ONE ACORN AT A TIME

by Richard Ostfeld and Felicia Keesing

Richard Ostfeld (center) with field technician Kelly Oggenfuss (right) and Michael Newhouse (left)

UNDERSTANDING THE SPREAD OF INFECTIOUS DISEASES

Dutchess County, New York, leads the nation in cases of Lyme disease. The research team of Richard Ostfeld and Felicia Keesing focused on forest patches in the area to show that ecology can help stop the spread of infectious diseases.

The phrase, "Mighty oaks from little acorns grow" is a way of saying that great things can have very modest beginnings. But, once you know a little more about acorns, you might discover that they are anything but modest. We have found, for instance, that we can predict how many cases of Lyme disease will occur in a particular year based on how many acorns were produced two years earlier! How is that possible?

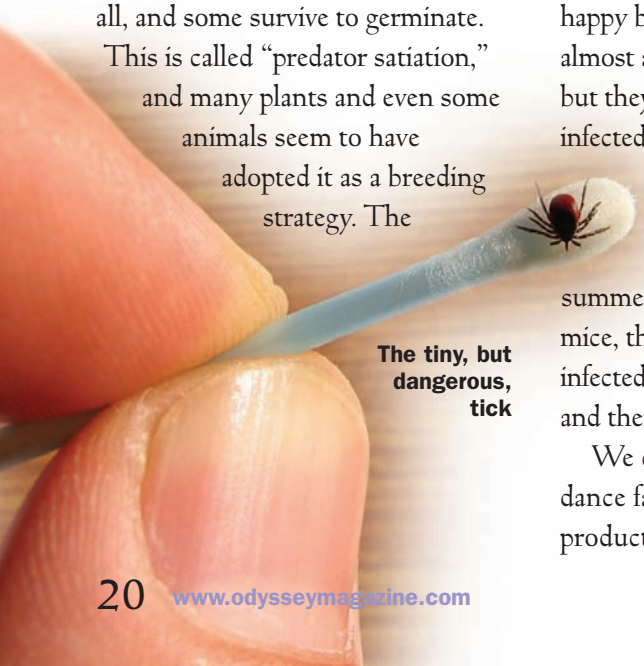
Lyme disease — An inflammatory disease that is transmitted by ticks; symptoms include a rash, fever, joint pain, and headache

Lipids — Organic compounds, including fats and oils, that together with carbohydrates and proteins make up the principal structural material of living cells

So Many Acorns

Let's start with the nutritional content of these nuts. Acorns are filled with enormous quantities of proteins and *lipids*. These nutrients allow newly germinating oak seedlings to grow robust tap roots so that they can quickly penetrate thick leaf litter and start gathering their own water and nutrients. But the cost of providing such a head start to your offspring is that you're also making them quite tasty to *granivores* (seed-eaters). Once they hit the forest floor, acorns are quickly attacked by creatures such as squirrels, bluejays, turkeys, deer, bears, and wild pigs. Acorns are so tasty, in fact, that in some years each and every one that is produced gets eaten, and the poor parent trees fail to produce even a single seedling.

But oak trees have evolved a way of dealing with voracious acorn consumers. They produce so many acorns at once that all the granivores in the forest can't possibly eat them all, and some survive to germinate. This is called "predator satiation," and many plants and even some animals seem to have adopted it as a breeding strategy. The cost to an oak tree of producing many thousands of acorns in a given fall is so great that it takes several years to store up enough nutrients and energy before the tree can do it again. The result of this evolved strategy for foiling seed predators is that extensive oak forests produce bumper crops of acorns every 3 to 6 years or so, with intervening years seeing only a trickle of nuts.

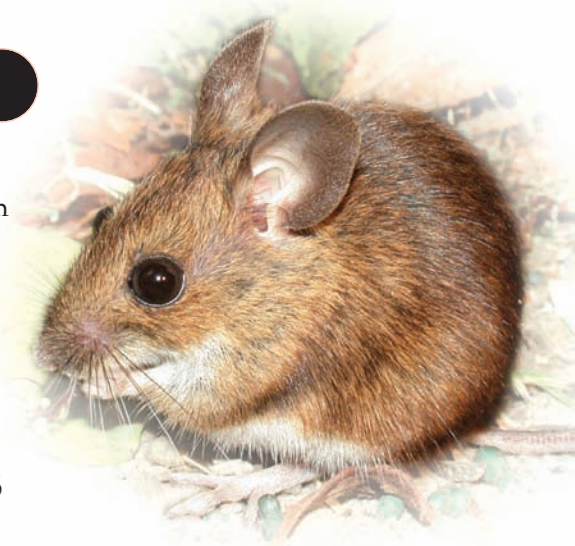


The tiny, but dangerous, tick

Hungry Mice, Ticks, and Lyme Disease

What does this have to do with Lyme disease? The short answer is — mice! The *spirochete* (corkscrew-shaped) bacterium that causes Lyme disease tends to proliferate inside the bodies of white-footed mice, one of the most common and widespread mammals in the United States. Mice get infected when ticks carrying these bacteria bite them, and then mice incubate the bacteria and pass the infection on to the next generation of ticks. These ticks are perfectly happy biting a squirrel or raccoon or almost any other mammal or bird, but they're much less likely to get infected if they bite one of these non-mouse hosts. The more mice scurrying about on the forest floor in any given summer, the more ticks will bite mice, the more ticks will become infected with the Lyme bacterium and therefore be dangerous to us.

We can predict mouse abundance fairly accurately from acorn production the previous fall. This is because during good acorn years, each mouse gathers up hundreds of nuts, creating a huge cache that they then exploit all winter long. Such well-provisioned mice grow fat, survive winter well, and reproduce early and often next spring. The result is that the summer after an acorn year the forest floor is literally crawling with mice. The summer after a good mouse year the forest floor is crawling with infected ticks. Our research has revealed that the size of the acorn crop is an excellent predictor of the number of human Lyme disease cases two years later, when these infected ticks are seeking new hosts.



The cute white-footed mouse aids in the transmission of Lyme disease.

The size of the acorn crop is an excellent predictor of the

The Biodiversity Angle

Acorns aren't the only things that affect mouse numbers. Predatory owls, hawks, weasels, and the like can kill enough mice to regulate their populations. Other small mammals and birds that eat the same foods can suppress mice through competition for this food. By intensively studying the numbers of bird

and mammal species — or *biodiversity* — in forests throughout the northeastern United States, we have found that some of these species — especially larger and predatory species — don't inhabit small patches of forest. When forests are replaced by suburban or industrial developments, the small bits (patches) that remain don't offer these predators enough food or shelter. We predicted that Lyme disease risk would be higher in smaller forest patches. We reasoned that this would occur because mice would be more abundant and also more tick-infested where some of their predators and competitors were absent. Our predictions were strongly supported by data from forest patches in Dutchess County, New York, which leads the nation in cases of Lyme disease. Patches less than about three to four acres had about four times as many infected ticks as patches greater than about 10 acres. Before this work was published in scientific journals there was little evidence that biodiversity can directly protect human health.

Ecology as a Health Science?

Surprisingly enough, more human infectious diseases are transmitted from wildlife *reservoirs* (mostly mammals and birds) than from one person to another. Lyme disease is only one of these; others include plague, avian influenza, West Nile virus, monkeypox, SARS, and rabies. Even HIV/AIDS was originally a disease of apes and only made the species jump to people in the mid- to late-20th century.

Yet other diseases, like malaria, yellow fever, and dengue fever, are transmitted from one person to another by an arthropod *vector* (usually a mosquito or tick). This means that the risk of human disease might depend more on the ecology of the wildlife reservoirs or of the vector than on anything people might do. If we're sick with these diseases we certainly want a doctor who is good at diagnosis and treatment. But if we want to avoid these diseases in the first place, we might want an ecologist to tell us where and when risk will be high.

The best situation of all for public health would be for biomedical experts and ecologists to combine forces to reduce disease. We are trying to facilitate this by describing our results to local, national, and international experts in biomedical sciences. Such communication is harder than it might seem, because different scientific disciplines tend to have different ways of asking and answering questions, and quite different technical languages. We think the avoidance of illness and death are worth making an effort at greater communication between these two fields.

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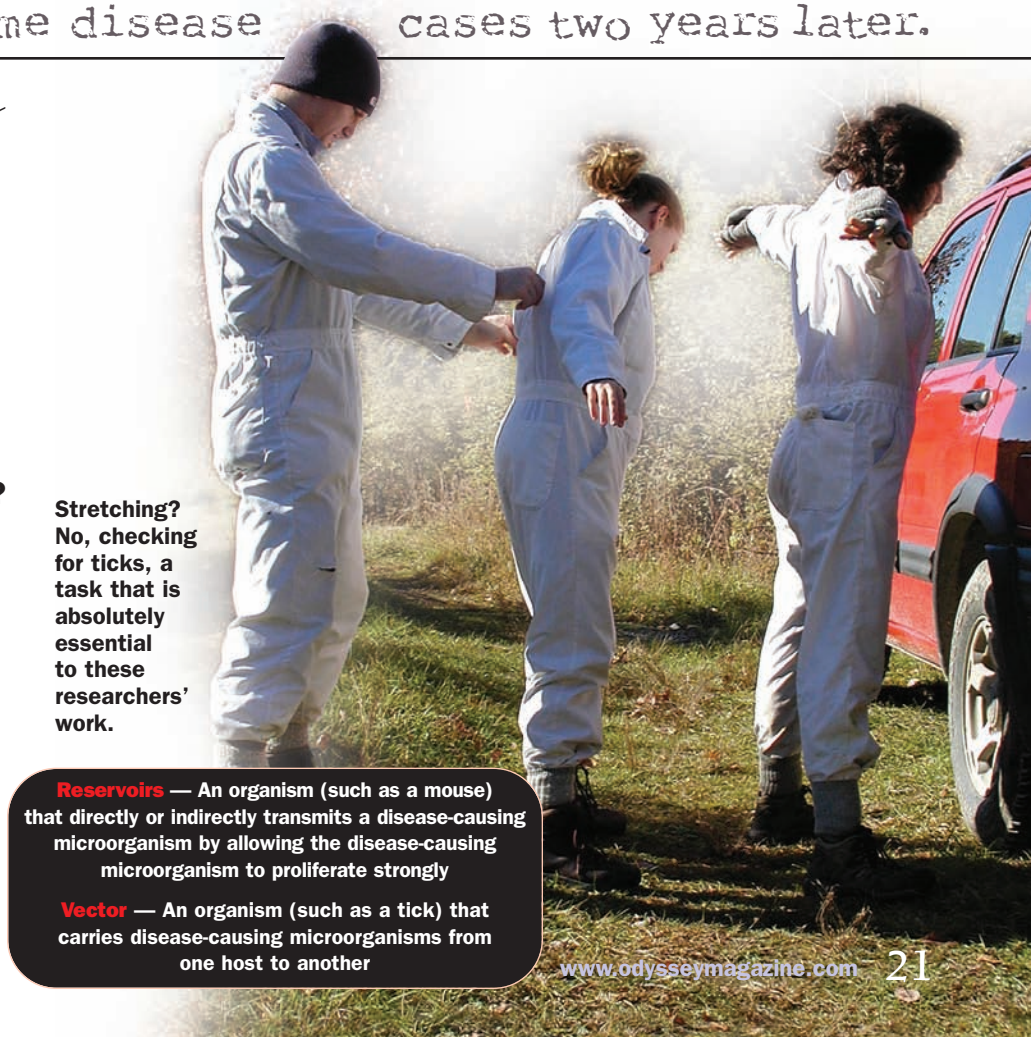

Stretching? No, checking for ticks, a task that is absolutely essential to these researchers' work.

Reservoirs — An organism (such as a mouse) that directly or indirectly transmits a disease-causing microorganism by allowing the disease-causing microorganism to proliferate strongly

Vector — An organism (such as a tick) that carries disease-causing microorganisms from one host to another