Public Health Significance of Ticks in Alameda County

Ticks are the most important group of medically important arthropods that transmit animal disease agents to people in the U.S. including California. In 2018, for example, the Centers for Disease Control and Prevention (CDC) reported that 77% of all cases of vector-borne diseases from 2004 to 2016 were transmitted by ticks (versus mosquitoes and fleas). Lyme disease (LD) alone comprised 82% of the tick-borne case reports.

Alameda County Vector Control Services District (ACVCSD) has had a longstanding interest in ticks and educating the public about them. Here, we describe the tick-surveillance program of the District from 2009 to 2022. Other topics covered are tick biology, the public health significance of ticks and preventative measures for minimizing tick-bites. Emphasis is placed on testing the commonly encountered western blacklegged tick (*Ixodes pacificus*) for presence of the agent of LD (*Borrelia burgdorferi*) and closely related bacteria. This tick is a notorious human-biter, and the only proven carrier of *B. burgdorferi* to people in California. Populations of *I. pacificus*, and the percentage of such ticks infected with *B. burgdorferi*, were found to fluctuate markedly within and among sites from year-to-year. These findings inform the public where the risk of exposure to potentially infected ticks may be greatest in Alameda County. The more we understand about ticks, their ecology and the microbes they can transmit, the better we are prepared to prevent and treat tick-borne diseases.

WHAT ARE TICKS?

Ticks are bloodsucking, external parasites of reptiles, birds and mammals. They belong to the diverse Phylum Arthropoda, which also includes insects, mites, spiders and scorpions; centipedes and millipedes; and many other fascinating creatures. All of them possess jointed appendages, segmented bodies and typically rigid exoskeletons, but lack backbones. Although more than 5.5 million species of insects have been estimated to be present globally, only about 900 species of ticks have been described so far. But, certain ticks are notorious pests and carriers of microbial disease agents to wildlife, domestic animals and humans.

All ticks have four life stages: the egg, two immature stages (larva, nymph) and adults.
Like insects, larvae have three pairs of legs, whereas nymphs and adults have four pairs. After the immature or adult females feed to repletion, proteins acquired from blood enable larvae and nymphs

to transform to the next stage. And fed female ticks use protein to produce hundreds or thousands of eggs. In comparison, some species of male ticks drink little or no blood.

Ticks comprise two major families, the slow-feeding hard ticks (Ixodidae) and the rapid-feeding soft ticks (Argasidae), which exhibit significantly different life histories and morphological features. After attaching to the skin of a host, for example, hard ticks usually take several days to feed fully. Soft ticks complete feeding much more rapidly, often within less than an hour. Hard ticks also manifest greater species richness – roughly 80% of all described tick species are ixodids – and they transmit a greater array of microbial disease agents than do argasids.

Ixodes pacificus
(Image from ACVCSD)

Dermacentor similis
(Image from ACVCSD)

Dermacentor occidentalis
(Image from ACVCSD)

Adult Females of Hard Ticks Commonly Found in Alameda County (not to scale)

About 48 tick species are established in California, but only six (12.5%) frequently attach to people. They are the western blacklegged tick (*I. pacificus*), the Pacific Coast tick (*Dermacentor occidentalis*), *Dermacentor similis* (formerly *D. variabilis*), the Rocky Mountain wood tick (*D. andersoni*) and two species of soft ticks, the Pajahuello tick (*Ornithodoros coriaceus*) and *O. hermsi*.

Ticks range considerably in size depending upon the species, life stage and whether they have fed or not. Unfed females of *O. coriaceus*, one of the largest ticks in California, have a body length of up to 2/5th of an inch, whereas unfed *Ixodes peromysci* females, one of our smallest ticks, has a body length of only about 1/20th of an inch.

TICK-BORNE DISEASES IN CALIFORNIA

Nine tick-borne diseases, caused by a virus, 9 bacteria or a protozoan, afflict humans in California. Another malady, tick paralysis, produced by toxins secreted by females of certain hard ticks while feeding, has been reported in wildlife (e.g., deer, gray fox), dogs, cattle and ponies, but not in people. The 9 tick-borne diseases, their causative agents and primary tick vectors (carriers) are as follows:

Tick-borne Disease	Causative Agent	Primary Tick Vector(s)
Anaplasmosis	*Anaplasma phagocytophilum*	*Ixodes pacificus*
Babesiosis	*Babesia duncani*	*Dermacentor albipictus*
Borrelia miyamotoi disease (aka hard-tick relapsing fever)	*Borrelia miyamotoi*	*Ixodes pacificus*
Colorado tick fever	CTF virus (genus *Coltivirus)*	*Dermacentor andersoni*
Lyme disease	*Borrelia burgdorferi*	*Ixodes pacificus*
Pacific Coast tick fever	*Rickettsia* 364D (aka *R. philipii)*	*Dermacentor occidentalis*
Rocky Mountain Spotted Fever*	*Rickettsia rickettsii*	*Dermacentor* spp., *Rhipicephalus sanguineus*
Soft-tick relapsing fever	*Borrelia hermsii, B. nietonii*	*Ornithodoros hermsi*
Tularemia	*Francisella tularensis*	*Dermacentor* spp.

*In 2024, a newly recognized spotted fever disease resembling Rocky Mountain Spotted Fever was described from northern California by Dr. Will Probert and co-workers. Its causative agent, *Rickettsia* sp. CA6269, and tick vector(s) still are being investigated.

LYME DISEASE IN CALIFORNIA

LD is a potentially debilitating but seldom fatal, multi-systemic illness caused by a suite of corkscrew-shaped bacteria known as spirochetes. First recognized in Lyme, Connecticut in the mid-1970s, it is the most commonly reported vector-borne disease in the U.S. In fact, the CDC estimated that an average of 476,000 cases of LD occurred annually from 2010 to 2018. In marked contrast, only 861 confirmed cases were reported by the California Department of Public Health (CDPH) from 2012 to 2021. Nonetheless, LD accounts for more than half of all tick-borne illnesses reported yearly by the CDPH. Hence, here we focus on LD and its primary tick vector in the far-western United States, *I. pacificus*.

The first recorded Californian case of LD was contracted by a hiker who had been bitten by a female *Ixodes* species tick in Sonoma County in 1975. That tick, though no longer available for confirmation, undoubtedly was *I. pacificus*. Ten years later, the first isolate of the LD spirochete (*B. burgdorferi*) in western North America was reported from a host-seeking *I. pacificus* adult collected at the University of California Hopland Field Station in Mendocino County. That isolate was cultured at the Rocky Mountain Laboratories in Montana by Dr. Willy Burgdorfer, the renowned scientist who discovered the spirochete while dissecting *Ixodes scapularis* ticks from Shelter Island in 1981. Three years later, the bacterium was named in his honor.

After LD was designated a reportable disease in California in 1989, more than 3,200 cases were documented through 2021. The number of confirmed cases ranged 33 to 107 cases per year from 2012 to 2021, roughly one-third of which were contracted out-of-state. Certain low population-density and predominantly rural counties (e.g., Mendocino and Santa Cruz) posed a higher risk of LD than other counties. Their health departments reported an incidence of ≥3.0 cases per 100,000 person-years among counties that tallied at least 26 cases. In the Bay Area, the incidence was much lower and ranged from 0.21 in Solano County to 1.58 in Sonoma County. Densely populated Alameda County reported 59 cases, and an incidence of only 0.37 cases per 100,000 person-years.

Reported Lyme Disease Cases in the San Francisco Bay Area 2012 to 2021								
Alameda	Contra Costa	Marin	Napa	San Francisco	San Mateo	Santa Clara	Solano	Sonoma
59	52	36	10	57	27	64	9	77

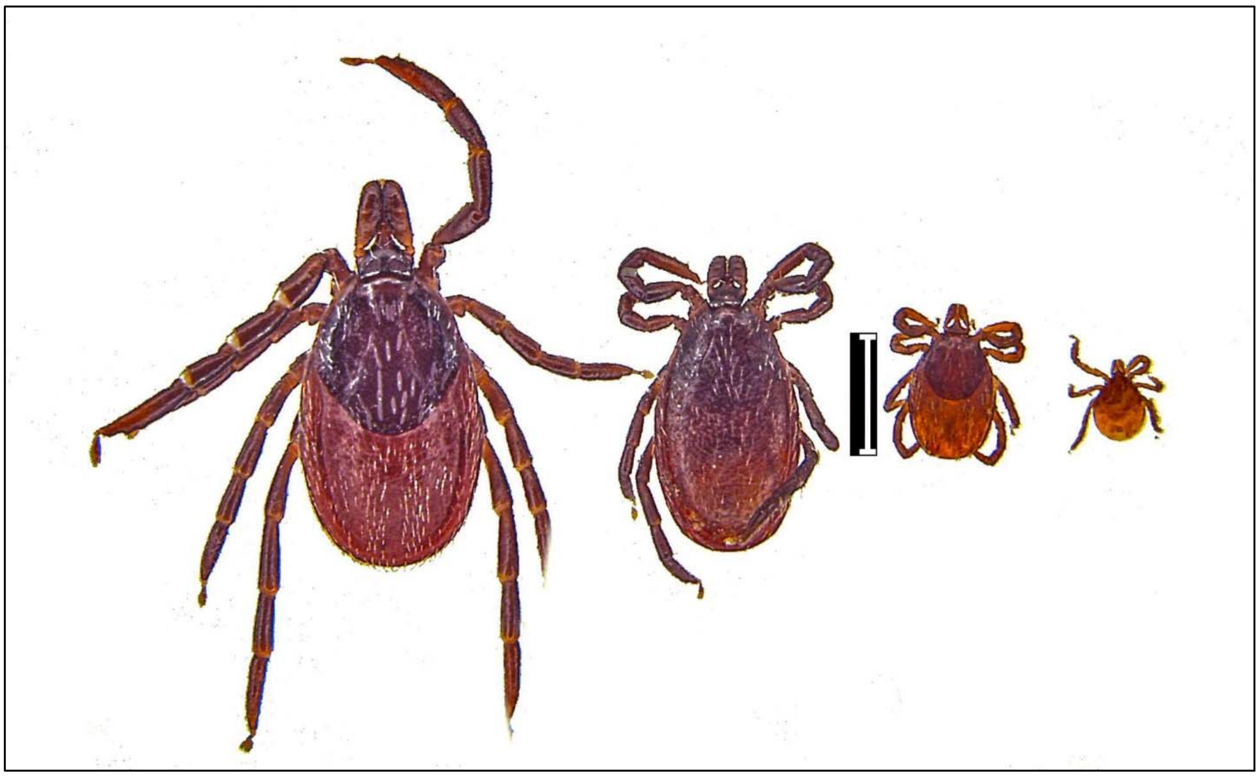
WHAT IS LYME DISEASE?

LD begins in up to 60 to 80% of patients as a slowly expanding reddish rash known as erythema migrans 3 to 32 days after the bite of an infectious tick. This rash may not be noticeable on dark-skinned people. It usually begins at the site of tick-attachment and may expand to several inches in diameter before disappearing within 3 to 4 weeks. Antibiotic treatment reduces the duration of the rash to about a week. Many patients also experience flu-like symptoms during the early stage of illness, particularly fatigue, headache, fever and chills.

Left untreated, the patient may experience other signs or symptoms days to years later. These can involve the skin (multiple secondary rashes), musculoskeletal system (migratory pain in joints, tendons, muscles or bones), neurologic system (profound fatigue, severe headache, facial paralysis, memory loss) and enlarged lymph nodes. Inflammation of the heart or eyes, or liver damage, can occur, too, though not very often, and deaths are rare. Co-infections with other tick-borne disease agents, such as *A. phagocytophilum*, occur occasionally.

THE WESTERN BLACKLEGGED TICK

Ixodes pacificus has been recorded from 56 out of 58 Californian counties. It has the broadest host range of any tick in the state. In total, 108 species of lizards, birds and mammals had been recorded as hosts of *I. pacificus* by 2007. Larvae and nymphs feed preferentially on lizards and to a lesser extent on birds and small mammals for several days, while adult females secure their blood meals from medium- to large-sized mammals like dogs or deer for about a week. Only the nymph and adult female are known to transmit LD spirochetes to people. An unfed nymph is approximately the size of a poppy seed or 1/25th of an inch long. It has a dark, brownish-black sclerotized plate (scutum) on its back, and a pale-colored, translucent abdominal integument



Parasitic stages of the Western Blacklegged Tick (I. From left to right: adult female, adult male, nymph and larva. Scale bar = 1/25th inch.

revealing its blackish midgut. Attached nymphs are overlooked frequently due to their small size, often concealed feeding-sites (e.g., back, hair) and reduced-feeding times compared to female ticks.

Unfed adult females are roughly 1/8th inch long, and possess elongated, forward-projecting mouthparts and brownish-black legs. The scutum also is dark brownish-black, covers the anterior half of the dorsal surface, and the abdomen is reddish-orange. While feeding, females become extremely bloated, expanding to 3/8th inch in length or longer while increasing their initial body weights 100-fold or more. That would be like a 150-lb. person ingesting a 15,000-lb. steak during one, albeit protracted, sitting. At 1/10th inch, unfed adult males are smaller than females, oval-shaped and brownish-black. Although males seldom bite people, they may imbibe small quantities of blood and barely increase in size. The pinhead-sized larvae rarely are found attached to people, too. In northwestern California, adult ticks begin host-seeking in late fall, reach peak abundance in winter and taper off in spring. Nymphal ticks are active from January through October, but usually peak around mid- to late spring (April/May). Consequently, people recreating or working outdoors potentially could be exposed to the bites of infectious *I. pacificus* ticks year-round.

Approximately 1 to 3% of host-seeking *I. pacificus* adults and 2-15% of nymphs occupying suitable habitats are infected with LD group spirochetes in this region, though there can be considerable year-to-year variation in the abundance of infected nymphs and the prevalence of infection in such ticks. In Alameda County, for instance, county-wide surveillance activities in which ticks were collected from diverse habitats and time-frames, *B. burgdorferi*-group positive infection prevalences in host-seeking nymphs and adult ticks were as follows: 6.5% of 2,890 *I. pacificus* nymphs and 0.9% of 3,070 adults collected between 2009 and 2012, 8.3% of 2,686 *I. pacificus* nymphs and 3.5% of 1,845 adults from 2013 to 2016 and 4.0% of 2,972 *I. pacificus* nymphs and 2.0% of 3,737 adults between 2017 and 2022. Combining surveillance data gathered from 2013-2022 revealed that 6.1% of 5,658 *I. pacificus* nymphs and 2.5% of 5,582 adults were infected.

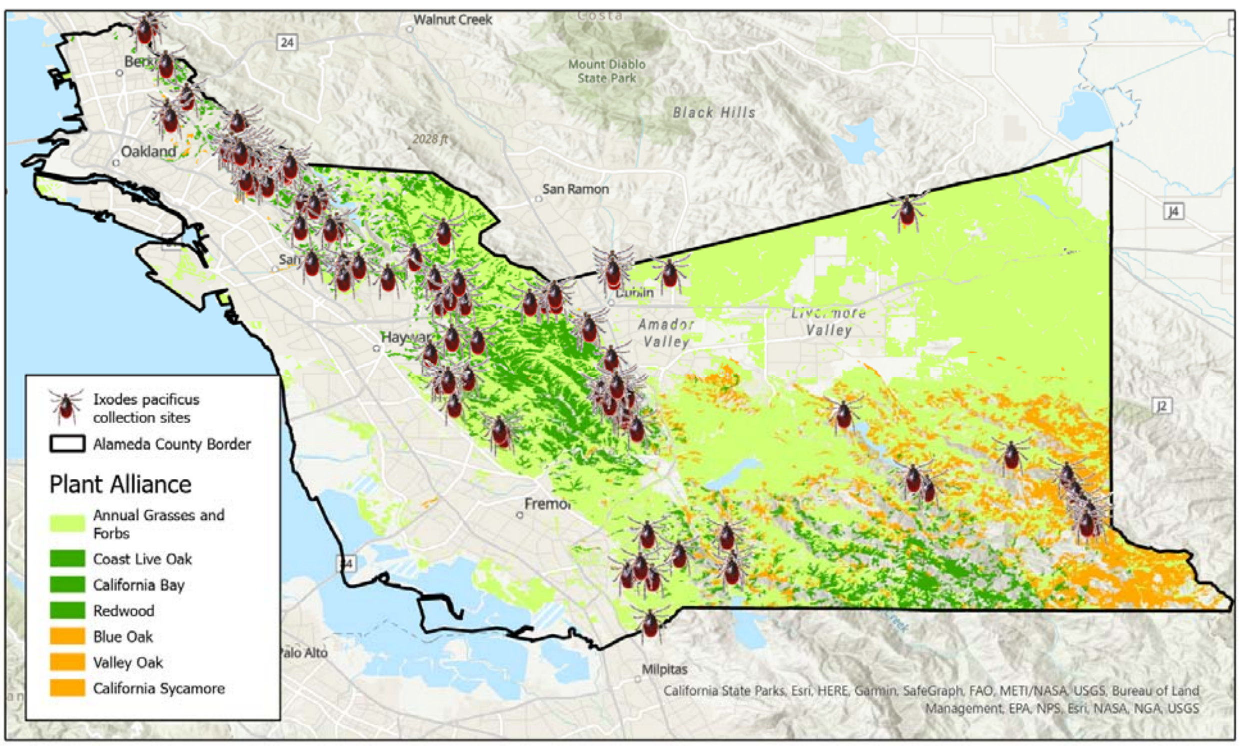
These year-to-year, fluctuating infection prevalences demonstrate why the long-term ACVCSD tick surveillance program is crucially important. Since LD risk varies both spatially and temporally, the District can inform Alameda County residents where and when humans are most apt to encounter infected ticks on an annual basis.

Five species of LD group spirochetes (*B. americana*, *B. bissettiae*, *B. burgdorferi*, *B. californiensis*, *B. lanei*) and a hard-tick relapsing fever group spirochete (*Borrelia miyamotoi*) have been detected in *I. pacificus* in Alameda County; *B. maritima* has been isolated from another *Ixodes* tick (*I. spinipalpis*) that bites people infrequently. Besides *B. burgdorferi*, only *B. bissettiae* and *B.*

miyamotoi are known to infect people in California, but less than a handful of such cases have been reported statewide so far.

RISKY AREAS FOR ENCOUNTERING VECTOR TICKS

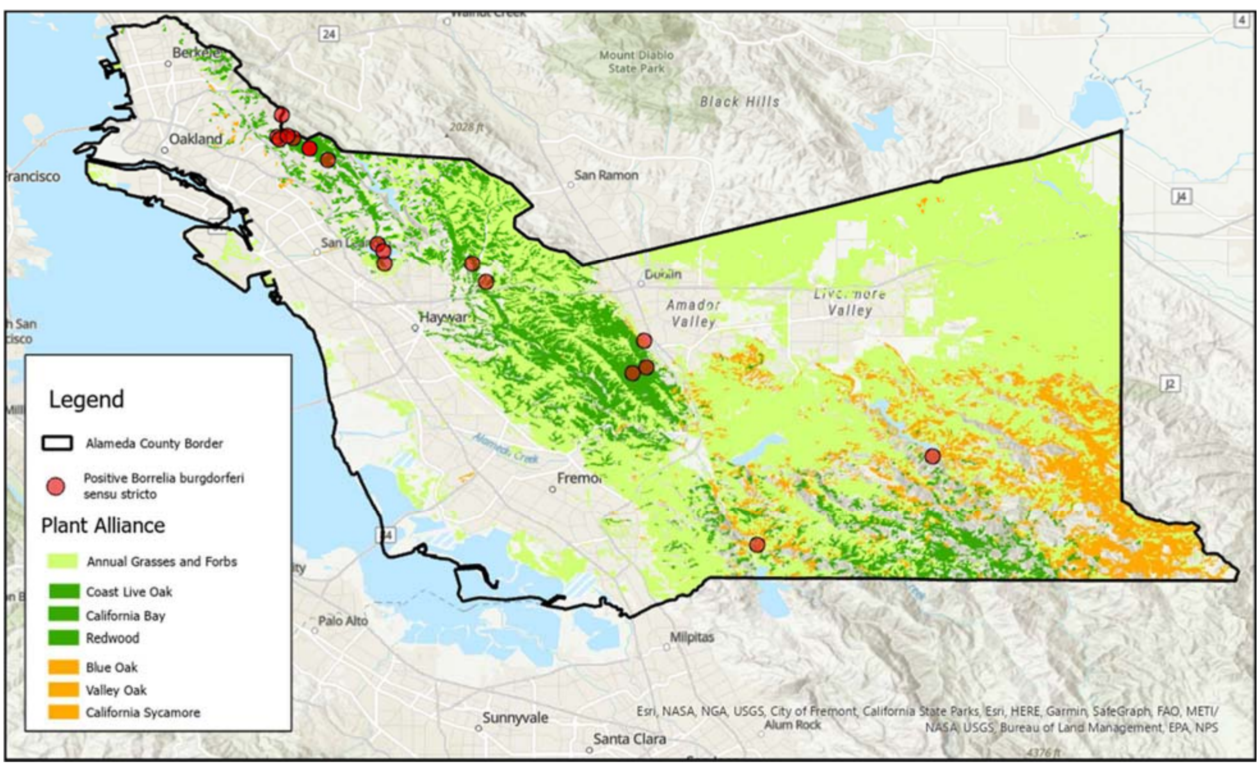
A plant alliance (loosely, a habitat type) is a vegetative classification that describes repeating patterns of plants across a landscape (Source: California Native Plant Society). Each alliance is defined by its plant species composition. During the foregoing 2009-2012 countywide *I. pacificus* survey, 63 sites representing four plant alliances in either maritime or inland areas were sampled multiple times: California Bay and Coast Live Oak; Redwood; Valley Oak, Blue Oak and California Sycamore; and Annual Grasses and Forbs. The riskiest habitat for probable human exposure to LD spirochete-infected nymphs was the Valley Oak, Blue Oak and California Sycamore Alliance in inland areas. Overall, four times as many infected nymphs (12.2%) were found in that alliance versus the second-ranked California Bay and Coast Live Oak Alliance in maritime areas (3.2%). In comparison, the infection prevalence in adult ticks collected in those alliances was identical and considerably lower (1.3%).



Spatial distribution of Western Blacklegged Ticks collected in Alameda County by plant alliance. Mapping by Stephanie Kurniawan

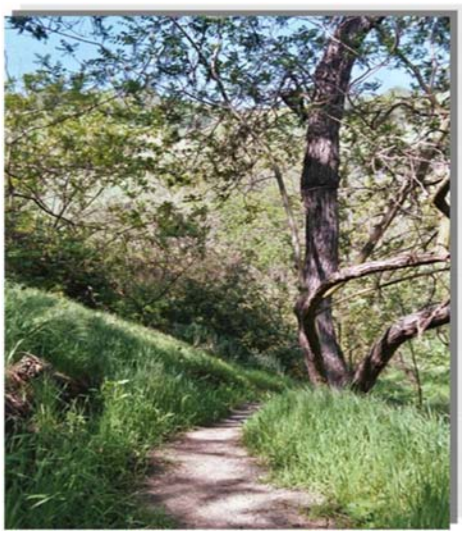
The nymphs are encountered most often in deciduous woodlands carpeted with leaf litter. Researchers survey populations of host-seeking nymphs by dragging white flannel cloths ("tick drags"), typically 1-m^2 in size, over litter areas, woody debris (logs, branches) and large rocks. In some habitats when nymphal populations are peaking in spring, large numbers of nymphs can be collected from certain logs and big rocks, which indicates that people should not utilize them as natural rest stops or lunch counters.

By comparison, adult ticks can be abundant in grasslands, woodland-grass and shrubby habitats (chaparral, coastal scrub) in flatlands or hills. In hilly country, most adults congregate on low-lying vegetation bordering the uphill margins of hillside-hiking trails versus the downhill margins. In fact, research in northwestern California has demonstrated repeatedly that approximately 80-90% of *I. pacificus* adults seek their mammalian hosts along the uphill sides of hiking trails. So, while hiking on narrow trails, avoiding direct contact with vegetation lining the uphill margins could reduce your exposure to host-seeking adult ticks by up to 80 to 90%. Another area where the adults assemble are edges where two vegetational types like grassland and chaparral merge.



Geographic distribution of Western Blacklegged Ticks found to be infected with *B. burgdorferi* in Alameda County by plant alliance. Mapping by Stephanie Kurniawan

In sum, nymphs pose a greater risk of infecting people than adult ticks because they are tiny, have spirochete-infection prevalences greater than those of adult ticks, and feed more rapidly. Moreover, nymphal bites are painless, but attachments by the larger adult females sometimes are painful, thereby facilitating their detection and prompt removal.



Adult ticks often seek their hosts on trailside grasses and forbs in fall and winter

Nymphs can be abundant in leaf-litter and on woody debris in forests during spring and early summer months

PREVENTING TICK-BITES*

Before You Go Outside:

Ticks are common in areas having trees, shrubs, tall grasses, rocks, logs and fallen leaves. They also live in oak, pine and redwood forests.

- In campgrounds and parks, ticks may occur on wooden picnic benches and in natural woody debris, so be aware while sitting or resting on picnic benches, logs as well as rocks.
- If you live adjacent to or near natural areas, ticks may occur in your backyard, neighborhood or schoolyard.
- Ticks that bite humans occupy many different habitats throughout California and the U.S., so whenever you travel it is important to be aware of their presence.

In California, ticks can be active throughout the year, though they are more abundant in winter and spring.

- o Certain outdoor activities can bring people into close contact with ticks.
- o People who spend time outside in grassy, brushy and forested areas are more likely to be bitten.
- o Examples of outdoor activities that can increase your exposure to ticks include hiking, camping, gardening, playing in leaf litter, nature photography and scouting.
- o If you work outdoors, take similar precautions

Dress for Protection

- o When possible, wear a long-sleeved shirt and long pants. Tuck shirts into pants, and legs into socks to prevent ticks from having easy access to your skin.
- o Wear light-colored clothes to help you spot ticks that might have crawled on you.
- o Consider wearing clothes that are pre-treated with permethrin, a product that kills and repels ticks. When using permethrin, follow the instructions on the label carefully. Apply permethrin to clothing and gear before putting them on. Never spray permethrin on your skin.

Apply Tick Repellent

- o Always read and follow label instructions when using any repellent.
- o Use Environmental Protection Agency (EPA) registered insect repellents containing DEET, picaridin, IR3535, oil of lemon eucalyptus (OLE) or para-menthane-diol (PMD). These products provide varying lengths of protection—the longer the protection, the better.
- o Apply EPA-registered repellents on clothes and exposed skin when authorized, especially from your waist down, on your legs, ankles and feet – these areas are more likely to come in contact with ticks while walking or sitting outdoors.

Check Yourself and Others for Ticks While Outdoors

- o Check yourself and others for ticks regularly while walking, hiking or spending time outdoors, especially after brushing up against grasses or shrubs, or after sitting on rocks, logs and wooden picnic benches.
- o Ticks sometimes are hidden in hard-to-see areas like your armpits, back, behind your

knees or ear lobes, in your hair or on your backpack. Inspect these areas carefully. Seek help checking areas you can't easily see or reach.

After you return home

- o Check your clothing, gear and pets for presence of ticks.
- o After reentering your home, examine your entire body for ticks.
- o Use a mirror or ask a family member to inspect those areas that you can't easily observe.
- o If you find a tick attached to your skin, remove it immediately.
- o Parents should carefully examine their children.
- o Continue to check your body and bedding daily for 3-days after having been outdoors in areas known or suspected of harboring ticks.

Dry Clothes

- o Disrobe, put the clothes you were wearing outdoors into a hot dryer for at least 10 minutes to kill any ticks that may have climbed aboard. If your clothes became wet outside, run the dryer for 20 minutes. Then wash and dry the clothes as usual. Exposure to heat will kill all ticks.

Shower

- o Take a shower within two hours or as soon as possible after returning indoors. Showering and scrubbing your head and body with soap will at least remove any unattached ticks that could be on your body. The shower is a great place to do a full body tick-check.

- o An attached tick occasionally may carry more than one microbial disease agent.

How to Remove Ticks

- o If you find a tick crawling on your clothes or skin, brush it off. If you find a tick attached to your skin, remove it right away.

Fig. 1. Grasp tick as close to the skin as possible

Grasp the embedded tick with fine-tipped tweezers, tissue or tick removal tool (never with bare hands) as close to your skin as possible (Fig.1). With a slow, steady motion, pull the tick's body away from the skin. Do not jerk or twist the tick as you extract it.

Fig. 2. Do not grasp tick behind its mouthparts

Grasping the tick higher up on its body can increase the risk of "squeezing" tick bodily fluids into the bite-site (Fig. 2). Do not apply alcohol, fingernail polish, heat from a lit match or petroleum jelly to the tick to try to get it to back out. These methods are ineffective and may increase the likelihood of the tick transmitting disease agents.

Ticks can be submitted to certain commercial laboratories or governmental agencies for testing for presence of *Borrelia burgdorferi* or other disease agents. Call your local commercial laboratory first to find out if the tick should be submitted alive or after having been preserved in 70 or 80% isopropyl alcohol.

*Adapted from California Department of Public Health —Tick-borne Disease Prevention
https://www.cdph.ca.gov/Programs/CID/DCDC/Pages/TickBorneDiseasePrevention.aspx#

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ACKNOWLEDGMENTS

We gratefully acknowledge the many staff members of the ACVCSD who contributed invaluably to the information presented herein, particularly Joyce E. Kleinjan (tick collections, culturing spirochetes), David James and Wade Lee (organizing tick collections) and all the District staff who helped collect ticks, Natalia Fedorova (molecular studies, manuscript review), Bruce Kirkpatrick (editorial advice) and Stephanie Kurniawan (mapping images).

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