THE INFLUENCE OF TRAFFIC ON TURFGRASS SOILS
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While traffic is something everyone living in Southern California is thoroughly familiar with, it has a different meaning when it comes to the turfgrass environment. There are two components of traffic on turf:

1) Wear—the effects of traffic on the above-ground grass plant and its various parts. It usually involves tearing, abrasion, crushing, or breaking of leaves and/or stems and runners (stolons).

2) Soil Compaction—the result of the weight of a person or vehicle compressing the soil underneath the turfgrass stand. This results in the reduction of pore space between the soil particles and even the flattening of soil clumps or "aggregates" at or near the surface. This reduction in soil pore size hinders entry of water and oxygen into the soil. Less oxygen in the soil impedes root functions such as water and mineral uptake, gas exchange, and root cell division. Less pore space means a denser soil that offers more physical resistance to root growth as well.

Professor John Madison, a former instructor of mine, felt that soil compaction was the single greatest detriment to grass growth in highly trafficked turf situations.

What types of traffic are we talking about?

- Player or foot traffic
- Turf equipment and vehicles (golf carts, mowers, rollers)

These would be the normal, regular sources of traffic encountered daily on sports and recreational turf facilities. Other types of traffic can cause problems on turf such as heavy construction equipment during development of a sports complex or other unusual traffic such as automobile traffic or parking. We won’t assume that these types of traffic are part of the regular compaction causes in this discussion.

Other types of traffic damage include divoting and soil displacement, but since these are readily apparent and are correctable by simple replacement, there is little difficulty in dealing with them.

During 1993 while on a sabbatical leave, I spent four months at the Sports Turf Research Institute, Bingley, England, where I conducted turf traffic trials to evaluate grass species and cultivar wear resistance. After returning to California, I participated in traffic studies at the UCR Turf Research Center, but concentrated more on the soils aspects, rather than the grass effects of traffic.

To evaluate the effect of traffic on soil, specific evaluations of soil cores can determine the changes in soil structure brought on by actual or simulated traffic treatments. Soil structure encompasses two aspects: (1) the pore space between the mineral soil particles; and (2) the physical clumping of soil particles into larger aggregates (soil structure). The size and shape of these larger soil particles account for the amount of large pore space in the upper soil horizon and for the ability of water and air to enter the soil environment. Both aspects determine the density of the soil, especially if the soil is a loam or clay type or a sand with significant clay and/or silt fractions.

Let’s look at the influences of traffic on soils under sports turf or other high use turf areas.

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Pore Space: Soil compaction results in the squeezing of the soil in the upper inch or two so there is less large pore space, making the soil more dense. Clay soils are the most affected by compaction, resulting in the flattening of the "plastic" aggregates when they are wet. This seals off the top of the soil making water penetration and air movement into the soil much more difficult. Without free air and water movement into and through the soil, the pore atmosphere will become saturated with carbon dioxide and other toxic gases from root and microbial respiration. This can result in the death of the root system. Soil that remains saturated with water for long periods due to compaction are even more likely to cause root death since oxygen moves much more slowly through water than through open pores.

Moisture Relations: Soil moisture not only becomes more difficult to manage in a compacted soil but the amount retained in the soil increases. This increased water retention maintains the moist state where further compaction can take place. Dry soils are resistance to compaction, so managing irrigation to avoid wet soil surfaces when heavy traffic is expected will help reduce damage.

Infiltration and Percolation: Water movement into and through soil slows due to reduced pore size.

Soil Temperature: Denser soils hold more water and as a result retain heat longer, resulting in higher summer soil temperatures.

Soil Strength: As particles are pressed together, their cohesiveness increases. In turf this correlates to physical impedance to root growth in soils. An instrument called a Penetrometer is used to measure soil hardness (penetration resistance or soil strength). This instrument provides a quick determination of relative soil compaction on sports turf.

Soil Aeration: Pore space in soils is far more important than the mineral component of soils. Oxygen travels through air 1,000,000 times faster than through water! Water-logged soils (as found in compacted soils) is far less likely to contain adequate oxygen than non-compacted soils. A simple equation for determining soil porosity follows where the soil’s particle density is estimated to be 2.65 megagrams (Mg) per cubic meter.

\[ \text{Total soil porosity} = 1 - \frac{\text{dry bulk density}}{\text{particle density}} \times 2.65 \text{ Mg/m}^3 \]

Bulk Density: This term is used to quantify the density of soils. It is a measure of the dried soil weight divided by the volume of that dry soil sample. Bulk density increases as compaction increases as does water runoff (see Table 1).

\[ \text{Bulk density (g/cm}^3) = \frac{\text{weight (g)}}{\text{volume cm}^3} \]

Table 1. Effect of Foot Traffic on Soil*

<table>
<thead>
<tr>
<th>Compaction</th>
<th>Infiltration Rate (in./hr.)</th>
<th>Runoff from Rain</th>
<th>Non Capillary Porosity of Top Inch (Vol. %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>1.5</td>
<td>0</td>
<td>33.1</td>
</tr>
<tr>
<td>Moderate</td>
<td>0.67</td>
<td>52</td>
<td>19.2</td>
</tr>
<tr>
<td>Heavy</td>
<td>0.35</td>
<td>76</td>
<td>6.1</td>
</tr>
</tbody>
</table>

Table 2. Recommended Soil Porosity for Trafficked Turfgrass

<table>
<thead>
<tr>
<th>Turf Use</th>
<th>% Total Pore Space</th>
<th>% Non-Capillary Pore Space</th>
</tr>
</thead>
<tbody>
<tr>
<td>Golf Green Mix¹</td>
<td>40-55</td>
<td>12-18</td>
</tr>
<tr>
<td>Sports Turf Soils²</td>
<td>-</td>
<td>10-12</td>
</tr>
</tbody>
</table>

¹USGA at -0.04 bars
²J. H. Madison - at field capacity after compaction

References