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Forests of NW conceal startling biological secrets

☐ Scientists estimate that 8,000 species inhabit a single site

By JON R. LUOMA

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Environmentalists have focused great attention on spotted owls and old-growth trees in the forests of the Pacific Northwest.

But a small cadre of researchers who have been studying insects and other invertebrates of the forest soil now say that the old-growth forest has been hiding underfoot perhaps its most astonishing biological secret.

Detailed studies of arthropods, including insects, spiders, mites and centipedes, in the soils of old-growth forests suggest that the soil under the region's forest floor is the site of some of the most explosive biological diversity found on Earth.

Some experts believe that these temperate forests harbor a diversity of species that approaches the much-touted biological diversity of tropical rain forests.

As part of one of the most detailed analyses of arthropod diversity ever conducted, scientists now estimate that about 8,000 species inhabit a single study site in an Oregon old-growth forest, most of them in the soil.

The findings are "especially surpising because we think of that kind of diversity as being related to the tropics, not the temperate forests," said Melody Allen, executive director of the Xerces Society, an invertebrate conservation group based in Portland.

Insects: Bugs serve as forests' recycling engines

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But scientists say that those numbers are far less significant than still-sketchy hints of the role insects and other arthropods apparently play in the temperate forest ecosystem.

"We've come to suspect that these invertebrates of the forest soil are probably the most critical factor in determining the long-term productivity of the forest," said Andrew Moldenke, an entomologist at Oregon State University in Corvallis.

In tropical rain forests, twigs, fallen leaves and dead organisms are decomposed rapidly by bacteria and fungi that thrive in the warm, wet ecosystem. But in the temperate forests of the Pacific Northwest, arthropods appear to be linchpins in the decomposition process.

Billions of extremely tiny insects, mites, "microspiders" and other invertebrates serve as biological recycling engines that crush tons of organic litter and debris, from logs to bits of moss that fall to the forest floor, into finer and finer bits.

Bacteria and fungi living in the digestive tracts of the arthropods and in the soil then progressively reprocess the finely crushed, once-living tissue into basic nutrient chemicals to feed roots and, hence, the above-ground ecosystem.

New techniques for solidifying and examining soil samples offer great promise in increasing understanding of the rich ecosystems in the forest soil.

Researchers caution that they still know "almost nothing" about precisely how all the thousands of arthropods interact and survive.

Taxonomists working in the region have been able to identify about 3,400 arthropod species at a single research site, the H.J. Andrews Experimental Forest in Oregon, a sort of living forest laboratory operated by the U.S. Forest Service.

Many of those species have never before been named and described. In comparison, the count of all species of reptiles, birds and mammals combined is 143.

Yet, according to John Lattin, director of the Systematic Entomology Laboratory at Oregon State University, the number of species cataloged so far probably represents less than half of the estimated species present on just the Andrews Forest site.

Simply to describe and name the yet-unnamed species will take years, in part because of the sheer numbers of arthropods in even a small area, according to Lattin.

Most of the soil arthropods are exceedingly small, as tiny as 1 or 2 one-hundredths of an inch long.

That is as small as or smaller than the period at the end of this sentence. And surveys have shown that the soil under a single square yard of forest can hold as many as 200,000 mites from a single suborder of mites, the oribatids, not to mention tens of thousands of other mites, beetles, centipedes, pseudoscorpions, springtails, "microspiders" and other creatures.

Moldenke and his students have in recent years begun studying soil and arthropod ecosystems using a technique called thin-section microscopy, originally developed by oil-exploration geologists.

That approach has revealed that the very structure of temperate forest soils, and hence much of their biological and chemical activity, is determined by the dietary habits of the soil arthropods.

Thin-section microscopy is accomplished by insinuating, in a pressure chamber, epoxy into a carefully removed core of soil.

Once the epoxy hardens, the now rocklike soil sample can be sliced into exceedingly thin wafers and polished smooth for examination under a microscope.

The technique preserves the soil with its parts in place, from larger bits of partly decayed plant matter to microscopic soil particles.

On one such slide, Moldenke showed a visitor the image of what was clearly a needle from a coniferous tree, partly decayed, but still mostly intact.

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Magnified, however, the small needle in the soil turns out to be an assemblage of thousands of infinitesimal fecal pellets arranged in almost precisely the shape of the needle.

Not long after a bit of vegetation falls, millipedes descend on it, grinding it up. Chewed-up bits of vegetation pass through the insects' digestive tracts in a matter of seconds and are redeposited virtually in place as a pellet.

A closer microscopic look at each pellet reveals that each is nothing more than chopped-up bits of plant cells, reassembled into a sort of jigsaw puzzle of plant matter. These tiny clumps of cell tissue will, in turn, be eaten by other arthropods.

Deeper in the soil, the jigsawlike cell-tissues become progressively less recognizable, as successive waves of "microshredder" arthropods crush and partly digest these fecal pellets, like a series of minute millstones grinding food down to finer and finer bits.

Cell tissue cannot dissolve in water. Yet for a living ecosystem to perpetuate itself, nutrient chemicals that are locked into insoluble organic molecules in tissues of dead organisms must somehow be made soluble to be taken up by the roots of plants.

Each arthropod extracts only the whisper of nutrition from food that was once living cell matter. But in the process, each arthropod exposes more surface area to decomposer bacteria.

The bacteria, in turn, biochemically process a trace more cell matter on the pellet's surface into soluble compounds, making more nutrition available to the next arthropod until, eventually, insoluble cell matter becomes soluble nutrients

Precisely how all these biological and chemical interactions occur, and which of the thousands of species' survival is key to the survival of others, are matters that remain poorly understood.

"We've reached the point where we know just a little bit more about the fauna of the forest soil at the end of the the 20th century than was known at the beginning of the 19th," Moldenke said.

And researchers still don't know why there are so many invertebrate species in the forest soil in the first place. "There are still a lot of questions about why there's so much diversity," said Lattin.

Moldenke agreed. "I don't know what the implications of all that diversity are," he said. "Neither does anybody else. And that's the scary part. I guess what concerns us is that the kinds of above-ground ecosystems that most ecologists have studied in the past is a very small part of what's really out there.

"When you have an awful lot of species, it means almost by definition a great number of processes: thousands of different functions taking place. If we instead continue to manage forests on the basis that the ecosystem is much more simple than it really is, we may be setting ourselves up for a big surprise, and it may not be a nice surprise."