

# A Healthy Ecosystem

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## Why Turf Needs “Good” Nematodes

**D**o you know that terrestrial ecosystems (which include turfgrass systems) would not function well without the right types of nematodes? Terrestrial ecosystems continue to function well as long as beneficial organisms are present in adequate numbers and at the right time in the web that supports these systems. The turfgrass soil system would function poorly if the right types of beneficial organisms were not present in optimum numbers. If the soil in the turfgrass system harbors the right balance and types of organisms (example bacteria, fungi, protozoa, nematodes, tiny arthropods including certain mites), only minimal input of fertilizer and other agrochemicals may be necessary for adequate management of the turfgrass. This would mean reduced costs associated with fertilizer and pesticide applications, fewer trips to the greens, and decreased probability of ground or drinking water contamination. One attribute of a healthy ecosystem would be the absence of negative impacts on adjacent systems (for example, streams and other contiguous aquatic systems).

### Simple Bacteria to Complex Animals

The turfgrass soil ecosystem comprises essentially a microbe-animal-plant-soil aggregate system. The most abundant animals in the turfgrass soil ecosystem are nematodes. Bacteria and fungi are the most abundant organisms but they are comparatively simple life forms. Pro-

tozoa (for example amoebae, ciliates and flagellates) are next in complexity although still relatively simple (since they lack organ systems). Nematodes are complex, animalistic organisms, which possess organ systems (connected by nerve cells). The great majority of nematodes play beneficial roles in the soil ecosystem. Many feed on soil bacteria, while others feed on fungi. Still there are others that feed on other nematodes (predators) or those with no apparent specialty (omnivores). Only a minority of nematodes directly rob nutrients from plants.

### Microbes Lock Up Nutrients

Plants, including grasses, have for millions of years thrived and protected themselves using a cooperative system that works well (without need for substantial fertilizer inputs). In that system, the most numerous and ubiquitous inhabitants (bacteria) possess elaborate enzyme (protein) systems that allow them to break down complex organic matter. These soil bacteria have a very high requirement for nitrogen to make proteins. Proteins essentially run the whole show in living things. If you ignored all components except the carbon and nitrogen that make up a bacterium, then about 1/6 or so of the bacterium would be nitrogen. This means that a lot of the nitrogen in organic matter or free nitrogen in soil solution is eventually locked up inside bacteria. Therefore, if your turf soil had only “good” microbes (and no other organisms such as nematodes and protozoa), a

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significant amount of nitrogen and other nutrients would be locked up by these microbes and would be unavailable to the plant roots. This is significant when we consider the fact that each millimeter cube (not meter!) of turf soil could potentially harbor 1 million or more bacteria.

## Nematodes Help Unlock Nutrients

So how can the nitrogen locked up in microbes become available for plant uptake? That is where the primary consumers come in. The most abundant primary consumers in a healthy soil are the protozoa and tiny invertebrate animals such as nematodes (good nematodes!). The carbon-to-nitrogen ratio in animals such as nematodes is many times higher than that in bacteria, and so nematodes have a high demand for carbon. To get enough carbon, bacterial-feeding nematodes must consume many bacteria to satisfy their appetite for carbon. But since bacteria have a relatively high nitrogen (low carbon) content because of their highly proteinaceous nature, nematodes must excrete the excess nitrogen (usually as ammonia) that would otherwise build up to toxic levels in their bodies. The excreted ammonia is converted to nitrate, which becomes available for uptake by plant roots. Therefore primary consumers

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Nematodes in turn become a food source for predator nematodes, small arthropods, and fungi that feed on nematodes. Thus in a healthy turf system, populations of microbes, nematodes and other soil inhabitants are kept in check naturally. It is important to note here that the soil ecosystem is far more complex than what you and I at this moment are attempting to visualize. Only a minute fraction of all the species of life forms in the soil ecosystem have been identified and characterized by scientists. However, the roles of many key players are known.

## Free-Living Nematodes Up, Root-Feeding Nematodes Down

All turf systems will have at least one plant parasitic nematode species present. Plant parasitic nematodes poke many microscopic holes in roots and may cause significant leakage of plant cell contents when they feed on turf roots. In a healthy soil ecosystem with a well balanced community of predators, prey, and antagonistic microbes, proper organic matter decomposition, good soil structure/tilth and intact nutrient cycling processes, the number of root

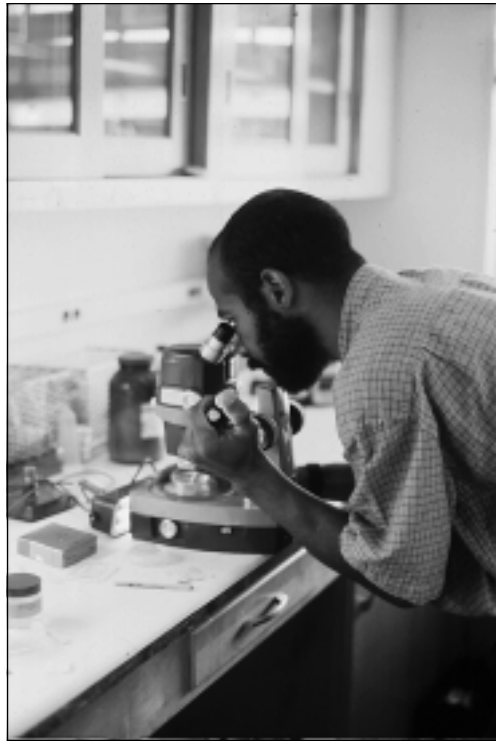
Sampling turf for “good” nematodes.



punctures by plant parasitic nematodes will be at a minimum. A strong correlation may exist among the best plant responses, lowest numbers of plant parasitic nematodes and highest numbers of free-living (beneficial) nematodes. Organic matter decomposition products are thought to increase overall numbers of bacteria in the soil, which will increase bacterial-feeding nematodes that may cause increases in nematode-feeding fungi, which in turn do not discriminate and will feed on plant parasitic nematodes also. Infected or antagonized plant parasitic nematodes have decreased chances of puncturing, withdrawing or causing leakage of nutrients from plants. Leaky or punctured roots attract secondary fungi and bacteria that accelerate root rots or simply debilitate or predispose root systems. A compromised turf root system will not take up nutrients properly and will be more susceptible to invasion by pathogenic fungi and bacteria (which in fact are only a small minority).

## Encourage All Types of “Good” Nematodes

Turfgrass managers need to encourage the buildup of free-living nematodes in their turf. They should attempt to maximize the ratio of beneficial to plant parasitic nematodes in their turf. Entomopathogenic nematodes, which are special types of bacterial-feeders, comprise only a tiny fraction of the beneficial nematodes in soil. In fact, entomopathogenic nematodes are parasites (of insects) and not free-living nematodes per se. Their survival depends on a selfish requirement to feed on “clean” bacteria inside an infected insect. However, an increase in all types of beneficial nematodes should be encouraged. Superintendents should request a count of the number of all beneficial nematodes in their turf when submitting samples to a lab for nematode analysis. Simply divide the number of beneficials by the number of plant parasitic nematodes to get a ratio for your turf. Separate samples should be taken from trouble spots and healthy-looking areas in mid-spring and mid-fall. One way turf managers inadvertently destroy beneficial nematode animals in their soil system is with applications of certain agrochemicals repeatedly or in high concentrations to the turf. If zero nematodes are counted in your soil sample, then your soil system is certainly unhealthy (for want of a better word). The health of the microbial population in your soil will be reflected in the status of free-living nematodes thriving in your turf soil ecosystem.



*Extracted nematodes being studied in the laboratory.*

## Bioindicators of Soil Vitality

The presence of nematode animals in the turf soil system is a sign of soil vitality. Soil vitality (presence of beneficial animals) is indicative of good soil health. Because golf courses and lawns are not isolated systems like aquaria or indoor plants growing in a suitable potting mix, the need to maintain healthy soil ecosystems is an imperative (especially if we must protect contiguous ecosystems). One obvious signal or sign of trouble (degradation) would be the absence of beneficial nematodes or a preponderance of plant parasitic forms. Microbes are extremely important in healthy soil systems for capturing nutrients and forming humus. However, without ‘predators’ of microbes (for example nematodes, protozoa, etc.), a substantial portion of unleached nutrients immobilized by microbes may still not become available to plants in adequate amounts for growth.

Moreover, nematodes possess sensory nerves just like the ones in the human nostril and so these animals are very sensitive to changes in soil health status. Free-living nematodes therefore integrate or reflect the functioning of essential processes in your turf soil system. Because of the ubiquitous distribution of nematodes and their possession of sensory organs, we are using free-living nematodes in turf systems to give an early warning of potential environmental problems.

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