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Brief Report

Tick-Borne Diseases in America's National Parks: Observations and Recommendations for Improved Public Health

Sarah P. Maxwell

School of Economic, Political and Policy Sciences, University of Texas at Dallas, Richardson, TX 75080, USA; sarah.maxwell@utdallas.edu

Simple Summary: Lyme disease case reports approach nearly half a million annually in the United States, but the true extent of all tick-borne disease cases is largely unknown. Outside of the Northeast, and in areas where Americans enjoy camping, hiking, and back-backing, such as the U.S. National Parks, risk assessment using human disease reports is challenging given the lack of local vs travel-acquired data at the county level. The use of multimodal data sets, including canine serological reports and established tick presence is needed to advance knowledge regarding potential disease risk. This brief report serves as a discussion starter, noting known disease and tick presence while highlighting inconsistencies and patterns for future evaluation.

Abstract: National parks provide visitors access to hiking, camping, and the outdoors. These activities are associated with an increased risk of tick exposure. This brief report is observational, depicting case reports using raw data, and is not intended to analyze or establish risk but rather to examine geographic areas for potential future research and to identify disparities between canine and human disease reports within the same location. Locally vs. travel-acquired data are not provided by most public health departments in the U.S. Therefore, multimodal data analyses are needed for an improved understanding of disease risk. With data limitations in mind, observations from human and canine comparisons, in addition to tick presence, in this report include (1) tick-borne diseases are reported at most national park areas in the U.S., with the highest case reports in park areas located in Maine and Minnesota; (2) the average total tick-borne diseases combined (i.e., Lyme disease, ehrlichiosis, and anaplasmosis) for park areas allowing dogs is 15.34%. In comparison, the average for national parks without dogs is 8.7%, indicating the need for further study to assess human activity with pets, considering geography and ecology as potential explanatory factors; (3) canine data do not align with human data in many national park geographic areas; and (4) *Ixodes scapularis* presence overlaps with human and canine disease. Using multimodal data can assist with assessing risk when travel vs. local acquisition is unknown.

Keywords: U.S. national parks; tick-borne diseases; Lyme disease; canine

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1. Introduction

There are 429 national park sites, including battlefields and monuments, in the United States. The total land area covers more than 84 million acres in the United States (50 states, the District of Columbia) and US territories (American Samoa, Guam, Puerto Rico, and the Virgin Islands) [1]. Sixty-three of these sites are titled "national parks" in the United States and U.S. territories and comprise the main park locations within the national park system. These 63 parks within the continental US and Hawaii (designated as the US National Parks by the National Park Service) are the focus of this report, as they account for the largest land areas of public use and are known for outdoor recreation, tent camping, and backpacking. Additionally, the National Park Service officially designates these 63 areas as U.S. national parks. The overall number of visitors to the national park system totaled more than 325 million in 2023 [2], while the 63 national parks welcome about 92 million visitors

annually. This brief report considers 61 designated national parks due to data availability, and given the sizable acreage coverage the parks consume in the U.S., along with the high number of visitors.

Ectoparasite, and particularly tick presence in national parks, are not currently established. Medically important disease-causing ectoparasites are generally categorized as arthropods or arachnids. Within the arthropod category, mosquitoes are the most predominant vectors of human disease; ticks are second. The true number of human tick-borne disease cases is largely unknown, particularly outside of areas considered non-endemic, as states maintain different reporting practices, and local vs. travel-acquired disease is not generally reported at the county level. Additionally, data across years are not readily available for diseases other than Lyme. Analyzing risk is typically established through tick testing, but those data are sparse. For national parks outside of the Northeast, human disease reports are limited, and, similar to other counties across the U.S., reports often fail to note the geographic location where the tick bite encounter occurred.

This observational report aims to stimulate discourse regarding the patchwork collection of limited official data to which researchers have access, identifying national parks as an example of multiple tick-borne disease data limitations. Importantly, a host of data limitations currently prevent researchers from properly establishing disease risk. These include (1) official tick-borne disease data are scattered by year and disease; (2) lack of locally vs. travel-acquired disease data makes quality research difficult, as official disease reports fail to confirm disease acquisition within a park location or at the county level; (3) national parks are difficult to study, as official disease data exist primarily at state levels, which are often reported for brief time periods.

Identifying knowledge gaps is an essential component of zoonotic disease prevention [3]. Tick-borne disease risk has been evaluated in individual parks and regions (e.g., the Northeast). These studies typically focus on specific geographic areas within a given park(s), on a particular tick species, or on human or wildlife reports of disease [4–9]. A comprehensive study of tick-borne disease (TBD) risk in U.S. national parks concluded that a lack of systematic surveillance for vector-borne pathogens equates to unknown risk for employees and visitors [5]. This 2013 study also notes the limits of TBD data secured from neighboring communities rather than the actual parks, given varying terrains and human behavior differences [5]. I, therefore, consider outdoor activities in the national parks, such as camping and hiking, and report human, canine, and tick data only in counties that overlap with park boundaries in this observational report.

With limited disease surveillance, visitors who become infected in a national park may fail to link a park visit to subsequent flu-like illness, arthritis, anxiety, or a host of other TBD symptoms [10,11]. The CDC notes that Lyme arthritis, for example, can develop within one to a few months post-infection [10]. Pace and O'Reilly, in Journal: Tickborne Diseases: Diagnosis and Management, state that "Tickborne diseases are increasing in incidence and should be suspected in patients presenting with flulike symptoms during the spring and summer months. Prompt diagnosis and treatment can prevent complications and death. Location of exposure, identification of the specific tick vector, and evaluation of rash, if present, help identify the specific disease" [12]. Tick bites are typically small and may go unnoticed; however, symptoms with the absence of a tick bite history do not exclude a TBD [13]. Those infected with tick-borne diseases may not develop symptoms for weeks and may test negative if they started antibiotics or are tested within the first few weeks before antibodies have developed [14,15]. It typically takes 4–6 weeks for Lyme disease tests, in particular, to appear positive [14,15].

Camping and hiking off trails are both risk factors in tick and tick-borne disease exposure [16]. Although travel history and details of summer activities are necessary for diagnosis, medical interviews typically neglect these discussions [13]. There is also evidence that exposure via occupation, for example, may increase TBD risk. Park rangers were found to be at increased risk of Lyme disease [17]. Additionally, park employees from Rocky Mountain and Great Smoky Mountains National Parks were found to be infected

with spotted fever group *rickettsiae* and *B. henselae* at both sites and other TBDs in Great Smoky Mountains National Parks [4].

The objective of this Brief Report is not to assess risk or provide a formal methodology, but rather to document known and unknown variables, recognize data limitations, and stimulate future research that includes more nuanced data, such as tick presence and tick testing, particularly within national parks, forests, or grasslands outside of the Northeast, where dogs are allowed, and in parks where canine serological reports of confirmed disease do not align with human disease cases. I conclude that nuanced studies are warranted across all national park areas in the U.S., particularly in areas suspected to be non-endemic, and where emerging tick-borne diseases are not yet established.

2. Tick-Borne Disease Data and National Parks

This brief report depicts TBD presence in 61 out of the 63 national parks in the United States due to data availability. Each park's geographical coordinates were correlated to a county through LatLong.net using the main park entrance address as provided by the National Park Service. Counties serve as approximate locations for the parks, as some parks span multiple counties. Following Eisen et al. (2013) recommendations, disease data that align with park location were collected rather than data from surrounding communities where employees or visitors may not be present and where behaviors, such as camping or hiking, may also be less likely [5].

The informal methodology is an observational approach to document confirmed cases of disease, using county-level data that overlaps with national park locations. I evaluate human and canine confirmed cases in parks that allow tent camping and where dogs are welcome. *Ixodes scapularis* tick presence reported and established, is presented for 13 of the counties as tick testing is limited. Canine-human disease alignment is also examined. Numerous studies have been undertaken using one or more of the same factors; these studies illuminate biological and ecological nuances; for example, the discovery of a specific tick species above 7000 feet and within sagebrush or noting national park employees' increased risk of exposure or disease [3–7].

Data were selected by availability. The Centers for Disease Control and Prevention offer TBD data at the county level for diseases other than Lyme Disease only from 2016 to 2019. Given that these are the only official county-level TBD data currently available to researchers across states, the CDC data set was selected. Each TBD case report during the selected CDC-reported years is provided in table format.

Tables and maps are utilized to demonstrate the presence of TBDs at any point in time, indicating human or canine TBD presence is established.

The review includes tables and maps that detail the following:

1. Total visitors to national parks, including numbers for tent camping and backpacking. Data on national park visitation and usage were obtained from the U.S. National Park Service and cited in Appendix A.
2. Incidences of human TBDs by proxy county for each national park geographic area.
3. Canine cases with confirmed TBD serology in each national park geographic area.
4. *Ixodes scapularis* tick presence, 2024 CDC.
5. Thematic and overlaid mapping of select TBDs with U.S. national parks.

Methodological notes: Many emerging tick-borne diseases are not mandated as reportable diseases to states and consequently are excluded from this report. Discrepancies in years among tables occur due to varying data accessibility. The maps were generated using Excel (Microsoft 365) and the DataWrapper App (2024), an online mapping tool. The overlay maps present a visual representation of established TBDs and do not establish actual risk.

3. Observations

There is evidence that TBDs are reported in most of the United States National Park areas in this report, either via canine serology or human testing within the county. Excep-

tions include Great Basin National Park (Nevada), Great Sand Dunes National Park and Preserve (Colorado), Guadalupe Mountains (Texas), and the two national parks in Hawaii. These parks either had zero or very low case reports. However, in some cases (e.g., Hawaii), human reports are zero, while canine TBD case reports are present.

Acadia (Maine) and Voyageurs National Park (Minnesota) geographic areas had the highest human Lyme disease incidences and high overall canine TBDs. The top national park locations for canine Lyme disease were Shenandoah, Acadia, New River Gorge National Park and Preserve, Isle Royale, and Voyageurs.

Tables and maps are presented below, documenting national park visitation, human tick-borne disease reports in national park geographic areas, canine TBDs by national park-county location, and *Ixodes scapularis* tick presence in counties where data are available. Additional information is located in Appendices A–C.

3.1. U.S. National Park Visitation

The top 15 most visited parks are provided in Table 1. This table also includes the number of tent campers and backpackers in 2022. Appendix A provides a full table of national parks included in this study with historical visitation and camper visits.

Table 1. United States national park historical visitor usage, 1919–2022 (top 15 most-visited).

National Park	County	State	Number of Visitors (2022)	Number of Tent Campers (2022)	Number of Backpackers (2022)	Total Visits (1919–2022) *
Great Smoky Mountains	Blount	Tennessee	12,937,633	213,092	96,762	596,449,795
Grand Canyon	Canyon Coconino	Arizona	4,732,101	89,825	331,623	236,257,914
Yosemite	Mariposa	California	3,667,550	349,888	142,457	212,397,206
Rocky Mountain	Larimer	Colorado	4,300,424	110,586	34,645	205,814,841
Yellowstone	Park	Wyoming	3,290,242	10,909	34,758	199,248,728
Acadia	Hancock	Maine	3,970,260	136,183	1472	184,704,716
Olympic	Clallam	Washington	2,432,972	137,274	133,751	178,141,293
Grand Teton	Teton	Wyoming	2,806,223	0	40,010	168,093,258
Gateway Arch	St. Louis city	Missouri	1,618,774	0	0	143,551,484
Zion	Washington	Utah	4,692,417	133,666	10,375	137,947,697
Shenandoah	Madison	Virginia	1,449,300	108,384	67,738	134,969,283
Glacier	Flathead	Montana	2,908,458	90,422	28,261	122,039,197
Mount Rainier	Pierce	Washington	1,622,395	54,851	43,468	103,377,992
Hot Springs	Garland	Arkansas	2,646,133	633	0	102,721,821
Cuyahoga Valley	Summit	Ohio	2,913,312	0	0	96,436,221

* National Park total visitor data collection starting dates vary from 1919–1972.

3.2. Human Tick-Borne Diseases in U.S. National Parks

Table 2 presents human TBD data from the CDC from varying years, as available [18,19]. Table 2 includes diseases transmitted by both hard and soft tick vectors. Argasid (soft ticks) transmit all relapsing fever *borreliae* (except *B recurrentis*) [20]. The American Dog Tick and Rocky Mountain Wood Tick (soft ticks) are vectors for spotted fever, and the American Dog Tick can also spread Tularemia. Both are included in the human case data below.

Table 2. National park human TBDs by total TBDs (2016–2019) and highest number of visitors (2022).

National Park	State	Number of Visitors (2022)	All Human TBDs (2016–2019)
Acadia	Maine	3,970,260	1458
Voyageurs	Minnesota	221,434	1401
Hot Springs	Arkansas	2,646,133	294
Indiana Dunes	Indiana	2,834,180	204
Biscayne	Florida	701,023	146
Redwood	California	458,400	108
Cuyahoga Valley	Ohio	2,913,312	95
Congaree	South Carolina	204,522	69
Gateway Arch	Missouri	1,618,774	61
Shenandoah	Virginia	1,449,300	54
Joshua Tree	California	3,058,294	54
Isle Royale	Michigan	25,454	51
Channel Islands	California	323,245	44
Mount Rainier	Washington	1,622,395	40

National parks shaded in green are those with the highest number of visitors and secondary criteria as the highest number of those with tent campers in 2022. The top three parks with the highest number of visitors, tent campers, and TBDs were Acadia, Hot Springs, and Indiana Dunes. The top 15 parks for overall human TBD reports include (from largest to smallest) Acadia; Voyageurs; Hot Springs; Indiana Dunes; Biscayne; Redwood; Cuyahoga Valley; Congaree; Gateway Arch; Joshua Tree; Shenandoah; Isle Royale; Channel Islands; Mount Rainier; and Everglades.

Additional observational analyses of TBD reports at the most visited US National Parks are also provided, first for the largest total number of human tick-borne diseases reported in the county and next by the largest number of visitors. Table 2 indicates that Voyageurs National Park geographic area (Minnesota) has close to the same number of total human TBDs as the Acadia National Park area (Maine) and more than parks found in Ohio and Virginia. Other observations include elevated levels of reported TBDs over a short period in some of the most visited national parks.

3.3. Canine Tick-Borne Diseases in U.S. National Parks

Using a One Health approach, noting the connectivity of human diseases to that of animals and the shared environment, canine TBD reports were included. Canine anaplasmosis was notably high in Acadia, indeed, almost 2 ½ times higher than canine LD. Shenandoah National Park geographic area (Virginia) has the highest number of canine LD cases, with Acadia, New River Gorge National Park and Preserve (West Virginia), and Voyageurs (Minnesota) geographic locations with notably high cases of LD, respectively. Importantly, canine data indicate that LD is not always the most prevalent and, in some cases, absent, even in the presence of high TBDs, such as anaplasmosis (Capital Reef, Utah) or ehrlichiosis (Mammoth Cave, Kentucky).

Table 3 shows national park areas by order of highest canine TBDs. Orange-highlighted rows indicate national parks where dogs are allowed within the park. Six out of the eleven parks allowing dogs had total TBDs over 10%. The average total tick-borne diseases combined (i.e., Lyme disease, ehrlichiosis, and anaplasmosis) for parks allowing dogs is 15.34%, while the average for parks without dogs is 8.7%. National park geographic areas that permit canine companions have a higher average total tick-borne disease reports in the respective county. By individual diseases, average positive serology reports for canines

in parks allowing dogs were LD-4.5%, erhlichiosis-5.6%, and anaplasmois-5.3%. Where dogs are not allowed: LD-1.7%, erhlichiosis-3.4%, and anaplasmosis-3.7%. In sum, across all diseases, parks that allow canine companions demonstrate higher reports of TBDs in canines. The majority of national parks allowing dogs tend to be geographically located in the east-south-central and west-south-central regions, including states such as Arkansas or Kentucky, with known tick expansion. However, two national parks in Arizona are unique, as one (Petrified Forest) allows dogs and has high TBD rates. In contrast, the second (Grand Canyon) does not allow canines and has considerably lower reports of canine TBDs. Both areas have similar topography, but the Petrified Forest ecology is shortgrass prairie and some grasslands with diverse plants and animals [21].

Table 3. Canine tick-borne diseases, percent positive of all dogs tested in the county, 2023 by National Park Service county location (orange shaded parks allow dogs).

National Park	County	State	% Positive Lyme Disease	%Positive Ehrlichiosis	%Positive Anaplasmo-sis	% Positive All TBDs
Acadia	Hancock	Maine	18.89	1.81	46.77	67.47
Mammoth Cave	Hart	Kentucky	9.09	36.36	6.06	51.51
Shenandoah	Madison	Virginia	21.62	10.81	10.81	43.24
Voyageurs	St. Louis	Minnesota	9.31	1.14	24.83	35.28
Isle Royale	Houghton	Michigan	12.12	0.77	16.2	29.09
Yellowstone	Park	Wyoming	9.09	18.18	0	27.27
Arches	Grand	Utah	0	10.34	16.38	26.72
Capitol Reef	Wayne (Grand)	Utah	0	10.34	16.38	26.72
New River Gorge National Park and Preserve	Fayette County	West Virginia	15.54	0.82	4.3	20.66
Hot Springs	Garland	Arkansas	0.3	18.07	0.9	19.27
Petrified Forest	Apache (Navajo)	Arizona	0.18	7.56	5.8	13.54
Katmai National Park and Preserve	Bristol Bay Borough (Kenai Peninsula)	Alaska	3.57	7.14	0	10.71
Kenai Fjords	Kenai Peninsula Borough	Alaska	3.57	7.14	0	10.71
Lake Clark National Park and Preserve	Lake and Peninsula Borough (Kenai)	Alaska	3.57	7.14	0	10.71
Canyonlands	San Juan (Kane)	Utah	1.18	4.14	4.14	9.46
Indiana Dunes	Porter	Indiana	5.46	1.27	2.05	8.78
Redwood	Humboldt	California	1.3	0.7	6.49	8.49
Gateway Arch	St. Louis city	Missouri	0.33	7.39	0.63	8.35
Carlsbad Caverns	Eddy	New Mexico	0.1	6.27	1.71	8.08
Denali National Park and Preserve	Denali Borough (Matanuska-Susitna Borough)	Alaska	1.09	2.17	4.35	7.61
Gates of the Arctic National Park and Preserve	Yukon-Koyuk (Matanuska-Susitna Borough)	Alaska	1.09	2.17	4.35	7.61
Wrangell– St. Elias National Park and Preserve	Valdez- Cordova (Matanuska-Susitna Borough)	Alaska	1.09	2.17	4.35	7.61
Cuyahoga Valley	Summit	Ohio	4.84	1.18	1.28	7.3
Bryce Canyon	Garfield	Utah	1.2	0.6	5.42	7.22

Table 3. *Cont.*

National Park	County	State	% Positive Lyme Disease	%Positive Ehrlichiosis	%Positive Anaplasmosis	% Positive All TBDs
Kobuk Valley	Northwest Arctic Borough	Alaska	1.65	2.67	2.88	7.2
Grand Canyon	Canyon Coconino	Arizona	0.45	3.97	2.23	6.65
Grand Teton	Teton	Wyoming	1.08	2.89	2.53	6.5
Big Bend	Brewster	Texas	0.9	3.14	2.4	6.44
Haleakalā	Maui	Hawaii	0.41	3.9	2.05	6.36
Dry Tortugas	Monroe	Florida	1.3	2.32	2.58	6.2
Kings Canyon	Tulare	California	0.24	2.72	2.55	5.51
Sequoia	Tulare	California	0.24	2.72	2.55	5.51
Glacier Bay National Park and Preserve	Hoonah-Angoon Census Area	Alaska	0	3.6	1.8	5.4
Mesa Verde	Montezuma	Colorado	0.46	2.76	1.96	5.18
Guadalupe Mountains	Hudspeth (El Paso)	Texas	0.41	3.04	1.51	4.96
Crater Lake	Klamath	Oregon	0.66	2.3	1.64	4.6
Biscayne	Miami-Dade	Florida	0.39	2.64	1.35	4.38
Death Valley	Inyo	California	0	4.35	0	4.35
Glacier	Flathead	Montana	1.14	0.86	2.31	4.31
Lassen Volcanic	Tehama	California	1.35	1.01	1.95	4.31
Great Smoky Mountains	Blount	Tennessee	1.47	2.17	0.62	4.26
White Sands	Dona Ana	New Mexico	0.3	2.29	1.58	4.17
Everglades	Collier	Florida	0.98	1.02	2.03	4.03
Olympic	Clallam	Washington	0.19	1.54	2.3	4.03
Yosemite	Mariposa (Tuolumne)	California	1.11	0.59	2.31	4.01
Saguaro	Cochise	Arizona	0.5	2.3	1.15	3.95
Mount Rainier	Pierce	Washington	0.4	1.41	1.79	3.6
Rocky Mountain	Larimer	Colorado	0.49	1.66	1.16	3.31
Congaree	Richland	South Carolina	0.77	1.84	0.55	3.16
Black Canyon of the Gunnison	Montrose	Colorado	0.33	1.25	1.45	3.03
Zion	Washington	Utah	0.41	1.35	1.22	2.98
Pinnacles	San Benito	California	0.5	1.11	0.99	2.6
Joshua Tree	Riverside	California	0.24	1.19	1.15	2.58
Hawai‘i Volcanoes	Hawaii	Hawaii	0.18	1.05	1.23	2.46
Wind Cave	Fall River (Pennington)	South Dakota	0.39	0.77	1.27	2.43
Badlands	Pennington	South Dakota	0.3	0.77	1.27	2.34
Channel Islands	Ventura	California	0.22	0.86	1.01	2.09
North Cascades	Skagit	Washington	0.21	0.88	0.97	2.06
Great Basin	White Pine (Elko)	Nevada	0.79	0	0	0.79
Great Sand Dunes National Park and Preserve	Alamosa	Colorado	0	0	0	0
Theodore Roosevelt	Billings	North Dakota	0	0	0	0

Table 4 provides the highest percent of positive tests among canines in counties that represent national parks in the U.S. national park locations shaded in orange represent overlap with the highest human TBD cases. Human TBD cases include diseases, such as Rocky Mountain spotted fever, that canines may acquire but for which data are not available. Observationally, overlap between human and canine confirmed cases occurs in eastern portions of the U.S. In some cases, western regions of the U.S. report over 25% positive canine serology but considerably smaller reports of any human TBD.

Table 4. National Parks by percentage of canines testing positive for TBDs (2022) (orange shaded represents highest human TBD case reports).

National Park	County, State	Percent Total Canine TBDs
Acadia	Hancock County, Maine	67.47
Mammoth Cave	Hart County, Kentucky	51.51
Shenandoah	Madison County, Virginia	43.24
Voyageurs	St. Louis County, Minnesota	35.28
Isle Royale	Houghton County, Michigan	29.09
Yellowstone	Park County, Wyoming	27.27
Arches	Grand County, Utah	26.72
Capitol Reef	Wayne County, Utah	26.72
New River Gorge National Park and Preserve	Fayette County, West Virginia	20.66
Hot Springs	Garland County, Arkansas	19.27
Petrified Forest	Apache County, Arizona	13.54
Katmai National Park and Preserve	Bristol Bay Borough, Alaska	10.71
Kenai Fjords	Kenai Peninsula Borough, Alaska	10.71
Lake Clark National Park and Preserve	Lake and Peninsula Borough, Alaska	10.71
Canyonlands	San Juan County, Utah	9.46

Table 5 provides Blacklegged Tick (*Ixodes scapularis*) presence data, either reported or established in 13 of the national park geographic regions. Data were not collected or available for all other proxy counties. Established tick presence is defined as "Six or more *I. scapularis* . . . of a single life stage, or more than one life stage of the tick collected in the county within a 12-month period" [22]. Reported ticks are defined as "Less than six *I. scapularis* . . .of a single life stage collected in the county within a 12-month period" [22]. Counties classified as "no records" do not imply tick absence. No records may result from no sampling efforts in the county, tick collection, or reporting.

Table 5. *I. scapularis* presence (reported and established) in U.S. national park geographic areas.

National Park	State	*I. Scap* Reported or Established	Human TBD Confirmed Report	Canine TBD Confirmed Report
Acadia	Maine	Established	Lyme Disease, Babesiosis, Anaplasmosis, Spotted Fever, Tularemia	Lyme Disease, Ehrlichiosis, Anaplasmosis
Biscayne	Florida	Established	Lyme Disease, Babesiosis, Anaplasmosis, Ehrlichiosis	Lyme Disease, Ehrlichiosis, Anaplasmosis
Congaree	South Carolina	Established	Lyme Disease, Spotted Fever	Lyme Disease, Ehrlichiosis, Anaplasmosis
Cuyahoga Valley	Ohio	Established	Lyme Disease, Anaplasmosis, Spotted Fever	Lyme Disease, Ehrlichiosis, Anaplasmosis

Table 5. *Cont.*

National Park	State	*I. Scap* Reported or Established	Human TBD Confirmed Report	Canine TBD Confirmed Report
Dry Tortugas	Florida	Established	Lyme Disease, Babesiosis, Anaplasmosis	Lyme Disease, Ehrlichiosis, Anaplasmosis
Everglades	Florida	Established	Lyme Disease, Babesiosis, Anaplasmosis	Lyme Disease, Ehrlichiosis, Anaplasmosis
Hot Springs	Arkansas	Established	Lyme Disease, Ehrlichiosis, Anaplasmosis, Spotted Fever, Tularemia	Lyme Disease, Ehrlichiosis, Anaplasmosis
Indiana Dunes	Indiana	Established	Lyme Disease, Spotted Fever	Lyme Disease, Ehrlichiosis, Anaplasmosis
Isle Royale	Michigan	Established	Lyme Disease, Anaplasmosis	Lyme Disease, Ehrlichiosis, Anaplasmosis
New River Gorge National Park	West Virginia	Established	Lyme Disease	Lyme Disease, Ehrlichiosis, Anaplasmosis
Voyageurs	Minnesota	Established	Lyme Disease, Babesiosis, Anaplasmosis, Ehrlichiosis, Tularemia	Lyme Disease, Ehrlichiosis, Anaplasmosis
Gateway Arch	Missouri	Reported	Lyme Disease, Ehrlichiosis, Anaplasmosis, Spotted Fever, Tularemia	Lyme Disease, Ehrlichiosis, Anaplasmosis
Mammoth Cave	Kentucky	Reported	Lyme Disease, Ehrlichiosis, Spotted Fever	Lyme Disease, Ehrlichiosis, Anaplasmosis

Ixodes scapularis is found primarily across the eastern United States, including the Northeast, mid-Atlantic, and parts of the Midwest. *I. scapularis* vectors transmit the following pathogens: Borrelia burgdorferi and B. mayonii (both cause Lyme disease); B. miyamotoi disease (one type of relapsing fever); Ehrlichia muris eauclairensis (ehrlichiosis); Anaplasma phagocytophilum (anaplasmosis); Babesia microti (babesiosis); Powassan virus (Powassan virus disease); and tick paralysis. Tick paralysis is more commonly transmitted, however, by the *Dermacentor variabilis* (American dog tick) and *Dermacentor andersoni* (Rocky Mountain wood tick).

Dermacentor variabilis and *Dermacentor andersoni* are also associated with spotted fever diseases. Spotted fevers develop via the bacteria *Rickettsia.* Rocky Mountain spotted fever is the most common of the spotted fevers in the U.S. and is known to overlap geographically with other TBDs. Table 5 shows geographic areas where both diseases are reported in humans.

3.4. Thematic Tick-Borne Disease Mapping

Thematic maps in this brief report are not intended to represent the biological and ecological interactions needed to assess actual TBD risk in U.S. national parks. Thematic choropleth maps simply present a visual representation of established TBD presence. Figure 1 presents an overlay representation of RMSP on national park locations.

Figure 2 offers a visual representation of human and canine TBD cases using data over available years. The maps indicate that TBDs are present across all 61 observed U.S. national parks. Additional maps of all human TBDs between 2016 and 2019 are provided in Appendix B.

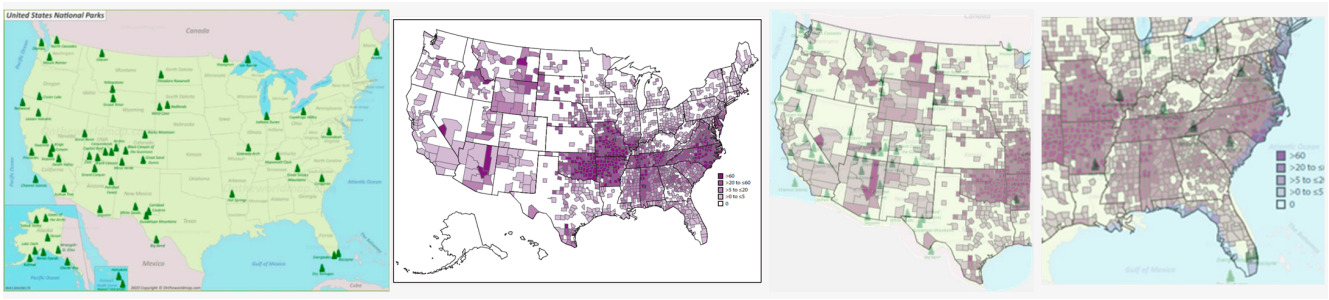


Figure 1. Thematic Overlay of Rocky Mountain Spotted Fever on US National Park Geographic Areas. [United States national parks [23]; Rocky Mountain spotted fever (2000–2013) [24].

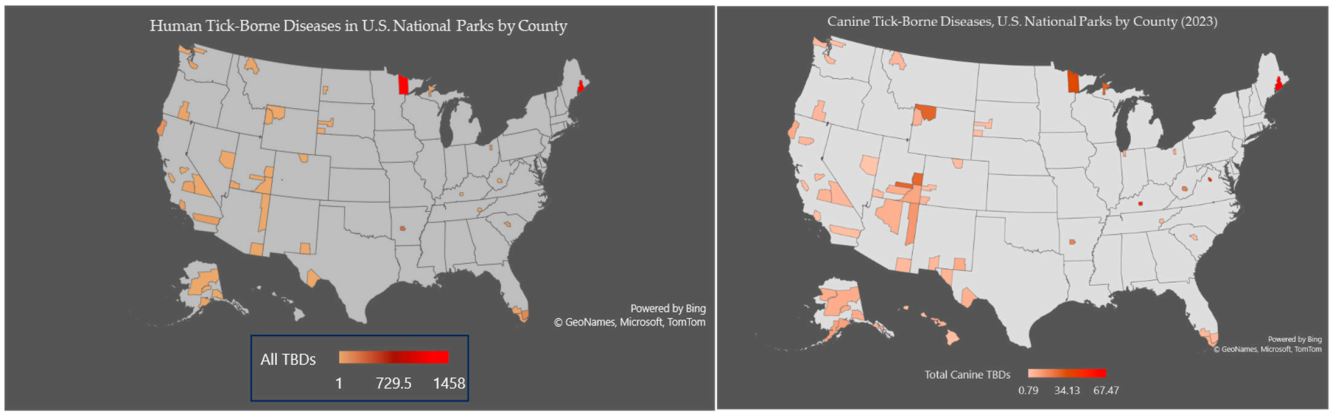


Figure 2. Tick-borne disease presence by total human and canine cases. Data by availability as presented in Figure 2: Human TBDs (2016–2019) and Canine TBDs, 2023.

4. Key Observations and Recommendations

This brief report asks readers to consider the complexity of diagnosis and public health communication with asymmetric or insufficient tick-borne disease data. Further analyses are recommended that include multimodal data approaches using canine, tick-presence, wildlife, ecosystem, human activities (e.g., tent camping or backpacking), and other factors that contribute to local understanding of disease risk, particularly in widely visited outdoor recreation areas, such as the national parks. Comparative data may enhance further research. Observationally, for example, canine and human data reports of TBDs are not aligned and warrant further study.

Given the tables and maps presented in this report, the following observations and recommendations are presented to assist with future TBD research in national parks:

Tick-borne diseases are established across almost all U.S. national park geographic areas, including Alaska, the southern tip of Florida, the Midwest, and the Western United States. However, in many instances, only one report of an individual disease between 2016 and 2019 is documented. It is not established that these case reports were locally acquired. The lack of locally acquired human data at the county level generally results in researchers pulling data from canines, tick presence, and other ecological or geographic variables to provide improved risk assessments. Recommendation: States should require reporting that includes locally acquired vs. travel-acquired patient history. Researchers may wish to access tick presence data from commercial tick collection laboratories to fill in data gaps.

The most prevalent canine diseases for all national park areas were ehrlichiosis, anaplasmosis, and LD, respectively. For humans, the largest number of cases were LD, spotted fever, Rickettsia, anaplasmosis, ehrlichiosis, babesiosis, and tularemia, respectively. Canine testing panels might include multiple TBDs, while human testing may focus on ruling out LD specifically. Recommendation: further research should consider the lack of alignment between canine and human disease reports.

Acadia National Park geographic area, as represented by Hancock County, has the highest number of human LD and highest rates of canine anaplasmosis, also indicating a potential lapse in comparable testing.

Outside of Maine's Acadia NP, the Mammoth Cave National Park area (Kentucky) has the second highest rate of canine TBD, particularly ehrlichiosis.

Importantly, canine data are useful in demonstrating that LD is not always the most prevalent and, in some cases, absent, even in the presence of high TBDs, such as anaplasmosis (Capital Reef NP, Utah) or ehrlichiosis (Mammoth Cave NP, Kentucky). After Mammoth Cave, Hot Springs and Yellowstone National Park geographic areas have the highest number of canine ehrlichiosis cases across all national parks.

The county overlapping Hot Springs National Park in Arkansas accounts for almost 2/3 of all human cases of Rocky Mountain spotted fever in all the national park geographic areas, with Congaree (South Carolina) and Gateway Arches National Park (Utah) second and third, respectively. Hot Springs (Arkansas) also has the largest number of human ehrlichiosis cases. Recommendation: the Centers for Disease Control and Prevention should expand access to all years for all TBDs at the county-level to better inform public health in assessing TBD trends.

Voyageurs National Park in Minnesota warrants the attention of public health officials. With over 1300 LD cases in three years, in addition to 56 cases of anaplasmosis, Voyageurs overall appears as likely a place to contract TBDs as Maine's Acadia National Park. Further research is needed that incorporates additional data and, preferably, more years. Note: The Lyme Disease Association, Inc. awarded a grant to create county-level data guidebooks for all U.S. counties. This work will be completed in 2025 and will be open access [25].

Available disease data vary over the years, so useful comparisons using multimodal data sets require improved data availability by states and the CDC. County-level data for all TBDs, if made available, would greatly enhance disease risk knowledge. Disease risk assessment is also improved by considering the abundance of infected ticks in addition to human behavior known to increase the likelihood of a tick bite encounter [26]. Recommendation: combining numerous data sets that cover human and pet activity, in addition to geological and ecological variables across all parks has the potential to improve collective public health knowledge.

Although it appears that allowing canine companions in national parks is potentially associated with increased positive canine serology reports, many of the parks allowing dogs are found in states with known TBB risk, e.g., Kentucky and Arkansas. However, only one state, Maine, has a national park that allows dogs in the Northeastern U.S. A nuanced review of ecological factors, tick presence, and additional One Health variables to review this observation is needed.

Comparing individual TBDs provides additional areas for further study. Using the raw data and maps of individual human TBDs in national park geographic areas (Appendices A–C) shows that TBDs are concentrated in different parks. The highest concentration outliers typically occur in only one or two parks. Lyme Disease (Maine and Minnesota); Babesiosis (Maine and Minnesota); Ehrlichiosis (Arkansas); Anaplasmosis (Maine and Minnesota); spotted fever (Arkansas); and Tularemia (Colorado). Using the highest case reports may indicate more locally acquired, as there are more data points, and can potentially serve as useful data for medical practitioners assessing potential patient co-infections in a region where a tick bite encounter or travel occurred.

Recommendation: The CDC and states should offer county-level data for all TBDs, including emerging TBDs, for extended periods. State-level data are not helpful to public health officials outside of the Northeast, as many larger states have varied ecosystems representing different levels of risk. New data collection efforts are currently in progress to collect county-level data on all TBDs through grant-funded research [27].

Recommendation: Future research should concentrate on the changing geographic distributions and ecologies of ticks within the parks. For example, forest fragments with fewer predators and animal life promote areas with more white-footed mice, and hence the

potential for increased TBD risk. Nuanced studies are indicated, as, for example, mice are known to prefer forested habitats and, in one study, were not likely to leave their habitat for neighboring private yards [28]. Given that geographical and ecological differences exist within park boundaries, capturing specific tick species and animal biodiversity indicators with advanced methodologies that include multiple indicators can enhance risk assessment in U.S. national parks.

Recommendation: National parks are encouraged to conduct tick awareness campaigns, educating visitors about the risk of ticks. The National Park Service could also conduct tick collection and testing programs, sampling ticks and asking visitors to report tick bite encounters within park boundaries.

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Conflicts of Interest: The author declares no conflicts of interest.

Appendix A. United States National Park Historical Visitor Usage, 1919–2022

National Park	County	State	Number of Visitors (2022)	Number of Tent Campers (2022)	Number of Backpacker Campers (2022)	Total Visits (1919–2022) *
1. Acadia	Hancock	Maine	3,970,260	136,183	1472	184,704,716
2. Arches	Grand	Utah	1,460,652	14,913	272	41,945,843
3. Badlands	Pennington	South Dakota	1,006,809	2710	2319	75,665,686
4. Big Bend	Brewster	Texas	514,107	26,609	55,173	18,653,670
5. Biscayne	Miami-Dade	Florida	701,023	2267	0	22,049,262
6. Black Canyon of the Gunnison	Montrose	Colorado	297,257	14,854	1685	15,683,073
7. Bryce Canyon	Garfield	Utah	2,354,660	45,527	1657	63,480,370
8. Canyonlands	San Juan	Utah	779,147	7500	80,264	18,390,466
9. Capital Reef	Wayne	Utah	1,227,608	24,023	3393	33,063,506
10. Carlsbad Caverns	Eddy	New Mexico	390,932	0	66	46,084,344
11. Channel Islands	Ventura	California	323,245	0	28,210	14,321,709
12. Congaree	Richland	South Carolina	204,522	6.055	805	3,633,668
13. Crater Lake	Klamath	Oregon	527,259	0	1588	38,651,916
14. Cuyahoga Valley	Summit	Ohio	2,913,312	0	0	96,436,221
15. Death Valley	Inyo	California	1,128,862	81,453	3283	53,817,670

National Park	County	State	Number of Visitors (2022)	Number of Tent Campers (2022)	Number of Backpacker Campers (2022)	Total Visits (1919–2022) *
16. Denali National Park and Preserve	Denali Borough	Alaska	427,562	0	33,335	20,474,258
17. Dry Tortugas	Monroe	Florida	78,488	5324	0	2,405,705
18. Everglades	Collier	Florida	1,155,193	0	12,305	61,762,217
19. Gates of the Arctic National Park and Preserve	Yukon-Koyuk uk Census Area	Alaska	9457	0	4017	276,790
20. Gateway Arch	St. Louis city	Missouri	1,618,774	0	0	143,551,484
21. Glacier Bay National Park and Preserve	Hoonah-Angoon Census Area	Alaska	545,758	724	3741	14,408,253
22. Glacier	Flathead	Montana	2,908,458	90,422	28,261	122,039,197
23. Grand Canyon	Canyon Coconino	Arizona	4,732,101	89,825	331,623	236,257,914
24. Grand Teton	Teton	Wyoming	2,806,223	0	40,010	168,093,258
25. Great Basin	White Pine	Nevada	142,115	23,091	316	4,630,936
26. Great Sand Dunes National Park and Preserve	Alamosa	Colorado	493,428	31,799	10,274	16,541,868
27. Great Smoky Mountains	Blount	Tennessee	12,937,633	213,092	96,762	596,449,795
28. Guadalupe Mountains	Hudspeth	Texas	219,987	17,114	1615	8,412,644
29. Haleakalā	Maui	Hawaii	1,087,616	20,614	5604	57,648,754
30. Hawai'i Volcanoes	Hawaii	Hawaii	1,580,961	936	4864	90,929,436
31. Hot Springs	Garland	Arkansas	2,646,133	633	0	102,721,821
32. Indiana Dunes	Porter	Indiana	2,834,180	22,460	0	81,940,271
33. Isle Royale	Houghton	Michigan	25,454	6201	27,619	1,209,809
34. Joshua Tree	Riverside	California	3,058,294	211,452	12,591	73,991,478
35. Katmai National Park and Preserve	Bristol Bay Borough	Alaska	33,908	5812	5391	1,850,132
36. Kenai Fjords	Kenai Peninsula Borough	Alaska	389,943	556	70	8,966,415
37. Kings Canyon	Tulare	California	640,986	111,236	13,798	56,621,230
38. Kobuk Valley	Northwest Arctic Borough	Alaska	16,925	0	7350	242,508
39. Lake Clark National Park and Preserve	Lake and Peninsula Borough	Alaska	18,187	0	5421	459,698
40. Lassen Volcanic	Volcanic Tehama	California	446,291	60,426	903	31,162,832
41. Mammoth Cave	Cave Hart	Kentucky	663,147	43,487	4802	87,892,199
42. Mesa Verde	Montezuma	Colorado	499,790	21,920	0	35,933,012

National Park	County	State	Number of Visitors (2022)	Number of Tent Campers (2022)	Number of Backpacker Campers (2022)	Total Visits (1919–2022) *
43. Mount Rainier	Pierce	Washington	1,622,395	54,851	43,468	103,377,992
44. National Park of America Samoa (excluded)			1887	0	0	286,995
45. New River Gorge National Park and Preserve	Fayette County	West Virginia	1,593,523	16,061	12,530	39,739,471
46. North Cascades	Skagit	Washington	30,154	0	23,310	14,987,192
47. Olympic	Clallam	Washington	2,432,972	137,274	133,751	178,141,293
48. Petrified Forest	Apache	Arizona	505,209	0	789	57,535,087
49. Pinnacles	San Benito	California	275,023	0	0	11,915,298
50. Redwood	Humboldt	California	458,400	4747	12,582	21,944,923
51. Rocky Mountain	Larimer	Colorado	4,300,424	110,586	34,645	205,814,841
52. Saguaro	Cochise	Arizona	908,194	0	3706	38,862,360
53. Sequoia	Tulare	California	1,153,198	102,700	31,562	69,632,956
54. Shenandoah	Madison	Virginia	1,449,300	108,384	67,738	134,969,283
55. Theodore Roosevelt	Billings	North Dakota	668,679	13,441	658	35,644,680
56. Virgin Islands	Saint John Island	U.S. Virgin Islands	196,752	0	0	27,218,519
57. Voyageurs	St. Louis	Minnesota	221,434	0	43,566	10,299,269
58. White Sands (excluded)						
59. Wind Cave	Fall River	South Dakota	607,418	4865	435	44,691,661
60. Wrangell– St. Elias National Park and Preserve	Valdez-Cordova Census Area	Alaska	65,236	0	195	1,961,672
61. Yellowstone	Park	Wyoming	3,290,242	10,909	34,758	199,248,728
62. Yosemite	Mariposa	California	3,667,550	349,888	142,457	212,397,206
63. Zion	Washington	Utah	4,692,417	133,666	10,375	137,947,697

* National Park total visitor data collection starting dates vary from 1919–1972.

Appendix B. Human Tick-Borne Diseases, United States by National Park (Green Shading Reflects Highest Visitation and Tent Campers)

National Park	County	State	Lyme Disease	Babesiosis	Ehrlichiosis	Anaplasmosis	Spotted Fever	Tularemia
1. Acadia	Hancock	Maine	1402	16	0	37	2	1
2. Arches	Grand	Utah	1	0	0	0	0	0
3. Badlands	Pennington	South Dakota	9	0	1	0	4	4
4. Big Bend	Brewster	Texas	1	0	0	0	0	0
5. Biscayne	Miami-Dade (Monroe)	Florida	139	2	1	4	0	0
6. Black Canyon of the Gunnison	Montrose (Chaffee)	Colorado	0	0	0	0	0	1

National Park	County	State	Lyme Disease	Babesiosis	Ehrlichiosis	Anaplasmosis	Spotted Fever	Tularemia
7. Bryce Canyon	Garfield (Iron)	Utah	0	0	0	0	0	0
8. Canyonlands	San Juan	Utah	0	0	0	0	0	1
9. Capital Reef	Wayne (Grand)	Utah	1	0	0	0	0	0
10. Carlsbad Caverns	Eddy	New Mexico	0	0	0	0	1	0
11. Channel Islands	Ventura	California	41	1	0	1	1	0
12. Congaree	Richland	South Carolina	51	0	0	0	18	0
13. Crater Lake	Klamath	Oregon	21	1	0	0	0	1
14. Cuyahoga Valley	Summit	Ohio	89	0	1	2	3	0
15. Death Valley	Inyo	California	2	0	0	0	0	0
16. Denali	Denali Borough	Alaska	1	0	0	0	0	0
17. Dry Tortugas	Monroe	Florida	17	2	1	4	0	0
18. Everglades	Collier	Florida	21	2	0	1	0	0
19. Gates of the Arctic	Yukon-Koyukuk Census Area	Alaska	1	0	0	0	0	0
20. Gateway Arch	St. Louis City	Missouri	39	0	8	1	12	1
21. Glacier Bay	Hoonah-Angoon Census Area (Sitka City and Borough)	Alaska	0	0	0	0	0	0
22. Glacier	Flathead	Montana	12	0	0	0	2	1
23. Grand Canyon	Coconino	Arizona	12	0	0	0	0	2
24. Grand Teton	Teton	Wyoming	11	0	0	0	0	1
25. Great Basin	White Pine	Nevada	0	0	0	0	1	0
26. Great Sand Dunes	Alamosa (Los Animas)	Colorado	0	0	0	0	0	0
27. Great Smoky Mountains	Blount	Tennessee	4	0	1	0	13	0
28. Guadalupe Mountains	Hudspeth (El Paso)	Texas	0	0	0	0	0	0
29. Haleakalā	Maui (Honolulu County)	Hawaii	0	0	0	0	0	0
30. Hawai'i Volcanoes	Hawaii	Hawaii	0	0	0	0	0	0
31. Hot Springs	Garland	Arkansas	3	0	51	4	233	3
32. Indiana Dunes	Porter	Indiana	199	0	0	0	5	0
33. Isle Royale	Houghton	Michigan	50	0	0	1	0	0
34. Joshua Tree	Riverside	California	50	0	0	0	4	0

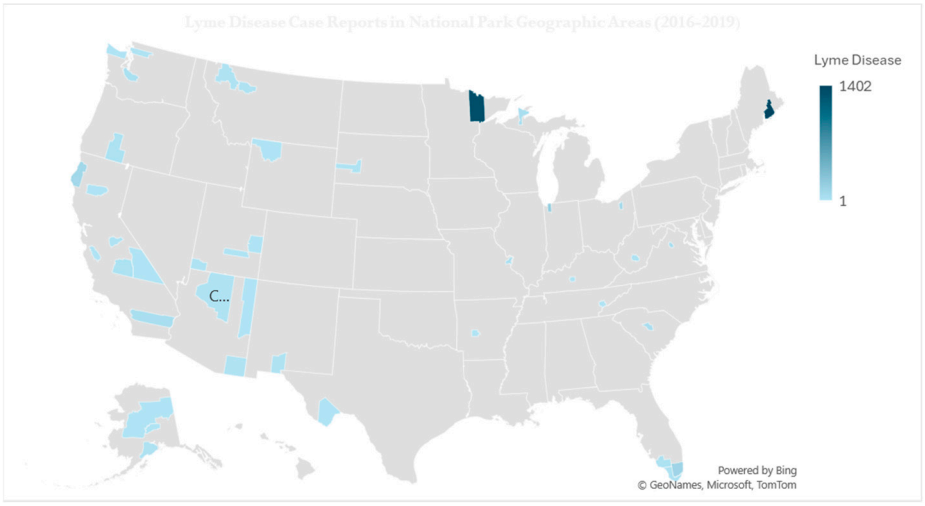
National Park	County	State	Lyme Disease	Babesiosis	Ehrlichiosis	Anaplasmosis	Spotted Fever	Tularemia
35. Katmai	Bristol Bay Borough (Matanuska-Susitna Borough)	Alaska	0	0	0	0	0	0
36. Kenai Fjords	Kenai Peninsula Borough	Alaska	19	0	0	0	0	2
37. Kings Canyon	Tulare	California	23	0	0	0	0	1
38. Kobuk Valley	Northwest Arctic Borough	Alaska	0	*	*	*	*	*
39. Lake Clark	Lake and Peninsula Borough	Alaska	0	*	*	*	*	*
40. Lassen Volcanic	Tehama	California	4	0	0	0	0	0
41. Mammoth Cave	Hart	Kentucky	4	0	1	0	3	0
42. Mesa Verde	Montezuma (La Plata)	Colorado	0	0	0	0	0	0
43. Mount Rainier	Pierce	Washington	38	0	1	0	0	1
44. National Park of American Samoa			*	*	*	*	*	*
45. New River Gorge National Park	Fayette County	West Virginia	18	0	0	0	0	0
46. North Cascades	Skagit (Chelan County)	Washington	9	0	1	0	0	1
47. Olympic	Clallam	Washingtor	3	0	0	1	0	0
48. Petrified Forest	Apache	Arizona	1	0	0	0	2	0
49. Pinnacles	San Benito	California	4	0	0	0	0	0
50. Redwood	Humboldt	California	105	0	0	2	0	1
51. Rocky Mountain	Larimer	Colorado	0	0	0	0	1	6
52. Saguaro	Cochise	Arizona	8	0	0	0	5	0
53. Sequoia	Tulare	California	23	0	0	0	0	1
54. Shenandoah	Madison	Virginia	53	0	1	0	0	0
55. Theodore Roosevelt	Billings (Stark County)	North Dakota	0	0	1	0	1	0
56. Virgin Islands	Saint John Island	U.S.Virgin Islands	0	*	*	*	*	*
57. Voyageurs	St. Louis	Minnesota	1328	14	2	56	0	1

National Park	County	State	Lyme Disease	Babesiosis	Ehrlichiosis	Anaplasmosis	Spotted Fever	Tularemia
58. White Sands	Dona Ana	New Mexico	6	0	0	0	0	0
59. Wind Cave	Fall River	South Dakota	0	0	0	0	1	2
60. Wrangell—St. Elias	Valdez-Cordova Census Area	Alaska	2	*	*	*	*	*
61. Yellowstone	Park	Wyoming	2	0	0	0	0	0
62. Yosemite	Mariposa	California	7	0	0	0	0	0
63. Zion	Washington	Utah	11	0	0	0	2	2

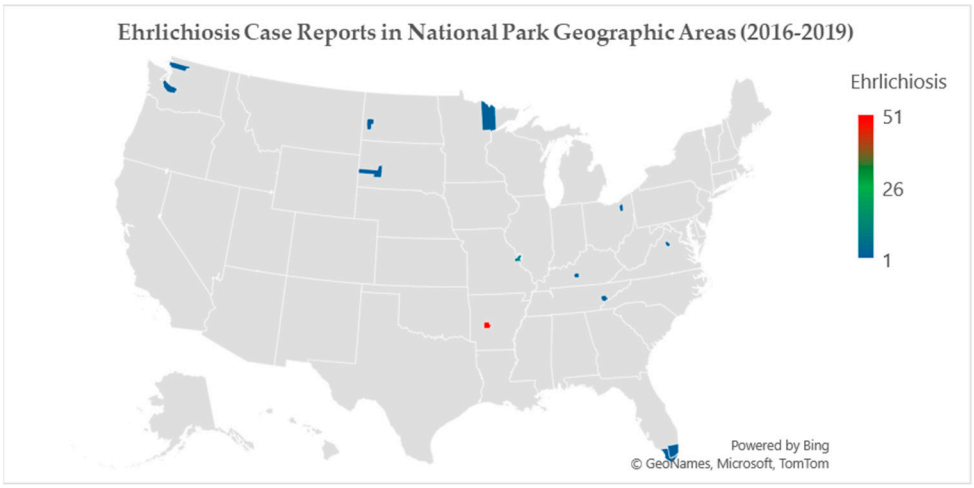
* Represents no available data.

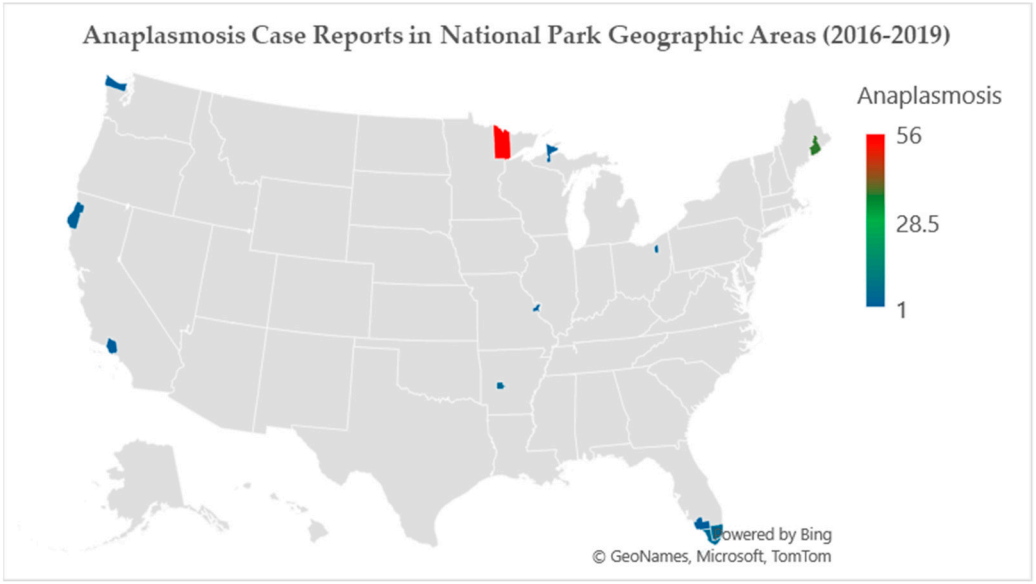
Appendix C. Maps of Tick-Borne Diseases in National Park Geographic Areas (2016–2019)

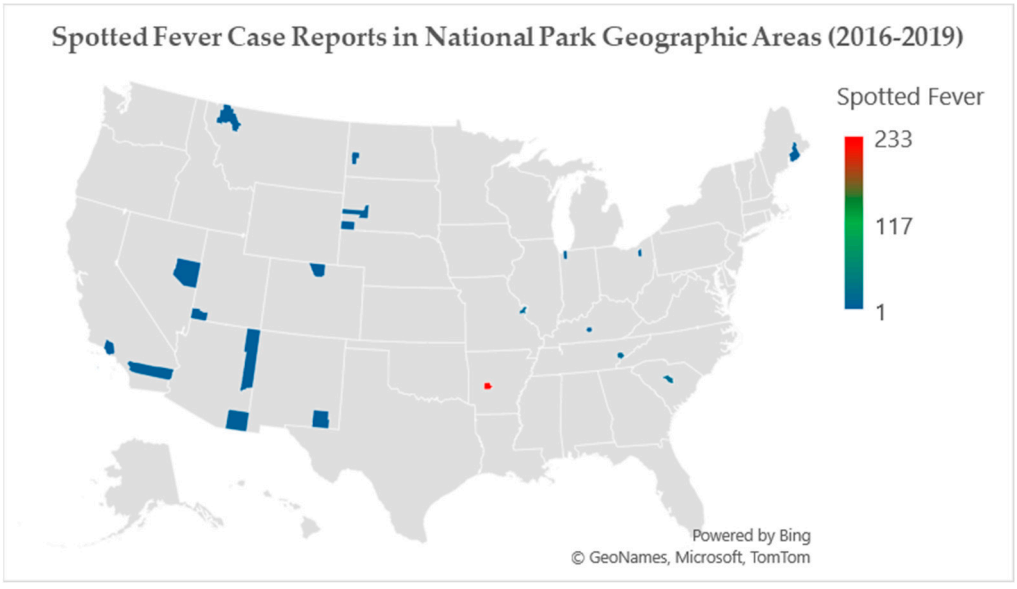
The following maps show human tick-borne disease, as reported by states to the CDC, for years 2016–2019.

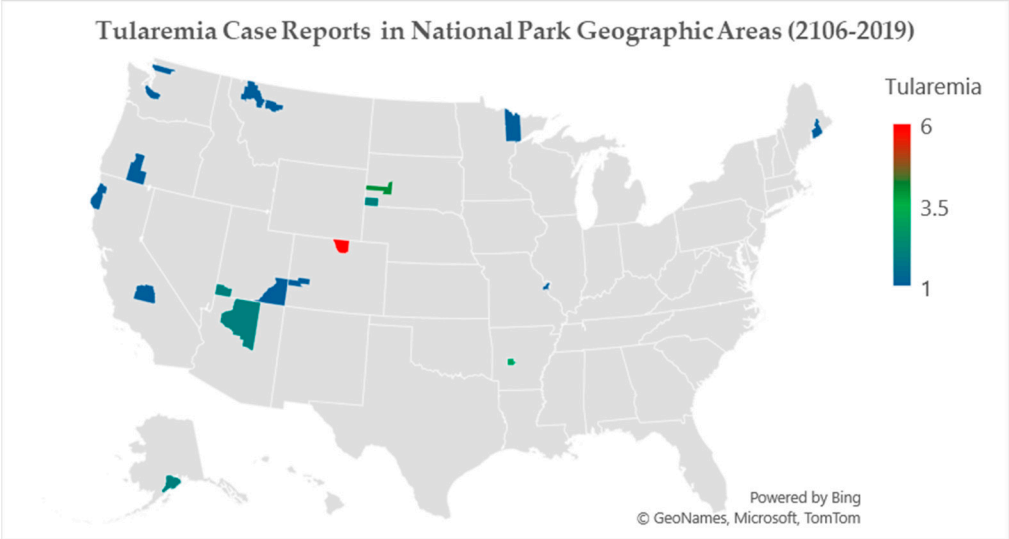





Ehrlichiosis Case Reports in National Park Geographic Areas (2016-2019)
Ehrlichiosis
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Anaplasmosis Case Reports in National Park Geographic Areas (2016-2019)
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Spotted Fever Case Reports in National Park Geographic Areas (2016-2019)
Spotted Fever
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