Sand Survey

by Larry Stowell, Ph.D.

In 1994, a Soil Works Golf Tournament was hosted by Eric Lover at Dove Canyon. We had hoped to have 50 superintendents participate in the event which would have resulted in 100 sand analyses (two analyses were provided to each attending superintendent who wanted to participate). Only 9 superintendents chose to participate in the sand survey making statistical analysis a bit more challenging. This is not the reason for the long delay in presentation of preliminary results, the project was more difficult than initially perceived. The following is a preliminary report that summarizes our findings. The full report will be included in the 1994 PTRI Annual Report that will be completed this month (I hope).

Summary: A proposed method of measurement has been developed that allows comparison of different sands that may help us understand root zone performance. The measurement utilizes a mathematical model to yield a straight line that describes the particle size distribution. The model reported below may have value in the future to help determine how a green needs to be managed and when a green has outlived its usefulness and should be rebuilt. At this point, I am only speculating about the usefulness of the model. However, the exercise below will help us all better understand some of the complex physical interactions that occur in a golf course green.

Objectives: Evaluate the sand composition of Southern California golf course greens to determine if they are close to or deviate greatly from USGA specifications and determine if there are any correlations between sand composition and the other chemical parameters evaluated during normal soil testing.

Background: The physical characteristics of a golf course green is determined by the size and shape of the sand particles used to construct the green, the age of the green, and the materials that have been added to the green to improve its physical characteristics. Although the USGA has developed criteria for selecting sands for new construction, we do not have a method of easily evaluating the quality of sands from existing greens and how to manage greens of various sand compositions.

The USGA has developed a series of criteria that describe the general parameters for a good performing root zone mixture. Those criteria are: Not more than 10% of particles in the very coarse sand and fine gravel categories (retained on 1 and 2 mm screens). At least 60% of the particles in the coarse sand and medium sand categories (retained on the 0.25 and 0.50 mm screens). Not more than 20% of the particles fall into the fine sand category (retained on the 0.15 mm screen), not more than 5% in each of the very fine sand, silt, and clay categories and not more than 10% total for these categories.

In addition, total porosity should be between 30% and 50%. Air-filled porosity should be between 15% and 30% , capillary porosity between 15% and 25% and saturated conductivity of water should be accelerated for our region at 12-24 inches per hour. Organic matter should be between 1% and 5% (for more information see USGA Green Section Record, March/April 1993).

The above parameters are known to produce a good root zone material for golf course greens that are constructed to meet the other USGA specifications. However, these specifications do not help evaluate our greens. In this study, we developed a new method of comparing root zone mixtures that are already in the ground to determine if we can gain some insight into management based upon the root zone physical composition. This is the first step in developing a better understanding of Southern California golf course green physical composition.

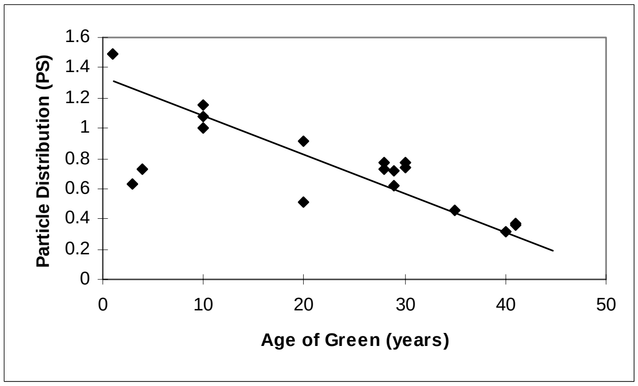
Materials and Methods: Two green soil samples were submitted from each of 9 golf courses. Soils were characterized as either "good" or "poor" performing soils based upon the superintendents observations of performance during the summer months. Each soil was analyzed for physical composition by sieving. In addition, a full chemical analysis was carried out on the soil in attempt to find correlations between soil physical characteristics and chemical composition. All physical and chemical analyses were conducted by Brookside Laboratories, New Knoxville, Ohio. The parameters measured included: age of the green, area of the green (sq ft), number of rounds, variety of turfgrass, number of aerations per year, % sand, % silt, % clay, Organic matter at 440 C, particulate retention on 2.00, 1.00, 0.50, 0.25, 0.15, 0.106 and 0.053 mm screens, total exchange capacity calculated by summation, pH, OM by ashing, sulfur, easily extractable phosphorous, Bray II phosphorous by Melich III, calcium, magnesium, potassium, sodium, % calcium, % magnesium, % potassium, % sodium, % other cations, % hydrogen, boron, iron, manganese, copper, zinc, aluminum, and electrical conductivity. All elements were reported in parts per million (ppm). All statistical analyses were carried out using Systat for Windows, Version 5.0.2, SPSS Inc. Chicago, IL. A full set of raw data is available upon request.

Results and Discussion: In order to evaluate the relationship between each of the parameters, a method called regression or correlation analysis was used. This process is the statistical equivalent of plotting the values on a graph and then determining whether the relationship is significant or if the relationship is simply due to chance. For example, Figure 1 illustrates the interaction between the age of a green and the new parameter that describes particle size distribution (PS). A description of PS will follow. A high PS value indicates that the sand may have a good particle size distribution (other factors that influence a "good" sand will be discussed in the annual report). In the example below, the young green with the PS value of 1.47 meets USGA specification. The negative slope, -33, indicates that as the PS values of a green decreases, the age increases. This suggests that the PS values drop when greens age. The slope of the line is a measure of the strength of the interaction. In this example, the slope of the line is -33 and indicates that it takes about 33 years to drop the PS value by a factor of 1. Further research will be needed to determine the value for PS which results in a difficult to manage green, what management factors might be needed for greens that have lower PS values, and if the PS value can be increased by intensive deep tine aeration and backfilling using a high PS value sand.

At this point, it is necessary to stress that these results are preliminary and should not be used to make management decisions or to evaluate the suitability of a root zone mixture. The USGA specifications are always the target. The PS values developed here will be investigated further to determine if the PS value can be applied to management situations but not for selection of a root zone mixture.

Development of the proposed PS value followed numerous attempts to remove curvature in the percent particle size distribution results. More common methods were implemented but the model chosen provided the best fit lines. For example, Figure 2 illustrates the relationship between the cumulative percent of particles that are retained on each sieve. Only data

Figure 1. Relationship between age of a green and the particle size distribution. The probability that the regression line is due to chance is less than one in 1,000 (P<0.001).



from the 5 largest screens were used in all analyses. The problem with relationships that curve when plotted is that the slope is always changing. Figure 3, on the other hand, illustrates the results of transforming the data using a mathematical equation to yield a straight (or nearly so) line. Straight lines provide many advantages. The example using the age of the green and the PS value illustrated in Figure 1 is a demonstration of how this information might be applied. (Irani, R. R., and Callis, C. F. 1963, Particle size measurement, interpretation and application, John Wiley, NY.).

Regression analysis was used to determine if there were any relationships between the PS value for each sand and the corresponding chemical parameters. Table 1 reports the results of the significant correlations. Some of the more interesting correlations included sodium levels and PS values. In this case, sodium was strongly negatively correlated with PS. If the PS value is high, approaching USGA specifications (about 1.5) the sodium level tended to be low. If the PS value was low, non-USGA specification, the sodium levels were higher. There is an estimated

Figure 2. Screen size and cumulative percentage of particles that are retained on sieves. Curves that do not reach 100% indicate that some particles were smaller than the smallest screen. The lower curve indicates a large proportion of silt and clay particles passed through the small screen. The upper curve is a USGA specification sand.

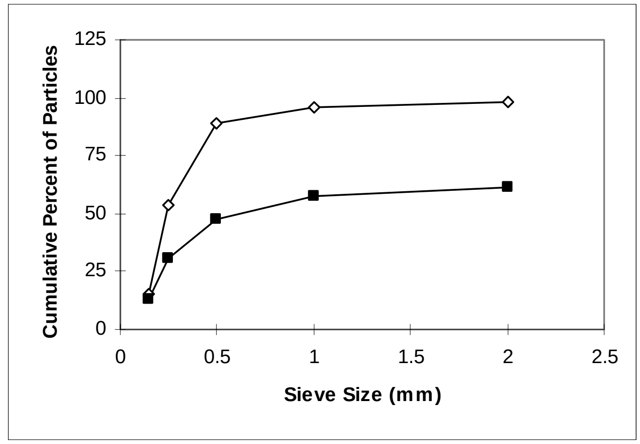
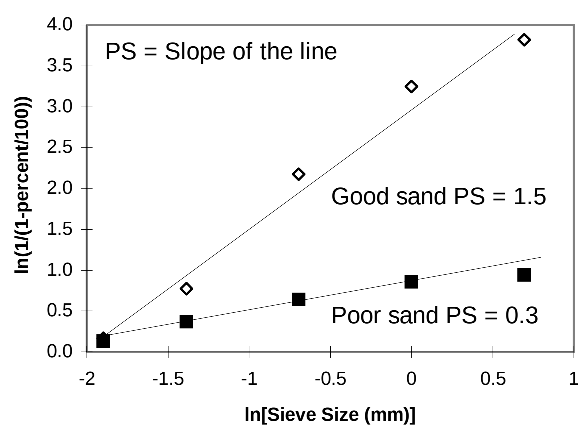


Figure 3. Mathematically "transformed" data that is presented in Figure 2. The advantage of developing linear models is that a slope and intercept defines the entire interaction between sieve size and cumulative particles retained. When the intercepts are similar, only the slope of the lines are needed for investigative purposes.



increase of 100 ppm sodium for a drop in PS value of 1.

Sand % was the only parameter that was positively correlated with PS. The positive correlation with sand % and the negative correlations between silt % and clay % were expected. All of the remaining parameters were negatively correlated. In short, when the PS values drop as the green ages, many nutritional factors accumulate in the root zone sand. One of the strongest interactions is iron where we see an increase of almost 250 ppm when the PS level drops by a factor of 1.

Uncertainty: There is currently a great deal of uncertainty in the potential for use of a model as described above. One important factor is the good correlation between PS and age of the green. Upon further investigation, the age of the greens were also found to be strongly correlated with the same factors listed below. Does the PS value represent aging of sands and decomposition of sands into smaller particles or were the older greens constructed with sands that had lower PS values intially? Correlations alone should be used with caution and they do not necessarily describe a cause and effect relationship. Additional study will help determine if the proposed PS model is meaningful in practical terms. For example, if the PS value drops below 0.5, will the green need to be aerated more aggressively than a green with a PS value of 1.0?

Table 1. Significant correlations between PS and soil chemical factors. Statistically significant correlations must have a probability that the interaction is due to chance of less than 5% or 0.05. The lower the probability due to chance, the more likely the relationship correctly describes the interaction between PS and the parameter.

Parameter	Slope	Regression Coefficient	Probability the interaction was due to chance
Sand %	32.03	0.92	0.000
Silt %	-29.44	0.91	0.000
Clay %	-2.59	0.68	0.002
Age	-33.01	0.75	0.000
OM 440 C	-3.20	0.71	0.001
OM ash	-2.654	0.54	0.021
N-release from OM	-23.72	0.50	0.036
Bray Phosphorous	-69.21	0.51	0.014
Magnesium	-112.33	0.57	0.014
Sodium	-100.58	0.66	0.003
Boron	-0.68	0.72	0.001
Iron	-247.37	0.53	0.025
Copper	-11.09	0.53	0.023