Small in size, great in importance: Invertibrates in your soil

Andrew Moldenke, Summer 2001

Though it is both conventional and convenient to describe soil properties in chemical and physical terms, it is actually the biological component of soils that is far more significant for tree growth. Certainly over the course of years and centuries nutrients are incrementally obtained from the truly inorganic components of rocks and soil, but the vast majority of all the useful nutrients in the soil at any point in time are held in organic forms within the living biomass of soil microbes (bacteria and fungi).

Soil microbes function as a living sponge and obtain nutrients as they become available through decomposition or deposition. The more bacteria and fungi in the soil, the more efficient the sponge will be. Soluble nutrients not taken up by the soil microbes are lost to groundwater or stream runoff. Soil fauna regulates both the rate of incorporation of nutrients into the microbial biomass and the rate it cycles from the microbes into the tree roots.

Why should a landowner care about the tiny creatures in the soil? The most direct way soil invertebrates influence tree growth is by releasing soluble nutrients in their feces. Soil microbes rapidly absorb the majority of soluble nutrients in the forest soil because microbial metabolic rates and active surface areas are vastly greater than tree roots. By feeding upon microbes and excreting excess nutrients, soil invertebrates bit-by-bit (actually bite-by-bite) drive the flow of nutrients out of the soil microbes and into the tree roots. Remove the soil fauna and plant growth comes to a halt.

Fortunately, soil fauna is both plentiful and diverse. On the larger end of the scale, there are often 250,000 arthropods (insects and their relatives) in a single square yard of soil-literally hundreds of species. The most numerous arthropods are the fungivorous turtle-mites and springtails. At the smaller end there are usually thousands of bacteria-feeding and fungus-feeding nematode roundworms and tens of thousands of bacteria-feeding protozoa for every spoonful of forest soil! These may sound like large numbers, but they are small in comparison to a hundred miles of fungal strands (hyphae) per teaspoon and tens to hundreds of millions of bacteria per spoonful-perhaps more than 10,000 species per spoonful as estimated by microbial geneticists. Truly the soil is alive. Not only does soil seethe with life, but its structural components from the mostly organic humus down to the mostly inorganic A-horizon are actually the invertebrate fecal pellets themselves.

Northwest forest soils have the highest biomass of soil microbes and highest abundances of soil fauna worldwide. Natural variability in climate (day to day, year to year, northslope to southslope) leads to the evolution of a diverse soil fauna. The high levels of biodiversity in the soil then promote the stability of the forest community by buffering the effects of climate and disturbance ranging from forest fires to clearcutting. Some processes, like erosion and compaction, are serious threats to plants and soil fauna alike-but on the whole our soil health is very resilient. Because our soils are so biodiverse, the fauna differs distinctively by altitude, slope-face, humidity, canopy cover, plant litter species, and even by distance to nearest tree trunk or fallen log. Since all life in the soil is linked within the same foodweb (who eats whom), it is possible to use changes in the arthropod community (relatively easy to sample and identify) as indicators of potential serious changes in the microbes (very difficult to study).

Indicator species are an especially useful tool with which to evaluate the effects of forest practices and can be used to determine how long it takes soil microbes to recover. Ideally, indicator species analysis can identify which management protocols are most appropriate under different conditions. The non-target effects of protocols on soil biota are seldom evaluated, so use careful common sense as the soil biota are our most precious terrestrial ecological resource.

For example, since mites and springtails cannot return to original population densities until the microbes have recovered from prescribed burning, USDA Forest Service soil fauna analysis have proven that spring burning is both far less disturbing and far quicker to recover these species than summer burning.

Although we have examined so far how nutrients get from the microbial sponge into tree roots and how diverse that system is, we must consider the other element of nutrient "recycling"-how the nutrients from dead plant parts end up incorporated into microbial biomass. The chemical changes of decomposition are caused by exoenzymes released by fungi and bacteria into the soil immediately around them (just like we release enzymes into our intestine). For these enzymes to act, the soil nutrients have to be exposed to them. Nutrients in dead leaves or wood are locked up within plant cell walls. It is the role of the shredder (detritivore) to crush up the plant cells, break them open and expose the nutrients inside to enzyme attack.

Throughout Northwest forests, the principal shredder is the cyanide-producing millipede (Harpaphe haydeniana), which has a shining black body and bright orange racing stripes. Since the millipede crushes, filters and then recrushes its dead leaf diet, it increases the availability of nutrients 40,000-fold. After extracting what it needs, the millipede defecates a pellet of partially used nutrients covered with microbial fuel (intestinal mucus). Immediately, a microbial garden grows on the surface and then a soil fungivore comes along and breaks up the pellet, feeds, excretes with its own mucus, and the whole process repeats over and over again until all the nutrients are used up. It is the shredder that is key to the process. The cyanide-producing millipede alone eats 33 to 50 percent of all the dead coniferous and deciduous leaves that come to rest on the forest floor. It is one of the most critical links in the entire soil foodweb.

The next time you walk over the forest floor, remember that about 18,000 backs held up by 120,000 little legs (calculations based on my 9-½ shoe size) are supporting your boots. Just two of those tiny species (actually two springtails less than one-tenth of an inch long) that mix and detoxify the poisonous chemicals in oak leaves with inorganic clay particles in their guts are responsible for the growth of oak trees. Without these springtails, oak leaves would not decompose and tree growth would stop. Being tiny is not the same as being unimportant.

Glossary of Terms

Arthropods: Insects and their relatives.
Biomass: The total quantity, at a given time, of living organisms of one or more species per unit area or of all the species in a community.
Biota: The plant and animal life of a region.
Exoenzymes: Enzymes (protein-like catalysts that speed up chemical reactions) outside of the "body."
Fauna: Animals as a whole, especially those of a specific region.
Humus: Brown or black substance matter from partial decay of plant or animal matter.
Invertebrates: Lacking a backbone or spinal column.
Organic: Derived from living organisms.
Soil microbes: Bacteria and fungi.
Soluble: Capable of being dissolved.

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