COMPACTION AND CULTIVATION

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SOIL AERATION AND COMPACTION

Aeration is the process of replacing soil air with air from the atmosphere and is important in sustaining sufficient soil oxygen for root growth and other growth related activities. A major contributor to poor aeration is soil compaction caused by vehicular and foot traffic. Soil compaction can create turf management problems caused by alterations in the physical properties of the soil including:

- **decrease in total pore space:** associated with a decrease in macropore (large) spaces essential for internal drainage, channels for root growth, and air exchange. Micropore (small) spaces actually increase, and in turn increase water retention (although much of this water is unavailable for plant uptake).
- **decrease in soil oxygen content:** oxygen is essential for root respiration and growth. Nutrient uptake by roots is an active process requiring oxygen and therefore nutrient uptake is limited by poor air exchange induced by compacted soils. Respiring roots also produce carbon dioxide (CO_2) which can accumulate to plant damaging levels in compacted soils because of poor gas exchange with the atmosphere.
- **reduction in water infiltration and percolation rates:** which alters irrigation practices and scheduling.
- **increase in soil strength and density:** which reduce rooting density and depth.
- **increase in water retention:** compaction prolongs wet soil conditions which can delay spring green up (by delaying soil warming) and intensify compaction in trafficked areas. Conversely, dry compacted soils in summer warm up faster and promote high soil temperatures which can dramatically slow root growth.

COMPACTION AND TURFGRASS CULTURAL INTENSITY

The decline in root growth (rooting depth and numbers) and shoot growth (shoot density and biomass, growth rates and recovery) caused by soil related stresses associated with compaction can necessitate alteration of turf management practices and increased cultural intensity.

TABLE I. Benefits of commonly used cultivation/aeration methods associated with thatch, compaction, and seedbed preparation. (**KEY**: ◆ = yes, without indicating any level; ◇ = to some extent; √ = to a major extent).

		REDUCES SOIL COMPACTION			
CULTIVATION/ AERATION METHOD	REDUCES THATCH	NONE	SOME	SIGNIFICANT	PROMOTES SEED/ SOIL CONTACT
Power raking	◆	◆			◇
Vertical cutting	◆	◆			◇
Slicing					√
Spiking					◇
Hollow tine coring	◆			◆	√
Solid tine coring			◆		◇

Adapted from "One Solution: Aeration" by F. Buckingham in June 1987 issue of *Grounds Maintenance*.

Changes may include:

- **increased pesticide use:** low shoot density encourages encroachment of weedy species tolerant of compacted sites such as annual bluegrass, goosegrass, and knotweed. The result may be an increase in herbicide use and cost. Reduced turfgrass vigor and favorable moisture conditions can enhance disease activity (brown patch and Pythium blight).

- **increased fertilizer use:** turfgrass nutrient uptake from compacted soils may be reduced by 10 to 30% causing chlorotic, nitrogen deficient turf. However, increasing nitrogen fertilization can make a bad situation worse since the cause of the symptoms is not necessarily nutrient deficiency but rather limited root activity and viability. Additional nitrogen only further reduces rooting potential.

- **increased irrigation frequency and runoff:** irrigation efficiency decreases because low infiltration rates associated with compacted sites may promote pooling (ponding) and surface water runoff which in turn reduces the amount of water available to recharge the rootzone. Typically, multiple cycling of irrigation water (small amounts of water applied over an extended period using several irrigation events) must be practiced, which complicates irrigation scheduling. In addition, because of poor drainage and restricted rooting, small doses of water must be applied more frequently, creating wetter conditions that intensify compaction.

- **increased environmental and wear stress:** plant tissues become more succulent and have lower carbohydrate levels (a condition associated with poor drainage and frequent irrigation) which reduce environmental stress tolerance (heat, cold, drought, disease, wear). Any factor that contributes to increased tissue succulence (such as excess nitrogen, water, shade, and close mowing) in combination with compaction will reduce root and shoot response more than any one of these factors when considered alone. Additional maintenance is required to reduce or eliminate the symptoms.

TURF CULTIVATION PRACTICES AND OBJECTIVES (AND ASSOCIATED BENEFITS)

Turf cultivation practices are typically applied to the rootzone with the intent to limit surface disruption as much as possible. Cultivation methods available to turfgrass managers include coring (hollow tine, solid tine or shattercoring), slicing and spiking. However, these cultivation methods are not necessarily equal in their effectiveness to achieve important cultivation objectives such as thatch removal, alleviation of soil compaction, and preparations to enhance seed/soil contact for overseeding purposes **(Table 1)**, while at the same time limiting surface disruption that can affect turf use and preemergence herbicide effectiveness **(Table 2)**. Cultivation practices such as slicing and spiking, commonly used on golf courses, do not improve soil aeration to the same extent as do core cultivation practices, but are less disruptive to putting surfaces. Coring (especially hollow tine) is more disruptive to surface uniformity and requires a longer period for recovery. However, coring is the most effective method for improving aeration and alleviating compaction. A relatively new technology which uses short bursts of water injected under high pressure has been shown to provide reductions in compaction and improve aeration equal or superior to hollow tine core cultivation with less surface disruption.

TABLE 2 . Side effects of commonly used cultivation/aeration methods associated with surface disruption. (**KEY**: ◆ = yes, without indicating any level).

		DISRUPTS TURF USE			
CULTIVATION/ AERATION METHOD	BREAKS PRE-EMERGENCE BARRIER	NONE	SOME	SIGNIFICANT	POTENTIAL PENETRATION DEPTH (INCHES)
Power raking	◆		◆		
Vertical cutting	◆		◆		
Slicing	◆	◆			3-4
Spiking	◆	◆			0.5-1
Hollow tine coring	◆			◆	2-4
Solid tine coring	◆		◆		2-3

Adapted from "One Solution: Aeration" by F. Buckingham in June 1987 issue of *Grounds Maintenance*.

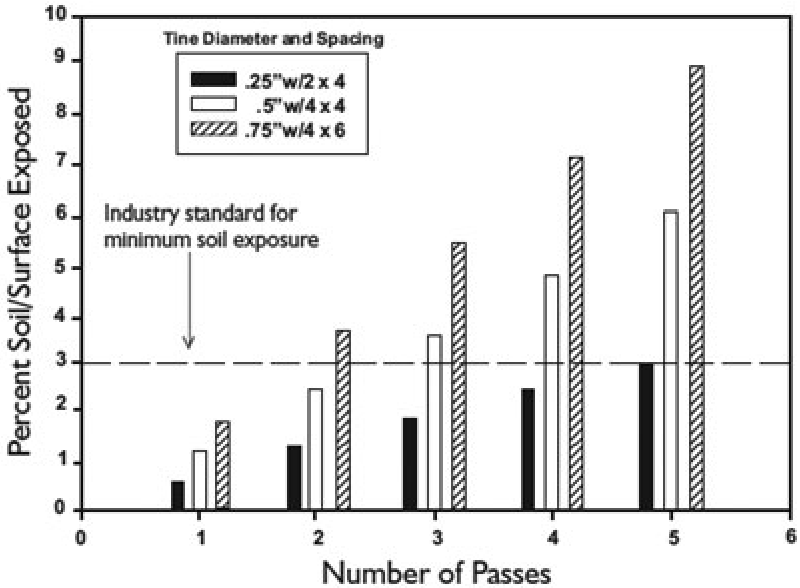
Coring involves closed-hollow tines or open spoons that penetrate the soil and remove (and deposit) the soil core at the turf surface **(see Figure 1)**. Core cultivation is the single most important management tool for controlling compaction. Other benefits of core aeration not listed in **Table 1** include:

- the release of gases such as CO_2 (which begins immediately after coring).
- increased soil infiltration rate which is the result of increased surface area from coring, reducing water runoff and puddling, and allowing wet soils to dry faster. For example, 1,000 square feet of turf after a single aeration event using a .75 inch diameter tine, spaced two inches on center, with a tine penetration depth of 2 inches, would be equivalent to 2180 square foot of surface area after aeration.
- enhanced rooting that occurs within core aerifier holes (within 2 to 3 weeks after coring).

- decreased thatch accumulation following core cultivation. This results from soil cores intermingling with the organic thatch layer and from accelerated decomposition associated with more favorable conditions (aeration) for microbial activity. Substantial amounts of thatch can be physically removed by core cultivation if thatch-containing plugs are collected and removed. The extent of thatch removal will vary with tine diameter, tine spacing, and the number of passes but can be as much as 10% or more **(see Figure 1)**.

- increased fertilizer uptake and use that results from aeration. Aeration also promotes incorporation of immobile materials such as lime and phosphorus into the rootzone.

FIGURE 1. Percent soil and surface exposed during coring operation: effects of tine diameter (inches), spacing (inches), and number of passes.



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