we then calculated the total number of hours of use over the playing season. All participants provided their maintenance program, including nitrogen fertilization treatments, mowing height and frequency, aerification, dethatching, topdressing, overseeding, number of times chemicals were applied to control weeds, insects and/or diseases, and growth enhancement products used. The maintenance practices were quantified for statistical purposes. All the fields in the study were irrigated.

At the conclusion of the study, the participants asked their athletic departments about the number of injuries that could be contributed by players to surface contact; we did not solicit the type of injury. Nine of the 12 schools responded.

FIELD EVALUATIONS

The field surfaces were evaluated at the end of playing seasons for percent grass cover (turf density), percent weeds, surface smoothness, depressions (areas on the fields that can accumulate surface runoff), and stones at the surface. The characteristics evaluated were assigned code numbers (shown in Table 1) for the purpose of statistical analysis. Separate ratings were taken from the heavily trafficked center of the fields from goal to goal and the less trafficked areas along the sidelines. Overall field conditions were determined using the sum of ratings for grass cover and surface smoothness, with ratings for weeds, depressions and stones at the surface subtracted from the sum. The data shown in Tables 2 and 3 are from the heavily trafficked centers of the fields.

Further, we evaluated the quality of the playing surfaces by determining surface hardness, traction, and penetration resistance with separate measurements taken from

Table 1. Rating System with Codes.

Percent grass cover (turf density)			Percent weeds			Depressions		
0	=	10%	1	=	<10%	0	=	none
1	=	11-20%	2	=	10-30%	1	=	few
2	=	21-30%	3	=	31-50%	2	=	moderate
3	=	31-40%	4	=	>50%	3	=	many
4	=	41-50%				4	=	extreme
5	=	51-60%						
6	=	61-70%						
7	=	71-80%						
8	=	81-90%						
9	=	>90%						
----------Smoothness----------								
1	=	surface is extremely uneven that will affect play and are hazardous						
2	=	surface is very uneven with irregularities that will greatly affect play						
3	=	surface is uneven with irregularities that will moderately affect play						
4	=	smooth surface with some irregularities						
5	=	smooth surface with no irregularities						

Table 2. Mean and range for characteristics on 12 varsity fields from center of field from goal to goal (2007 playing season).

Variable (code or unit)	mean	minimum	maximum
Usage			
hrs./week	12.1	3.7	21.4
total for year	186.2	39.0	412.0
Field Rating[1]			
overall field condition	7.6	1.0	13.0
surface smoothness (1-5)	3.5	2.0	5.0
turf density (0-9)	6.3	3.0	9.0
weeds (1-4)	1.3	1.0	3.0
Playing Quality			
hardness (g max)	55.8	34.8	103.9
traction (Nm)	38.9	28.8	48.3
penetration resistance (MPa)	1.2	0.5	2.5
Soil Properties			
gravimetric moisture (%)[2]	25.1	12.0	36.7
soil available K lbs. per acre	177	93	216
soil available P lbs. per acre	24	2	45
bulk density (g per cm^3)	1.46	1.27	1.68
organic matter (%)	5.4	1.0	9.1
pH	5.8	5.5	6.5
sand (%)	74.2	55.7	95.0
Maintenance			
N fertilization lbs. per $1000ft^2$	4.4	2.0	6.0
total maintenance score	16.8	8.8	26.8

1 Density, smoothness, weeds, depression and stones at surface are factored into score for overall field quality condition.
2 Soil samples for soil moisture were collected on day when playing quality measurements were made.

the centers of the fields and along the sidelines. This data also was taken from the heavily trafficked centers (see Tables 2 and 3). Surface hardness was measured using a Clegg Impact soil tester, which is an accelerometer fastened to a 5-pound missile that is dropped from a height of 1 foot with the peak deceleration measured in gravities (Gmax). The higher the Gmax the harder the surface. Traction was measured by a device comprised of a 6-inch steel disc with six soccer studs spaced at intervals around the disc. The disc was weighted with 75 pounds and dropped from a 6-inch height so that the studs fully penetrated the surface. The torque required for the studs to tear the surface was measured in Nm (Newton meters). Penetration resistance was measured using a Penetrometer with a cone point. The cone point was pushed slowly and at a constant rate into the top 2 ½ inches of soil. Twelve readings were taken with each apparatus and then averaged.

SOIL SAMPLES

Soil samples were collected from each field to determine textural class based upon the USDA-NRCS classification system, soil organic matter content, soil available phosphorus (P) and potassium (K). Particle size for determining textural class was analyzed using the hydrometer method by separating the sand, silt and clay fractions. Percent organic matter was determined by weight loss on ignition. Soil available P and K were obtained using the modified Morgan extractant. Two intact core samples, 2 inches in diameter by 2 ½ inches in length, were taken from the center of the heavily trafficked area and two taken along the sidelines with a brass cylinder fitted inside a metal tube for determining bulk density. These results along with bulk density samples taken from the center of the fields are shown in Tables 2 and 3.

Table 3. Significant correlations (r) for data obtained for 12 athletic fields for 2007 playing season.

Co-variables	Correlation coefficient (r)
Field related injuries	
density x field related injuries	-0.62*
Field ratings	
density x weeds	-0.62*
density x smoothness	0.63*
density x overall field condition	0.88***
smoothness x overall field conditions	0.84**
Usage	
hours of use/yr. x density	-0.50†
hours of use/week x g max (hardness)	0.57†
hours of use/week x MPa (penetration resistance)	0.56†
Soil properties and field ratings	
sand x density	0.57†
sand x smoothness	0.88***
sand x overall field condition	0.69*
organic matter x smoothness	-0.68*
bulk density x smoothness	0.81**
bulk density x overall field condition	0.58†
soil moisture x traction	-0.80**
Between soil properties	
sand x organic matter	-0.85***
sand x K	-0.70*
organic matter x K	0.85***
bulk density x sand	0.93***
bulk density x organic matter	-0.89***
Maintenance factors	
N fertilization x overall field condition	0.60*
overall maintenance x density	0.69*
overall maintenance x smoothness	0.74**
overall maintenance x overall field condition	0.86***
Playing quality factors	
g max (hardness) x MPa (penetration resistance)	0.92***

†,*,**,*** Significant at $P \leq$ 0.10, 0.05, 0.01, 0.001 levels, respectively.

STATISTICS

Correlation coefficients (r) were computed to identify relationships between ratings, hours of use, playing quality data, soil properties, maintenance practices and incidence of injury. Correlation is a measure of the strength of the association between two co-variables and is shown in Table 3. A perfect relationship or fit between two co-variables is indicated by an r value of "1" with values less than "1" indicating less than a perfect relationship. A negative sign (-) indicates an inverse relationship between any two co-variables. The degree of statistical significance of the correlation from weak to highly significant is indicated in Table 3 by the level of probability (P value) from weak (P£ 0.10) to highly significant (P£ 0.001).

FIELD QUALITY RATINGS AND MAINTENANCE

There was a wide range in field ratings for turf density, weed populations, smoothness and overall field conditions ranging from 3 to 9, 1 to 3, 2 to 5, and 1 to 13 respectively, Table 2. Turf density was positively related to smoothness (r = 0.63) and overall field conditions (r = 0.88), and negatively related to weed populations (r = -0.62) in which weed populations increased with progressively greater turf thinning and loss of density (Table 3). Percent weeds in two of the fields were 30% or greater, which also had the lowest scores for overall field quality conditions. Surface smoothness also had a major influence in improving overall field conditions (r = 0.84) Field maintenance had a considerable role in the condition of the fields. Turf density and surface smoothness increased significantly as maintenance inputs increased (r = 0.69), and (r = 0.74), respectively. Further, as maintenance factors increased, overall field quality increased (r = 0.86) with greater fertilizer nitrogen closely associated with improving overall field condition (r = 0.60).

SOIL PROPERTIES

The textural classes for the studied soils were classified as seven sandy loams with sand contents ranging from 55.7 to 74.3% sand, three loamy sands ranging from 79.2 to 83.2% sand, and two sand rootzones with 92% and 95% sand. Organic matter content in the 12 soils ranged from 1.0 to 9.1% by weight (Table 2). Bulk density values in the heavily trafficked centers ranged from 1.25 to 1.68 g cm-3 with bulk density increasing as the sand content increased (r = 0.93).

Moreover, as the sand content in the soil increased, smoothness of the surface increased (r = 0.88) and the overall field quality increased with greater sand content (r = 0.69). Field turf density also improved commensurate with an increase in sand content (Table 3). The improvement in turf density, smoothness, and overall field conditions are likely the result of better wear tolerance and a firmer surface as shown by our previous studies.

>> **Figure 1. PANELS TO THE LEFT** show high maintenance soccer field while the panels to the right show low soccer maintenance field receiving the same level of use of 146 hours for the season.

Surface smoothness and overall field quality also improved as the bulk density increased (r = 0.81 and r = 0.58, respectively), largely a result of a firmer surface due to greater sand content. We previously had found a highly significant correlation between surface hardness and bulk density.

USE AND INJURIES

The only effect from hours of use was on turf density, hardness and penetration resistance. As the hours of use per year increased, turf density decreased while hardness and penetration resistance increased. A loss in turf density was related to an increase in player to surface injuries. This accounted for 39% of injuries related to the field surface with higher densities associated with fewer injuries. These results underscore the relative importance of sustaining higher turf density for better cushioning and safer playing surfaces. To that end, overall field quality increased with higher N with an average seasonal N rate in this study approaching 4.5 lbs per 1000ft2.

We found no relationship between overall field conditions and hours of use. See Figure 1 in which hours of use were the same for two fields but maintenance input differed. An increase in maintenance input was closely associated with an increase in shoot density, surface smoothness and overall field quality; the likely reason for fewer injuries being reported. Shoot density was the single most important factor accounting for 39% of field related injuries with higher densities associated with fewer injuries. ■

W. M. Dest is Associate Extension Professor emeritus, University of Connecticut Storrs and sports turf consultant specializing in soil physical properties. J. S. Ebdon is Associate Professor of Turfgrass Management at the University of Massachusetts Amherst.