

The benefits of golf course turf

In the face of today's increased public scrutiny, this review summarizes the multifaceted benefits golf courses provide not only to wildlife and the environment, but to entire communities, as well.

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Over the past several years, allegations concerning the adverse effects of golf courses on environmental quality have received national media attention. These allegations were typically based on invalid, pseudo-scientific arguments that were nonetheless effective in enticing the media to promote these suggestions to a largely uninformed public. This article addresses our current state of knowledge concerning the benefits of golf course turf — as documented by sound scientific information.

Keeping perspective

A typical 18-hole golf course in the United States comprises 2 to 3 acres of putting greens, 1.5 to 3 acres of tees and 25 to 30 acres of fairway (Table 1). In other words, only 20 to 30 percent of the golf course area is used and maintained to meet specific criteria of the game. Thus, a majority of the property is devoted to low-maintenance rough, natural landscapes and water features.

In fact, a properly planned and maintained golf course offers many benefits to the overall community, in addition to the enjoyment, and physical and mental health benefits provided by the game itself. These environmental and human benefits are substantial when compared with those of alternate uses such as industrial buildings, businesses and residential housing — especially in urban areas, where a majority of golf courses are located. Greater environmental benefits also are derived from golf course facilities when compared with agricultural production in rural areas.

Humans have used turfgrasses to enhance their environments for more than 10 centuries. However, the scope and complexity of their environmental benefits are just now being quantitatively documented. In general, turfgrass benefits may be divided into three components: functional, recreational and aesthetic. This article summarizes the major benefits of golf courses resulting from their extensive use of turfgrasses, as well as the associated use of trees, shrubs and flowering plants.

FUNCTIONAL BENEFITS

Turfgrass serves as an inexpensive, durable ground cover that protects our valuable, non-renewable soil

resources. In fact, perennial turfgrasses are one of the most cost-efficient means of controlling soil erosion from wind and water, and thus are very important in minimizing dust and mud problems around homes, businesses, schools and other public facilities.

Studies and research reviews have shown that dense grass stands modify the flow of water over land such that the runoff is insignificant in all but the most intense rainfall events (23, 31, 33, 45, 46). In fact, only a few large storms each year are responsible for most soil erosion losses.

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The turfgrasses that cover the world's golf courses offer a wealth of benefits to society, including pollution control, soil building and temperature moderation.

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A key characteristic of mowed turfgrass that contributes to effective erosion control is a dense ground cover with a high shoot density that typically ranges from 30 million to more than 8 billion shoots per acre (5, 29). Regular mowing, as a practice in turf culture, enhances tillering, thereby increasing shoot density substantially compared with ungrazed grassland (5). Putting greens mowed at a height of 0.15-inch (4 mm) possess about 27 billion shoots per acre. Researchers have concluded that properly maintained turfgrass stands should not be a significant source of sediment entering bodies of water (22).

Some environmental activists and governmental officials are promoting the use of trees and shrubs to curb erosion along stream banks, waterways and other bodies of water, while discouraging the use of turfgrasses under the idea that clippings and lateral and subsurface movement of nutrients will pollute the water. However, the sparse nature of the surface cover and root systems of trees and shrubs does not even approach the effectiveness of grasses in controlling surface soil erosion. In addition, the pollution of water bodies by clippings has not been documented and is of questionable significance, particularly in relation to the volume and nutrient content of tree leaves that fall into water.

In summary, the effective erosion control provided by turfgrass is the combined result of a high shoot den-

sity and an extraordinary root mass for soil surface stabilization, as well as a unique shoot biomass matrix that provides resistance to lateral surface water flow, thereby slowing otherwise potentially erosive water velocities. When this major benefit is combined with the benefits of groundwater recharge and organic chemical decomposition, the relatively stable turfgrasses are an effective ecosystem for soil and water conservation, as well as soil restoration.

Surface water protection and groundwater recharge

A key mechanism by which turfgrasses conserve water is their superior capability to essentially trap and hold runoff, which results in more water infiltrating through the soil-turfgrass ecosystem. A mowed turfgrass possesses a low-growing leaf and stem biomass that ranges from 890 to 26,700 pounds per acre, depending on the grass species, season and cultural regime (27). This biomass is composed of a matrix of relatively fine-textured stems and narrow leaves with numerous, random open spaces. The matrix is porous in terms of its water infiltration capability.

Turfgrass ecosystems often support abundant populations of earthworms (34, 35). Earthworm activity increases the amount of macropore space within the soil, which results in higher soil water infiltration rates and water-retention capacity (28).

Studies in Maryland concerning

surface water runoff from turfgrass vs. conventionally cultivated tobacco reveal 10-fold reductions in water runoff, 190-fold reductions in nitrogen runoff, and 54-fold reductions in phosphorus runoff from turfed areas (Table 2). Other investigations have shown a similar ability of turfgrass to reduce runoff and therefore enhance soil water infiltration and groundwater recharge (7, 22, 25, 31, 45). Since turfgrass reduces runoff volume, it also decreases stormwater management requirements, such as costly concrete structures, that are frequently specified in urban tract development (38).

In urban areas, the runoff and sediment that occurs from impervious surfaces carries many pollutants (38), including metals such as lead, cadmium, copper and zinc; hydrocarbon compounds such as oil, grease and fuels; and household and industrial hazardous wastes such as waste oils, paint thinners, organic preservatives and solvents. Turfed catchment areas should be designed to hold, filtrate and degrade these polluted waters (38) before they enter streams, ponds and lakes.

Biodegradation of organic chemicals

A large population of diverse soil microflora and microfauna are supported by the soil-turfgrass ecosystem. Microflora constitute the largest proportion of the decomposer biomass of most soils. The bacterial biomass component ranges from 3.3 to 33 pounds per 1,000 square feet, and for fungi, 5.5 to 50 pounds per 1,000 square feet, with actinomycetes probably in a similar range (1). The soil invertebrate decomposer biomass ranges from 0.1 to 2.2 pounds per 1,000 square feet, with the higher values occurring in soils dominated by earthworms (15). Though soil animals play an important part in the decomposition process, only 10 percent or less of the carbon dioxide produced during decomposition has been attributed to them (32).

The bacterial population in the moist litter of grass clippings and thatch associated with a turf is commonly about 64.5 billion organisms per square inch of surface (9). The average microbial biomass pool is reported to

Table 1. Comparative turf use by area for a representative 18-hole golf course in the United States.

Turf use	Area (acre)	Percent of area
Roughs-water-woodland	130.0	72.2
Fairways	40.0	22.2
Building-parking lots	5.2	2.9
Tees	2.3	1.3
Putting greens	2.5	1.4
Total	180.0	

be 623, 756 and 970 pounds C per acre for cropland, forest and grassland systems, respectively (42). A microbial biomass of 1,068 pounds C per acre has been reported for grasslands in the United States (41). Microbial biomass values of mowed turfgrasses are not yet available, but are probably even higher for two reasons: the high carbon biomass contained in the senescent leaves and grass clippings that accumulate near the soil surface, and a more favorable soil moisture regime because of irrigation (42).

The turfgrass ecosystem also supports a diverse community of more than 100 taxa of nonpest invertebrates, including insects, mites, nematodes, annelids and gastropods, and dozens of species of rove beetles, ground beetles, ants, spiders and other groups of invertebrates (4, 11, 12, 13). Earthworms, oribatid mites, Collembola and other invertebrates also are abundant in turfgrass soils (4, 35, 44).

In summary, a diverse, large population of soil microflora and -fauna are supported by the decomposition of turfgrass roots, rhizomes and shoots. These organisms offer one of the most active biological systems for the degradation of organic chemicals and pesticides trapped by the turf matrix. Thus, this turf ecosystem is important in the protection of groundwater quality.

The gaseous dimension of atmospheric pollution control also is a concern. Carbon monoxide (CO) concentrations greater than 50 μ l often occur in urban areas, especially along roadsides (24). Certain turfgrasses, such as tall fescues, are useful as absorbers of carbon dioxide from these environments (19). More research, however, is needed on this aspect.

Soil restoration and improvement

An extremely important function of turfgrass is soil improvement through organic matter additions derived from the turnover of roots and other plant tissues that are synthesized from atmospheric carbon dioxide (CO₂) via photosynthesis. A high proportion of the world's most fertile soils has been developed under grass cover (20). The root depth potential of turfgrasses ranges from



In addition to the functional benefits of golf course turf, the recreational benefits to the more than 24 million American golfers are undeniable.

1.5 to 10 feet, depending on the species, extent of defoliation and soil/environmental conditions. Generally, C₄ perennial, warm-season turfgrasses produce a deeper, more extensive root system than the C₃ perennial, cool-season species (6).

More work has been reported on the rooting characteristics of Kentucky bluegrass than any other species. The root system biomass of a Kentucky bluegrass turf is in the range of 9,790 to 14,330 pounds per acre (8, 18). In the upper 6 inches of soil there are approximately 461,7000 roots and 2.3 x 10⁸ root hairs per gallon of soil, with a combined length of more than 174 miles and a surface area of about 106 square feet (17). This extraordinarily fibrous root density also makes turfgrass highly efficient in taking up applied plant nutrients, with the result being a negligible downward movement through the soil profile.

One researcher estimated that the annual root system turnover rate was 42 percent for turf (18). Using his esti-

mate, 6,017 pounds of root biomass per acre would be turned over into the soil each year. This estimate is low, however, because it does not account for root secretions, death and decay of fine roots and root hairs, and consumption of roots by soil animals (16, 39, 40).

Planting perennial grasses can accelerate soil restoration on environmentally damaged areas, such as highly eroded rural landscapes, burned-over lands, garbage dumps, mining operations and steep timber harvest areas. These areas may then be developed for golf courses and recreational uses.

Heat dissipation and temperature moderation

Turfgrasses dissipate high levels of radiant energy in urban areas through the cooling process of transpiration. The overall temperature of urban areas may be as much as 9 F to 12 F warmer than that of nearby rural areas. Irrigated, green turfgrass surfaces are especially effective in transpirational cooling. The maximum daily canopy temperature of a green bermudagrass turf was found to be 38 F cooler than that of an adjacent brown dormant turf, and 70 F cooler than a nearby synthetic surface (Table 3). The transpirational cooling effect of green turf and landscapes can save energy by reducing the energy input required for interior mechanical cooling of adjacent homes and buildings (26).

Noise abatement and glare reduction

The unique surface characteristics of turfgrasses function in noise abate-

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Table 2. Comparative surface water runoff losses from cultivated tobacco and turfgrass assessed on the same research site in Maryland.

Usage	Surface runoff loss		
	Inch/acre/month of water	Pounds/acre/month	
		Nitrogen	Phosphorus
Tobacco	0.1	2.08	0.42
Turfgrass	0.01	0.011	0.0078

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ment, as well as in multidirectional light reflection, reducing glare. Studies have shown that turfgrass surfaces absorb harsh sounds significantly better than hard surfaces such as pavement, gravel or bare ground (14, 37). These benefits can be maximized by an integrated landscape of turfgrasses, trees and shrubs. Unfortunately, the proper use of this combination of plants to maximize noise abatement has received little attention within the scientific community. Additional research is needed on this beneficial dimension.

Other functional benefits

Another long-recognized benefit of closely mowed turf is that it substantially reduces the number of nuisance pests such as rodents, mosquitoes, ticks and chiggers, thereby facilitating comfort in outdoor recreational and relaxation activities.

Several key insect vectors such as mosquitoes and ticks carry a number of serious human diseases. Of current concern is Lyme disease, which is spread by a tick commonly found in unmowed tallgrass and woodland-shrub habitats. A closely mowed turf offers a less favorable habitat for nuisance insects and disease vectors (10). Chigger mite population densities were found to be highest at the ecotone or transition area of a neighboring 24-inch tallgrass area beyond a mowed turf.

In addition, pollens can cause allergy-related discomfort and potentially serious health problems to susceptible individuals. Dense turfs



Landscape views and panoramic vistas offer golfers a sense of well-being and reduce the stress of today's lifestyles.

typically are void of the many weedy species that often produce allergy-related pollens. Furthermore, most turfgrasses mowed regularly at a low height tend to remain vegetative with minimal floral development, and thus have reduced pollen production. Cultivars are also available that do not produce pollen.

From a monetary standpoint, the golf industry contributes in excess of \$18 billion annually to the U.S. economy. This amount represents many jobs and a major allotment to the national economy.

Favorable wildlife habitat

The more than 70 percent of a golf course facility that is allocated to roughs and nonplay areas encompasses turfgrasses, trees and water in the primary rough, and turfgrasses, flowers, shrubs, trees and water in the secondary rough and perimeter areas. A diverse wildlife population can be achieved with an integrated landscape composed of turfgrass, tree, shrub and water features, such as that found on golf courses (21, 30). A study of golf

courses and parks in Cincinnati has shown conclusively that passerine birds benefit from golf courses, even to the extent that golf courses may be described as bird sanctuaries (2). Ponds, lakes and wetlands are very desirable features as used on golf courses because they create aquatic habitats, as well as diversity in the aesthetics of the landscape. Furthermore, properly designed urban landscape "green" areas such as golf courses and parks can promote plant and animal diversity, natural habitats and wetlands when compared with intensive agriculture and urban residential and business zones. Thus, golf courses are important naturalized spaces and habitats for wildlife, especially in areas of urban development and intensive agriculture. An effective strategy to communicate this beneficial role would be to publish and distribute or post a list of species observed on the golf course.

RECREATIONAL BENEFITS

There are approximately 15,000 golf courses in the United States, and together they offer 24 million golfers more than 2.4 billion hours of healthy outdoor exercise and enjoyment. The enjoyment and physical and mental health benefits derived from golfing on natural grasses are vital to a contemporary, industrialized society, especially in densely populated cities.

AESTHETIC BENEFITS

Most city dwellers appreciate the importance of green areas with views of grass, trees and open space, such as those provided by golf courses. Cities can be quite dismal without green grasses, with the consequences to inhabitants being a loss of productivity and a greater susceptibility to anxieties and mental diseases. For example, an outdoor view can contribute to a more rapid recovery of hospital patients (43). The role of nature — including parks, woodland areas and large landscape sites such as golf courses — in contributing to the quality of life and mental health of those in urban areas is significant (27). When there is a nearby natural landscape, individuals have an increased sense of neighborhood satisfaction

Table 3. Comparative temperatures of four surfaces assessed in August, College Station, Texas.

Type of surface	Maximum temperature in ° F	Percent temperature increase over green turf
Green growing turf	88	--
Dry, bare soil	102	16
Brown, dormant turf	126	43
Synthetic turf	158	80

and of general well-being.

Turfgrasses provide natural beauty and attractiveness that enhance the quality of life for human activities. The natural green of turfgrasses provides a pleasant, clean, cool environment in which to work, live and play. These aesthetic values are of increasing importance to the spirit and the mental health of citizens enmeshed in a rapid-paced lifestyle and ever-increasing urbanization. □

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