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LYME DISEASE: DISEASE ECOLOGY AND PUBLIC HEALTH RESEARCH

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DISEASE ECOLOGY AND PUBLIC HEALTH RESEARCH

◦ Research clears deer ◦ Killing deer will not reduce the risk of infection

◦ The culprit for recent uptick: acorns ◦ Opossums and foxes are nature's bulwarks against the disease

The white-footed mouse

"Unsung heroes"

Mast crop: boom or bust

Don't blame deer. They now may be off the hook as the main vectors of the infectious disease.

Instead, most scientists and publications point to the expected overpopulation of white-footed mice this year as the reason Lyme disease incidence is likely to surge in southwestern Pennsylvania and throughout the Northeast. So you might be tempted to blame mice — that is, until you realize the full story. That's where red oak acorns drop onto the scene.

Pittsburgh Post-Gazette: **What's to blame for the surge in Lyme disease?** (Mar 28, 2017)[1]

Nothing else — like culling deer or spraying lawns with tick-killing pesticide — has worked so far to stem the incidence of tick-borne disease.

New York Times: **Lyme Disease's Worst Enemy? It Might Be Foxes** (Aug 2, 2017)[2]

Despite the preponderance of infectious disease and public health research opinion, much of it relayed by the mainstream press, narrow self-interests persist in blaming deer. All say they want to hunt the animals to diminish the risk of infection. The Farm Bureau seeks to monetize deer by legalizing market hunting outlawed in every state under the Lacey Act (1900), the first conservation law in the United States. Others want to destroy deer whose breeding is stimulated by commercial logging activities promoted by shooting and partnered groups. The Division of Fish and Wildlife seeks suburban access for fellow hunters and clients.

Summary

- Independent, peer reviewed research has absolved deer of any significant role in the transmission of Lyme disease. Sources include: **Cary Institute's Tick Project**,[3] **Harvard's School of Public Health**[4], even the **Pennsylvania Game Commission**,[5]

- The **Yale School of Public Health** reported that the rate of infection was not significantly different before and after deer hunts. After deer kills, said **Harvard**, Lyme infections "went up."

- The white-footed mouse and abundant acorn crops are major drivers of recent spikes in infection. Research is yielding more surprises: The humble opossum is an "unsung hero" in the battle against the infection. Foxes and other small predators break the cycle of infection.

Resources

The blacklegged tick (Ixodes scapularis)

The Tick Project[6]

The Cary Institute is one of the largest ecological programs in the world. The Institute's Tick Project is testing environmental interventions to prevent Lyme and other tick-borne diseases in our communities. Project partners are the Centers for Disease Control and Prevention, Bard College, the New York State Department of Health, and the Dutchess County Department of Behavioral and Community Health.

Dr. Rick Ostfeld, senior scientist, Cary Institute: *"It's commonly believed that Lyme disease risk is tied to the presence of deer ticks and white-tailed deer. But this simply isn't correct."* ("Have Deer Gotten a False Rap for Lyme? ")[7]

Dr. Ostfeld ([in] the New York Times):

Indeed, several recent studies on mainland sites in New York and New Jersey (Jordan and Schulze, 2005; Ostfeld et al, 2006;[8] Jordon et al, 2007) on mainland sites in New York and New Jersey found no correlation between deer and ticks:

- When deer are scarce, ticks do not necessarily become scarce, because they have alternative hosts.
- Ticks are only dangerous if they are infected, and deer play no role in infecting ticks.
- The carrier most likely to bring Lyme-infected ticks into contact with human beings is not the white-tailed deer, but the white-footed mouse.
- Early tests that erroneously linked tick populations to deer density were flawed, said Dr. Ostfeld, because they were "conducted on an isolated island. [I]n the real world, there are dozens of other species that serve as host to ticks – including chipmunks, mice and birds."

Harvard School of Public Health: "Killing deer is not the answer to reducing Lyme disease, says HSPH scientist":[9]

- The tick that transmits Lyme disease is called the deer [blacklegged] tick. The adult tick takes a blood meal from deer, lays eggs and then dies. In Crane Beach [in Ipswich, MA], where I conducted my study, people thought that if they killed deer they would reduce the number of ticks. Deer were reduced [from around 400 in 1983 to just over 100 in 1991], but Lyme disease kept growing. The question was why? We killed deer but people still got Lyme disease.

Yale School of Public Health, Evaluation of Deer-Targeted Interventions on Lyme Disease Incidence in Connecticut (US National Library of Medicine/National Institutes of Health):[10]

- The deer hunt analysis did not show a clear decreasing trend in EM rash incidence in the original treatment area (Figure 3). The mean incidence rate was not significantly different before and after treatment (U=32.5, p=0.432). Neither the mean relative rate between the original treatment area and original control area, nor the mean relative rate between the original treatment area and expanded control towns was significantly different before and after treatment (Table 2). doi: [10.1177/003335491112600321]

  PMCID: PMC3072871;PMID: 21553675, Evaluation of Deer-Targeted Interventions on Lyme Disease Incidence in Connecticut, Jennifer M. Garnett, MPH, Neeta P. Connally, PhD, Kirby C. Stafford, III, PhD, and Matthew L. Cartter, MD, MPH

The Acorn Crop and White-footed Mice

New Scientist (Lyme disease set to explode and we still do not have a vaccine. 29 March 2017):[11]

> So how could a floor of acorns two years ago tell Ostfeld, author of a book on Lyme disease ecology and disease ecologist at the Cary Institute of Ecosystem Studies in Millbrook, New York, that 2017 would see an outbreak of Lyme disease? It's all down to what happens next.
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> A bumper crop of the seeds – "like you were walking on ball bearings" – comes along every two to five years in Millbrook. Crucially, these nutrient-packed meals swell the mouse population: "2016 was a real mouse plague of a year," he says. And mouse plagues bring tick plagues.

Opossums: Allies in the Battle Against Lyme Disease

Under-appreciated and over-trapped

The Cary Institute: The Virginia opossum is not the brightest of animals. When they are threatened, they pretend to be dead, which is where we get the expression "playing opossum." Sometimes, they do this in response to threats from oncoming traffic, which results in opossums becoming roadkill.

The next time you see an opossum playing dead on the road, try your best to avoid hitting it. Because it turns out that opossums are allies in the fight against Lyme disease.[12]

Possums, like many other small and medium sized mammals, are hosts for ticks looking for a blood meal. But opossums are remarkably efficient at eliminating foraging ticks.

"In a way, opossums are the unsung heroes in the Lyme Disease epidemic."

Rick Ostfeld, explains:

"Because many ticks try to feed on opossums and few of them survive the experience. Opossums are extraordinarily good groomers it turns out – we never would have thought that ahead of time – but they kill the vast majority – more than 95% percent of the ticks that try to feed on them. So these opossums are walking around the forest floor, hoovering up ticks right and left, killing over 90% of these things, and so they are really protecting our health."

So it's in our best interest to have opossum neighbors. This means keeping their habitat intact with thoughtful land use planning, tolerating them in our yards, and, whenever possible, avoiding opossum collisions.

New ecological role comes to light

An opossum caught by a fur trapper, before the kill. New Jersey's Division of Fish and Wildlife "furbearer biologist" stresses trapping for market value: "Opossum, expect in the neighborhood of $2."

Trappers call the opossum "the grinner" – the grimace is one of fear. According to a trappers' website, opossums "c--p all over the place" when trapped.

Reynard: Breaking the Cycle of Infection

The red fox

International studies ("Lyme Disease's Worst Enemy? It Might Be Foxes," *New York Times*, Aug 2, 2017) find that foxes and other predators of mice and voles can play an important role in breaking the cycle of infection.[13] Hunting (and fur trapping), fragmentation, and the removal of larger predators may all figure into the dwindling of small mammal predators like foxes, weasels, fishers and martens, say the authors. *The* Times *reports that killing deer has "not worked to stem the incidence of tick-borne disease."* The predators' mere presence reduced mouse density; the smaller animals "curtailed their own movement when predators are around." (Referenced study: Cascading effects of predator activity on tick-borne disease risk.)[14]

According to the Centers for Disease Control,[15] deer are transport hosts for adult blacklegged ticks; most humans are infected by tick at the lymphal stage:

In most cases, the tick must be attached for 36 to 48 hours or more before the Lyme disease bacterium can be transmitted. Most humans are infected through the bites of immature ticks called nymphs. Nymphs are tiny (less than 2 mm) and difficult to see; they feed during the spring and summer months.[16]

Centers for Disease Control dismissed study cited by hunt interests as "biologically implausible"

Kilpatrick Study. The Kilpatrick study, conducted by wildlife management sources,* was conducted in Mumford Cove, Connecticut. It contradicts the above public health authorities to assert a correlation between killing deer and a reduced reporting of Lyme cases. In 2011 and 2015, public health scientists criticized the studies (Kilpatrick and Labonte, 2003; Kilpatrick et al, 2014, see full citation, below) for self-reporting bias and for reporting an impact on human cases of Lyme a full year before any should have been discernable. When a second study (Garnett et al, 2011) accounted for the 2-year lag and relied on cases reported to the public health system, the incidence of Lyme was not significantly different before or after hunting.

In "Will Culling White-tailed Deer Prevent Lyme Disease?"[17] Kugler et al wrote (National Center for Emerging and Zoonotic Infectious Diseases, Division of Vector-Borne Diseases, Centers for Disease Control and Prevention, Fort Collins, CO, USA) Published in: Zoonoses Public Health. 2016 Aug; 63(5): 337–345. Published online 2015 Dec 18. doi: 10.1111/zph.12245 K. J. Kugeler,1 R. A. Jordan,2 T. L. Schulze,3 K. S. Griffith,1 and P. S. Mead):

> Residents reported 17 cases of Lyme disease in the year of the intervention and five cases in the first year following initial deer removal (Kilpatrick and LaBonte, 2003). There are two major limitations to this finding: first, the method of case ascertainment lacks standardization and is subject to bias associated with awareness of the intervention (i.e. placebo effect); and second, because of the role of deer in the 2-year lifecycle of the blacklegged tick (primarily feeding adult ticks), deer reduction should not impact nymphal tick populations, the principal source of human infections, until the second transmission season following the intervention. Therefore, the reported decrease in human cases observed in the year following deer removal lacks biological plausibility.
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> Additional surveys of the ~100 households in Mumford Cove revealed a consistently lower number of self-reported cases of Lyme disease in the years following the initial deer reduction (Kilpatrick et al., 2014). Unfortunately, the use of linear regression to analyse nonlinear data limits interpretability of the statistical significance of the reported correlations. In a separate effort, Garnett and others evaluated the impact of the Mumford Cove deer reduction on Lyme disease cases reported to the public health system, a method of case ascertainment not subject to the same limitations as self-report (Garnett et al., 2011). Specifically, they compared mean incidence of erythema migrans rash (EM) per 100 000 residents before and after the intervention (accounting for the expected minimum 2-year lag of impact of deer reduction on human disease) in both Mumford Cove and neighbouring 'control' communities. Mean EM incidence did not differ significantly before and after the intervention in Mumford Cove, nor in the control areas.

*Study participants are veteran associates of the Human Dimensions Research Unit, a shooting industry-agency think tank focused on the general advancement of hunting and trapping, hunter access to public and private land, and the production of guides and surveys for obtaining community-based hunts.

The Presence of Deer May Serve to Dilute Infection Rates

According to Kugler (see above), the presence of deer may in fact serve to "dilute" infection rates:

> Removal of a large proportion of the deer in any given area may have unanticipated effects on the broader Lyme disease enzootic cycle in both the short and longer term. For example, while deer are a preferred host for adult ticks, in circumstances where deer are plentiful, a portion of larval or nymphal ticks feeding on uninfected deer rather than on infected reservoir hosts could serve to limit or 'dilute' the local infection prevalence in ticks (Lacombe et al., 1993; Perkins et al., 2006). Broad population reduction could, at least temporarily, increase human risk of disease by increasing the number of questing adults seeking alternate hosts and by increasing infection prevalence among nymphs (Deblinger et al., 1993; Mount et al., 1997; Ginsberg and Zhioua, 1999; Rand et al., 2004). Incomplete understanding of these effects limits the ability to generalize findings from published studies that seek to link specific deer densities, tick abundance and Lyme disease risk.

Scientists Tie the Rise of Lyme and Other Tick-borne Diseases to a Scarcity of Traditional Mouse Predators

The Carey Institute's Tick Project reports that in the eastern United States, the risk of contracting Lyme disease is higher in fragmented forests[18] with high rodent densities and "low numbers of resident fox, opossum, and raccoons."

Small predators either consume white-footed mice,[19] the primary carriers of the Lyme bacteria, or, by their mere presence, keep the mice at bay.

The New Jersey Division of Fish and Wildlife and its partners manage forests and woodlands for fragmentation through logging and early successional habitats for "small game" species. State licensed fur trappers kill opossums mainly as unwanted, incidental takes. In addition, a number of fur trappers run lethal wildlife or pest removal services.[20] In 2018, fur trappers killed 3,822 red fox, 467 opossums, and 4,233 raccoons. In New Jersey, hunters can kill unlimited numbers of opossums and raccoons during the "small game" season that runs from October through February.

2018 Trapper Survey Results: https://www.nj.gov/dep/fgw/pdf/trapper_survey18.pdf

Addendum

Pennsylvania Game Commission: Wildlife Diseases

Lyme Disease & Deer - Revelation or Red Herring[21]

- The blacklegged tick (Ixodes scapularis) is the most important vector for Lyme disease transmission in the Eastern US. It has a 2-year life cycle consisting of three life stages: larval, nymph, and adult.
- Risk of exposure to Lyme disease is correlated with abundance of acorns, mice, and chipmunks – key hosts for subadult ticks and their corresponding food source.
- Deer are a dead-end host for the Lyme disease bacteria. They do not infect ticks with the bacteria that cause Lyme disease nor do they contract the disease when an infected tick feeds on them. They play no direct role in the transmission cycle.
- Adult ticks primarily feed on deer in mid-autumn to mate and acquire a final blood meal before females lay eggs to complete their life cycle.
- Larvae feed on mice, birds, and other small mammals in the summer and early fall. Nymphs also feed on mice, birds, and other small mammals but are most active in the late spring and early summer.
- Tick populations are not affected by deer abundance unless deer are eradicated or severely reduced.
- The density of ticks is more sensitive to the availability of hosts for subadult ticks (small mammals and birds) than hosts for adult ticks.
- Woodland rodents carrying the bacteria that cause Lyme disease, especially white-footed mice and eastern chipmunks, are most likely to infect larval and nymph stages of blacklegged ticks (Ixodes scapularis).
- People are most likely to contract Lyme disease from the bite of an infected nymph.
- Excluding deer can affect tick density. In areas smaller than 6 acres, the absence of deer may increase tick numbers. Exclusion from areas larger than 6 acres may decrease ticks numbers.
- Analysis of data from 4 states including Pennsylvania shows no relationship between the spatial distribution of Lyme disease and deer abundance.
- There is no clear relationship between deer density, tick abundance, and Lyme disease incidence.

Editor's note: Please click on the link for the complete article.

Washington Post: Why this adorable mouse is to blame for the spread of Lyme disease (July 17, 2017)[22]

> "That's something of a worry because where the mice go, so too go the infected ticks," said Ostfeld, who is co-heading the Cary Institute's Tick Project, along with his wife, Felicia Keesing, a biology professor at Bard College in New York.
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> Ostfeld said there are areas in the United States where Lyme disease is rare and, in those places, few or none of the white-footed mice are infected. But in an endemic area such as one that extends from Virginia to Maine, at least half and sometimes up to 90 percent of the mice are infected with Lyme bacteria.
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> "There's this very interesting and rather complicated set of ecological connections where the mice and, of course, ultimately the oak trees, sit at the center of this important risk to human health," said Clive Jones, emeritus terrestrial ecologist at the Cary Institute of Ecosystem Studies.
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> Jones, who has studied the connection between acorn production and Lyme disease in oak forests in the eastern United States, said that the more acorns there are in the fall, the greater the risk of Lyme disease to humans two years later. Because 2015 was a good year for acorns, 2017 could be a bad year for humans.

Boston Globe: The deer-Lyme disconnect: Why new hunting programs aren't going to check the spread of the disease [23] (May, 2011)

Deer became associated with ticks thanks, in part, says Ostfeld, to a 1979 scientific paper that described what was believed to be a new species of tick, I. dammini. Dammini seemed more common in northern latitudes and appeared to be abundant at all of its life stages on white-tailed deer, thus showing what scientists call a "preference" for the animal over other hosts. But the study was done on Nantucket, which had a scarcity of other mammals such as coyotes and foxes on which ticks might feed. By 1993, many scientists were beginning to believe that I. dammini was in fact identical to I. scapularis. Dammini was eventually scrapped as a separate species, but its common name – deer tick – has lived on.

"Deer tick is a discredited, incorrect, obsolete name," says Ostfeld. "But as long as you're calling it the deer tick, what animal are you going to accuse of fostering it?" In his book, Ostfeld analyzes more than a dozen studies comparing deer numbers with tick numbers. In most, deer were either eradicated or nearly eradicated in the area being studied. Overall, the results were startling.

In the first study, done on Great Island, Cape Cod, beginning in 1982, a reduction in the deer herd from at least 30 to less than 10 not only didn't decrease the number of larval and nymphal ticks scientists found on the white-footed mice they collected, but seemed to increase them. It wasn't until the herd was down to a lone doe that the number of ticks on the mice decreased significantly. At Crane Reservation in Ipswich, after the deer population was reduced from 350 in 1985 to 50 in 1991, larval and nymphal tick numbers did decline – but soon increased again to pre-hunt levels, "despite the vastly reduced deer density," says Ostfeld.

When researchers eliminated deer from Maine's Monhegan Island in 1999, where the next-largest animal with a significant population – besides humans and dogs – was the Norway rat, the number of ticks did decline to near zero. But a 1994 study that surveyed 22 natural areas, seven of which had no deer, on New York's Long Island found the number of nymphs in the deer-free zones "within the range seen in areas with rampant Lyme disease," Ostfeld writes.

Researchers have also found that where deer are eliminated or reduced, even if the number of ticks declines, the number of infected immature ticks often increases, in part, it's believed, because the small mammals that remain are likelier to transmit the B. burgdorferi bacterium.

Pittsburgh Post-Gazette: What's to blame for the surge in Lyme disease? (Mar 28, 2017)[24]

If you become infected with Lyme disease this year, blame the acorn — the bitter-tasting nut that falls from oak trees and looks to be wearing a knitted beret.

Don't blame deer. They now may be off the hook as the main vectors of the infectious disease.

Instead, most scientists and publications point to the expected overpopulation of white-footed mice this year as the reason Lyme disease incidence is likely to surge in southwestern Pennsylvania and throughout the Northeast. So you might be tempted to blame mice — that is, until you realize the full story.

That's where red oak acorns drop onto the scene.

Late last summer and early fall, red oaks, all in coordination, produced a mast production of acorns, which means six to 10 times more than they typically produce. The result was an early Thanksgiving feast for such "seed predators" as mice, chipmunks, shrews and deer, all well-documented Lyme-disease "reservoirs."

Mice, however, represent the most available target for the blacklegged or deer tick and routinely serve as major carriers of the Lyme bacteria, Borrelia burgdorferi. A 2004 University of California Irvine study, for example, showed that almost all mice become infected with Lyme bacteria "during a single transmission season" throughout the Northeast and Midwest.

New Jersey's Incoherent Deer Policy: The same groups whose activities create deer demand escalated kills

Editor's note: On December 6, 2018, The Assembly Agriculture Committee held a hearing on white-tailed deer. The only invited guests were the New Jersey Farm Bureau and the Department of Agriculture. After the hearing, the committee chair promised a "package" of bills aimed at escalating the already pervasive destruction of deer in New Jersey.

Monetizing wildlife. In 2014, well before the recent increase in reported Lyme cases, New Jersey agricultural interests sought to monetize deer through market hunting schemes [25]developed by David Drake, a former employee of the Rutgers Agricultural Extension Service. (The Farm Bureau calls the Service a "supporting" agency; the Service also supports the state hunting and trapping division and its political needs.)

Manufacturers and trophy hunters who wrote U.S. wildlife laws established wildlife management departments at state land-grant universities to "ensure that" the universities "worked hand-in-hand" with [game] agencies".[26] The hunting subculture is so entrenched within university wildlife departments that hard liners favored barring non-hunters from courses.[27] Syllabi adhere strictly to industry doctrine. "Graduates of these programs are then hired into governmental agencies. These agency members then feed staff into the universities' departments, and the cycle continues, each group enhancing the credibility of the other."[28] Over 70 percent of state agency employees say they are big "game" hunters. In behalf of these interests, Rutgers personnel promote the fur industry, oppose non-lethal deer management methods, and testify against humane farming reforms. Despite the publicized weight of scientific opinion, an assistant Rutgers Extension professor told nj.com that "too many" deer (and rodents, yet the emphasis was deer) – not the acorn crop – are to blame for the rise in reported Lyme cases.

Farming deer, and killing them, too. Self-interests are using Lyme disease to justify both privatizing wildlife and the long-sought escalated destruction of deer whose numbers rise in response to forest fragmentation for "small game" habitat. Likewise, the systemic management of wildlife management areas, private preserves, and leased hunting and "stewardship" lands for trophy bucks and deer breeding range adds to local deer numbers. As New Jersey Audubon's forest fragmentation and early succession activities and business create deer breeding range, its lobbyist claims "Lyme disease" as a reason for killing the animals.

Wildlife Habitat Incentive Program (WHIP) and other activities. The New Jersey Division of Fish and Wildlife and its partner, the New Jersey Audubon Society, aggressively pursue forest fragmentation[29] through commercial logging and burning[30].[31]

N0-see-ums: *Out-of-sight gun and ammo manufacturers, state wildlife agencies, Audubon, and "Nature-Related Businesses."* New Jersey Audubon and the Division of Fish and Wildlife are the co-leaders of the New Jersey Teaming with Wildlife Coalition. The coalition enjoys unimpeded control over New Jersey wildlife, related land-use policy, and the expenditure of public funds.

The National Teaming with Wildlife Steering Committee[32] is dominated by firearms, archery, and ammunition trade associations and hunting and fur trapping organizations—even sealers. The aforementioned self-interests remain largely anonymous, scratch each other's backs, give each other awards, and hand down state policy. The redundancy quotient is high; the same manufacturers and corporations are represented under trade associations and various conservation front groups as "nature related businesses." Logging, early succession, and the so-called "young forests initiative" create management- consultant –contract- grant fiefdoms and transfer "game" habitat management costs to the non-hunting public. The sporting arms industry remains off-stage, "out of the limelight."

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[1] https://www.post-gazette.com/news/health/2017/03/28/Lyme-disease-surge-in-Pittsburgh-Western-Pennsylvania-more-acorns-more-mice-carriers/stories/201703210143
[2] https://www.nytimes.com/2017/08/02/science/ticks-lyme-disease-foxes-martens.html
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[28] Kimnitz, D. [quoting Gill] 1998. Hunting Moves to Suburbia's Backyard: The Animals, The Agencies and the Passionate Conflict Over Backyard Kills. Journal of Environmental Law. Volume 6).
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