Overview of common Tick-Borne Diseases, Primary Vectors, and Wildlife Reservoirs in North America

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Introduction and Report Overview

Tick-borne diseases (TBDs) represent a significant and growing public health challenge across North America, particularly as their geographic range and incidence rates continue to rise. Managing these diseases requires a nuanced understanding of the ecological interactions involving tick vectors, wildlife reservoirs, and the environmental conditions that sustain them. This report synthesizes critical aspects of TBD ecology, focusing specifically on the relationships between tick vectors, reservoir hosts, and their shared habitats and microclimates. We begin with a detailed overview of the most prevalent tick-borne diseases in North America, including Lyme disease, anaplasmosis, ehrlichiosis, babesiosis, Rocky Mountain spotted fever, tularemia, and Powassan virus, emphasizing their respective epidemiological importance. Next, we provide an overview of the primary tick vectors responsible for transmitting these diseases, highlighting their geographic distributions and biological characteristics that make them particularly effective vectors. Following this, we describe the key wildlife species that serve as reservoirs or essential hosts in the life cycles of these pathogens, detailing their ecological roles and habitat preferences. Finally, we offer an extensive overview of the specific vegetative and microclimatic habitat conditions required by both tick vectors and wildlife reservoirs. Understanding these environmental requirements is vital, as they offer actionable insights into how targeted habitat and vegetation management practices can disrupt pathogen transmission cycles. Such interventions have the potential to significantly reduce TBD incidence by altering the habitat to reduce tick abundance, decrease reservoir host populations, and ultimately diminish human exposure risk.

Lyme Disease (*Borrelia burgdorferi*): The principal reservoirs are small mammals, especially the white-footed mouse (*Peromyscus leucopus*). In the eastern U.S., white-footed mice are the main natural reservoir of the Lyme spirochete, effectively infecting ticks that feed on them (Levi et al. 2012). Other rodents and shrews can also serve as reservoirs—for example, eastern chipmunks (*Tamias striatus*), short-tailed shrews (*Blarina brevicauda*), and masked shrews (*Sorex cinereus*) are capable of harboring and transmitting *B. burgdorferi* to ticks (Levi et al. 2012). Some bird species (such as certain songbirds) can occasionally infect ticks as well, though small mammals are the primary hosts maintaining the Lyme cycle. Notably, white-tailed deer (*Odocoileus virginianus*) are **not reservoirs** for *B. burgdorferi*—deer play a crucial role in the tick life cycle by feeding adult ticks, but they do not infect ticks with Lyme disease bacteria (Entomology Today 2023) (deer themselves do not get or transmit Lyme).

Babesiosis (*Babesia microti*): The same rodent hosts involved in Lyme disease also maintain *B. microti*, the protozoan causing human babesiosis. The white-footed mouse is the primary enzootic reservoir for *B. microti* in North America (CDC 2023a). Ticks (*Ixodes*) acquire Babesia by feeding on infected rodents and later transmit it to humans. Other small mammals like shrews and voles may contribute, but *Peromyscus* mice are considered the key reservoir in endemic areas (CDC 2023a).

Anaplasmosis (*Anaplasma phagocytophilum*): This bacterium (agent of human granulocytic anaplasmosis, HGA) is maintained in nature by both rodents and some larger mammals. White-footed mice, deer mice (*Peromyscus maniculatus*), and white-tailed deer are all known reservoir hosts for *A. phagocytophilum* in North America (NCCID 2023). Small rodents (mice, chipmunks, shrews) often carry strains that infect humans, similar to the Lyme cycle. Deer can harbor other strains and sustain the infection in an area, although in some cases deer may be more of a host for ticks than a highly competent reservoir for the human-infective strain (NCCID 2023). (Different strains of Anaplasma may preferentially infect deer vs. rodents, but collectively these animals keep the pathogen circulating.)

Ehrlichiosis (*Ehrlichia chaffeensis*): The primary reservoir host for *E. chaffeensis* (which causes human monocytic ehrlichiosis) is the white-tailed deer. Deer develop long-term infections and are considered the principal reservoir for this pathogen (Paddock & Yabsley 2007). Studies have shown that wild deer frequently carry *E. chaffeensis* in endemic areas and can infect ticks that feed on them (Paddock & Yabsley 2007). (Note: other *Ehrlichia* species like *E. ewingii*—causing granulocytic ehrlichiosis in humans—are also associated with deer or possibly other mammals, and *E. muris eauclairensis* in the upper Midwest is thought to use rodents as reservoirs. But *E. chaffeensis*—the most common cause of ehrlichiosis—is strongly linked to deer.)

Rocky Mountain Spotted Fever (*Rickettsia rickettsii*): This pathogen has a different reservoir dynamic. The tick vectors themselves are the main reservoir for *R. rickettsii* in nature (Wikipedia 2023a). The bacteria can be maintained in tick populations through transovarial transmission (infected female ticks pass it to their eggs), allowing the pathogen to persist in tick lineages without needing a mammalian host (Wikipedia 2023a; NCBI 2023). That said, wild rodents and small mammals can serve as short-term hosts; ticks may acquire *R. rickettsii* by feeding on infected chipmunks, squirrels, etc., and those animals can amplify infection rates locally (Nature.com 2023). Overall, *R. rickettsii* persists primarily via the American dog tick and Rocky Mountain wood tick life cycles, with occasional infection of mammals but mostly cycling within ticks over generations (Wikipedia 2023a).

Tularemia (*Francisella tularensis*): This bacterium is maintained in a broad range of wildlife. Various wild rodents and lagomorphs (rabbits and hares) are important reservoirs for tularemia (Purdue University Extension 2023). In many areas, the cottontail rabbit (*Sylvilagus*) is a well-known host that can harbor *F. tularensis* (hence the nickname "rabbit fever"). Small rodents (like voles, muskrats, squirrels) also commonly become infected and can serve as sources of infection for ticks or other vectors (Purdue University Extension 2023). Notably, the bacterium can persist in the environment (water, soil) for long periods, and ticks themselves may act as reservoirs to some degree. Hard ticks can carry *F. tularensis* transstadially and even transovarially, helping maintain the bacteria in nature (New Mexico Department of Health 2023). In summary, tularemia hotspots often correspond to areas with abundant susceptible small mammals (especially rabbits or muskrats) that ticks feed on.

Powassan Virus (POWV): Powassan is a tick-borne flavivirus with two lineages in North America. Its reservoirs are primarily small rodents. Ticks become infected when feeding on groundhogs (woodchucks), squirrels, mice, or other rodents that have the virus in their bloodstream (CDC 2023b). For the Powassan "deer tick virus" lineage (lineage II, often carried by *Ixodes scapularis*), white-footed mice are implicated as a major reservoir host (Cornell Cooperative Extension 2023). For the classic Powassan lineage I (often involving *Ixodes cookei*, the woodchuck tick), rodents like woodchucks and squirrels are thought to be important reservoirs (CDC 2023b). In both cases, the virus cycles between *Ixodes* ticks and small mammals; humans are incidental hosts. (Powassan is relatively rare, but its presence is closely tied to areas where these tick-rodent cycles occur.)

Other Tick-Borne Pathogens: *Borrelia miyamotoi* (a relapsing fever spirochete carried by blacklegged ticks) shares the same rodent reservoirs as Lyme disease in the U.S., principally *Peromyscus* mice and possibly squirrels. Heartland virus and Bourbon virus (emerging viruses in the central/southeastern U.S. associated with the Lone Star tick) are suspected to have wildlife reservoirs (possibly deer or small mammals), but those are still being studied. In summary, for most major North American tick-borne diseases, small mammals (rodents/shrews) and sometimes birds form the reservoir base—with the key exception that white-tailed deer serve as the major reservoir for *Ehrlichia chaffeensis* (ehrlichiosis) (Stromdahl & Hickling 2012), and ticks themselves play a significant reservoir role in the spotted fever Rickettsia group.

Primary Tick Vectors Transmitting Major Tick-Borne Diseases

Blacklegged Tick (*Ixodes scapularis*) – aka the deer tick: *Ixodes scapularis* is the primary vector for a suite of diseases in the eastern and central United States. This single tick species is responsible for transmitting Lyme disease, anaplasmosis (HGA), babesiosis, and *Borrelia miyamotoi* disease, among others (Maine.gov 2023). In fact, *I. scapularis* is sometimes called the "Lyme tick," as it is overwhelmingly the vector of *Borrelia burgdorferi*. It also transmits *Anaplasma phagocytophilum* (the anaplasmosis bacterium), *Babesia microti* (babesiosis protozoan), and the deer tick virus lineage of Powassan encephalitis virus (Maine.gov 2023). This tick is widely distributed in the Northeast, Mid-Atlantic, Upper Midwest, and spreading in the South; nymphs and adults actively bite humans. *Ixodes scapularis* has a two-year life cycle and typically feeds on small hosts (rodents, birds, lizards) in the immature stages and larger mammals (especially deer) as adults. (Its west-coast counterpart is *Ixodes pacificus*.)

Western Blacklegged Tick (*Ixodes pacificus*): The Pacific Coast vector equivalent to *I. scapularis*. It is the principal tick species transmitting Lyme disease and anaplasmosis in far western North America (Coachella Valley Mosquito & Vector Control District 2023). *I. pacificus* ranges along the West Coast (e.g., California, Oregon, parts of British Columbia). It feeds on lizards (notably western fence lizards), rodents, and occasionally birds as immatures, and on deer and other large mammals as adults. This species is known for a quirk: in California, its nymphs often feed on certain lizards whose blood can kill the Lyme spirochetes, resulting in a lower infection rate in ticks—but it can still transmit Lyme to humans where infection persists in rodent hosts. In summary, *Ixodes pacificus* spreads *Borrelia burgdorferi* on the West Coast (though infection rates in ticks are lower compared to the Northeast) and also can carry *A. phagocytophilum*. (Babesiosis is very rare in the West, but *I. pacificus* could theoretically transmit similar pathogens.)

Lone Star Tick (*Amblyomma americanum*): A very aggressive tick found in the Southeast, Mid-Atlantic, and expanding northward. *Amblyomma americanum* is the primary vector of ehrlichiosis in the U.S., transmitting *Ehrlichia chaffeensis* (and *E. ewingii*) to humans (Maine.gov 2023). It is also known to transmit tularemia (*Francisella tularensis*) and has been implicated in STARI (Southern Tick-Associated Rash Illness, a Lyme-like illness) (Maine.gov 2023). Lone Star ticks can carry the emerging Heartland and Bourbon viruses as well. This tick readily bites humans in all life stages (larvae, nymphs, adults) and has a wide host range. It is associated with white-tailed deer (its larvae/nymphs feed on many hosts, but adults commonly seek deer). *A. americanum* has become notorious in recent years for causing "alpha-gal" allergy (red meat allergy) via its bite. Geographically, it dominates in the Southeast and south-central states but has been moving into the lower Midwest and coastal Northeast. Unlike *Ixodes*, which prefer cool moist habitat, Lone Stars tolerate hotter climates and will actively hunt/“quest” in both shaded woods and sunny brushy fields, making them a particularly important human-biting tick.

American Dog Tick (*Dermacentor variabilis*): A common tick found widely in the eastern half of the U.S. and parts of the West. *Dermacentor variabilis* is the primary vector of Rocky Mountain Spotted Fever (RMSF) in the eastern U.S., and it can also transmit tularemia (Maine.gov 2023). Despite its name, this tick is abundant far beyond the Rocky Mountains (in fact, RMSF was first noted out West, but today most cases are in the Southeast). American dog ticks feed on medium to large mammals (they often bite dogs, hence the name, and will bite humans, especially adults). They are noted for thriving in more open habitats—fields, grassy meadows, and edges of trails—and do not require dense woodlands as Ixodes ticks do. *D. variabilis* adult females will attach for several days and can transmit *Rickettsia rickettsii* (RMSF agent) during feeding. This species' range extends from the Atlantic into the Midwest; on the Pacific coast, a related species (*Dermacentor similis*, formerly thought to be *D. variabilis*) exists. Dog ticks are large, brown with ornate dorsal patterns, and are often encountered in spring and early summer by people and pets. (They are also a cause of tick paralysis in animals and occasionally humans.)

Rocky Mountain Wood Tick (*Dermacentor andersoni*): A close relative of the dog tick, found in the Rocky Mountain states and western Canada. *Dermacentor andersoni* is a primary vector of RMSF in the Mountain West and also the chief vector of Colorado Tick Fever virus; it can transmit tularemia as well (USDA 2023). This tick inhabits higher elevation grasslands, shrublands, and open forests in the West. It feeds on similar hosts as *D. variabilis* (small mammals when young, larger mammals when adult). While human cases of RMSF in the Rockies are less common now, this tick remains important for transmitting the Colorado Tick Fever virus (a coltivirus causing a febrile illness) (USDA 2023). It has a seasonal activity peaking in spring/early summer. *Dermacentor andersoni* looks and behaves much like the American dog tick (and many references simply say Dermacentor ticks), but it’s region-specific.

Brown Dog Tick (*Rhipicephalus sanguineus*): An unusual case as this is a cosmopolitan tick that lives in close association with dogs (often in kennels or homes) and can complete its entire life cycle indoors. It is the vector of RMSF in the U.S. Southwest (including Arizona) where RMSF outbreaks have occurred in tribal communities with heavy infestations of brown dog ticks (Arizona Department of Health Services 2023). *Rhipicephalus sanguineus* primarily feeds on dogs at all life stages, but in absence of dogs will bite humans. In Arizona and northern Mexico, dense populations of this tick (fueled by free-roaming dogs) have led to significant transmission of *R. rickettsii* to people (Arizona Department of Health Services 2023). While not a major outdoor tick for most of North America’s ecology, it’s worth noting because controlling RMSF in some areas hinges on controlling this tick on dogs and around homes.

(Elsewhere, *R. sanguineus* can carry Mediterranean spotted fever, etc., but in North America its main importance is RMSF in specific locales.)

Groundhog Tick (*Ixodes cookei*): Vector of Powassan virus (lineage I). This tick feeds on woodchucks, skunks, and other medium-sized mammals (rarely humans). It is responsible for Powassan cases typically in Canada and the northeastern U.S. by bridging the virus from groundhog or squirrel hosts to humans (Maine.gov 2023).

Gulf Coast Tick (*Amblyomma maculatum*): Found in the Southeastern U.S. and along the Gulf, now expanding north. It transmits *Rickettsia parkeri*, which causes a spotted fever rickettsiosis (sometimes called American boutonneuse fever or Tidewater spotted fever). Cases of *R. parkeri* infection (which is generally milder than RMSF) have been identified in the South where this tick bites people. *A. maculatum* also can cause severe tick paralysis and transmits a livestock parasite (*Hepatozoon americanum* to dogs, via ingestion).

Asian Longhorned Tick (*Haemaphysalis longicornis*): An invasive tick species recently established in parts of the Eastern U.S. (first detected 2017). It is a parthenogenetic tick that can reproduce rapidly. Thus far, it has been found carrying *Theileria* protozoa that affect livestock and rare pathogens like *Rickettsia* and *Borrelia* species, but as of now no confirmed human disease transmission in the U.S. It is closely watched as a potential vector, given in Asia it transmits a serious virus (SFTS virus).

In summary, North America's major tick-borne diseases are transmitted by a handful of hard tick species: chiefly *Ixodes scapularis/pacificus* (for Lyme, anaplasmosis, babesiosis, Powassan), *Amblyomma americanum* (for ehrlichiosis and others), and *Dermacentor variabilis/andersoni* (for spotted fever and tularemia) (Maine.gov 2023).

Habitat Characteristics That Support Reservoir Hosts, Tick Vectors, and Disease Transmission

Understanding the environments that foster abundant reservoir wildlife and ticks is crucial. Ticks and their hosts each have particular habitat needs. Below, we outline the vegetative and microclimatic characteristics that support: (a) the most prevalent reservoir animals, (b) the most important tick vectors, and (c) high tick-borne disease prevalence and transmission risk. This knowledge can guide vegetation and land management protocols to disrupt the cycle and reduce disease risk.

Habitat of Key Reservoir Wildlife: Tick-borne disease reservoirs thrive in specific habitats, often those with ample cover and food. Many reservoir species are edge-adapted generalists that flourish in human-altered landscapes (e.g., fragmented forests, suburban yards), which unfortunately brings them and their ticks into close proximity to people:

White-footed Mice (and other small rodents): *Peromyscus leucopus* is highly adaptable but prefers wooded or brushy areas with plenty of ground cover. They are especially abundant in deciduous forests with dense undergrowth, leaf litter, fallen logs, stone walls, and thickets. These mice thrive in fragmented forests and patchy woodlots—even small forest fragments (<5 acres) can support high densities (The Land Between 2023). Fragmentation (breaking up large forests into small parcels) tends to boost white-footed mouse populations because it eliminates many predators and competitors, leaving the prolific mice to dominate (The Land Between 2023). Mice also benefit from forest edge habitats adjacent to fields or suburbs, where they find food (seeds, insects) and nesting sites in sheds or woodpiles. Vegetation that produces lots of seeds (e.g., oaks with acorns) can cause rodent population booms, indirectly increasing disease risk in mast years. Invasive shrubs like Japanese barberry or bush honeysuckle create ideal microhabitats for mice: the dense, thorny thickets protect mice from predators and provide humid, leaf-litter-rich shelter (Trinity College 2023). Studies have found significantly more white-footed mice in areas invaded by Japanese barberry than in native understory, likely because the mice use the thorny shrubs as safe harborage (Trinity College 2023). In summary, any habitat with thick ground vegetation, ample cover, and food (e.g., forest-floor debris, brush piles, unkempt hedgerows) will support the small rodents that serve as reservoirs for Lyme, anaplasmosis, and babesiosis.

Eastern Chipmunks & Squirrels: Chipmunks (another Lyme reservoir) also prefer forest edges and brushy areas. They often burrow along stone walls or under dense shrubs. Suburban gardens with shrubbery, woodlot edges, and overgrown fields can all harbor chipmunks. Squirrels (e.g., gray squirrels) use tree canopy and forest patches; while they are less important reservoirs than mice, they do get infected. Notably, on the West Coast, the Western gray squirrel has been identified as a major reservoir host for Lyme in California oak woodlands (Lane et al. 2005). Squirrels favor oak/mixed forests and urban parks—environments that overlap with ticks. Groundhog (woodchuck) burrows in brushy field-forest edges similarly create focal points for ticks (and are associated with Powassan virus cycles).

White-tailed Deer: Deer thrive in edge habitats that mix forests and openings. They are “edge specialists,” favoring areas where they can browse on abundant vegetation at forest margins and take cover in wooded patches. Suburban and agricultural mosaics (neighborhoods with interspersed woods, orchards, fields, golf courses) provide ideal deer habitat (Prince William Conservation Alliance 2023). In fact, suburban sprawl (with its lawns, ornamental shrubs, and patchy woods) has caused deer numbers to explode in many areas. Deer feed on a variety of plants—they find high-quality food in gardens and fertilized lawns, while nearby second-growth woods give them shelter (Prince William Conservation Alliance 2023). The lack of predators and hunting in suburban zones allows deer populations to reach very high densities. Because landscapes with abundant edge habitat support prime deer populations, fragmented and developed areas often have more deer than large continuous forests (Prince William Conservation Alliance 2023). Deer are not reservoirs for Lyme bacterium, but they are critical for adult tick survival—*Ixodes scapularis* in particular relies on deer as the primary host for adult females to get their blood meal and reproduce (Entomology Today 2023). Thus, habitats that support large deer herds (e.g., suburban green spaces, overgrown fields, patchy woods) indirectly support larger tick populations. *Ehrlichia chaffeensis* (which deer are a reservoir for) is naturally found in areas with high deer densities (e.g., the South-central U.S., wooded areas with lots of deer). In summary, forest edge, secondary growth, and suburban woodlots are a deer haven—and where deer go, the ticks follow.

Other hosts: Rabbits and hares favor brushy fields, thickets, and field edges; these are the places where tularemia can flourish (Purdue Extension 2023). Game birds and ground-foraging songbirds (e.g., robins, thrushes) in shrubby and forest habitats can carry ticks long distances and introduce Lyme to new areas. Birds often frequent ecotones (yard edges, hedgerows)—again, edge habitats. Shrews require moist leaf litter and dense ground cover; they live in forests or wetlands with lush undergrowth and contribute to Lyme cycles in such spots. In general, areas with diverse small wildlife and thick vegetation—especially invasive or early-successional plants—create “hotspots” of reservoir activity. Conversely, landscapes that are very open (short grass, little cover) or very mature/intact (deep core forest with predators present) tend to have fewer of these reservoir species.

General Microclimate Needs: Ticks of all species have a four-phase life cycle (egg, larva, nymph, adult) and spend the majority of their time in the environment (off-host). During those off-host periods, microclimate dictates survival. The two most important factors are humidity and temperature (Burtis et al. 2019). Ticks lose water easily through their cuticle, so they seek microhabitats that keep them moist—like the layer of damp leaves or deep turf thatch. If conditions get too dry (e.g., midday sun on a lawn), ticks will either descend to ground thatch or die after a certain exposure time. For instance, blacklegged tick nymphs may climb vegetation to quest, but if humidity drops, they’ll climb back down to the humid leaf litter to rehydrate (UMaine Extension 2023; Burtis et al. 2019). Ground litter, mulch, and dense vegetation act as a moisture reservoir, maintaining a boundary layer of humid air. Canopy cover from trees or shrubs reduces sunlight and evaporation, creating cooler, wetter conditions near the soil—ideal for ticks. Many ticks also enter a quiescent state during the hottest/driest times (resting until conditions improve). Temperature-wise, tick activity often increases with warm weather up to a point, but extreme heat can be lethal if coupled with low humidity. Snow cover and leaf litter help insulate overwintering ticks from extreme cold, improving survival in northern areas (Burtis et al. 2019).

In terms of vegetation structure, layered vegetation (leaf litter + herbaceous layer + shrubs) provides ticks with vertical options for questing and protection. Ticks will climb grassy or woody stems to the height of passing hosts. *Ixodes scapularis* nymphs, for example, usually quest on leaf litter or low bushes up to knee-height; *Amblyomma americanum* adults might climb higher on brush. Habitats with thick underbrush or tall grass thus allow ticks to efficiently latch onto hosts. Contrast this with a manicured lawn—short grass exposes ticks to sun and gives little height to quest on, so it's a far less suitable environment (though a few dog ticks or lone star ticks might still cross a lawn, they're at higher risk of drying out or missing hosts). To summarize, the ideal tick habitat in North America is often described as "woodland with a brushy understory and abundant leaf litter, adjacent to grassy areas frequented by animals." Such environments satisfy both microclimatic needs (cool, humid, sheltered) and access to hosts (edge zones attract deer, rodents, and birds). Removing any of those ingredients—e.g., reducing ground litter humidity or eliminating cover that hosts use—can significantly lower tick numbers.

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