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Reported County-Level Distribution of the American Dog Tick (Acari: Ixodidae) in the Contiguous United States

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Abstract

In the United States, tick-borne diseases are increasing in incidence and cases are reported over an expanding geographical area. Avoiding tick bites is a key strategy in tick-borne disease prevention, and this requires current and accurate information on where humans are at risk for exposure to ticks. Based on a review of published literature and records in the U.S. National Tick Collection and National Ecological Observatory Network databases, we compiled an updated county-level map showing the reported distribution of the American dog tick, *Dermacentor variabilis* (Say). We show that this vector of the bacterial agents causing Rocky Mountain spotted fever and tularemia is widely distributed, with records derived from 45 states across the contiguous United States. However, within these states, county-level records of established tick populations are limited. Relative to the range of suitable habitat for this tick, our data imply that *D. variabilis* is currently underreported in the peer-reviewed literature, highlighting a need for improved surveillance and documentation of existing tick records.

Keywords

Dermacentor variabilis ; American dog tick; tick surveillance; *Rickettsia rickettsia* ; *Francisella tularensis*

In recent decades in the United States, tick-borne diseases have increased in incidence and cases reported over an expanding geographical area (Eisen et al. 2017, Rosenberg et al. 2018). These trends can be explained, in part, by expanding geographical ranges of medically important hard ticks (Acari: Ixodidae) resulting in an increase in the numbers

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of persons exposed to potentially infectious tick bites (Eisen and Eisen 2018). Tick surveillance is intended to monitor changes in the distribution and abundance of ticks to aid in assessing and mitigating risk of human exposure to ticks and tick-borne pathogens (CDC 2018a). However, tick surveillance is not standardized or routinely conducted across the United States, which poses challenges in accurately representing the current distribution of medically important ticks.

Among the more than 80 species of ticks described in the United States, fewer than a dozen are commonly found to infest humans (Merten and Durden 2000). Arguably, based on their demonstrated ability to serve as vectors of human pathogens and their propensity to feed on human blood, the most medically important hard ticks in the United States include: the lone star tick (*Amblyomma americanum* [L.]), the Gulf Coast tick (*Amblyomma maculatum* [Koch]), the Rocky Mountain wood tick (*Dermacentor andersoni* [Stiles]), the Pacific Coast tick (*Dermacentor occidentalis* [Marx]), the American dog tick (*Dermacentor variabilis* [Say]), the western blacklegged tick (*Ixodes pacificus* [Cooley and Kohls]), the blacklegged tick or the deer tick (*Ixodes scapularis* [Say]), and the brown dog tick (*Rhipicephalis sanguineus* sensu lato) (Eisen et al. 2017). Distributions of these ticks were compiled in a seminal publication by Hooker (1909) followed by distribution maps by Bishopp and Trembley (1945). However, the distributions of these ticks, and consequently human risk of exposure to tick bites, have changed over time. Therefore, following criteria originally described by Dennis et al. (1998), recent studies updated the reported distributions of *D. andersoni* (James et al. 2006), *A. americanum* (Springer et al. 2014), and *I. scapularis* and *I. pacificus* (Eisen et al. 2016). Others have updated the distributions of *A. maculatum* (Teel et al. 2010) and *D. variabilis* (James et al. 2015), and other medically important ticks (CDC 2018b), but did not define distributions using the same county-scale criteria as Dennis et al. (1998).

Dermacentor variabilis is an important pest species and significant as a vector of both human and animal pathogens, including the bacterial agents causing Rocky Mountain spotted fever (*Rickettsia rickettsii*) and tularemia (*Francisella tularensis*) (Burgdorfer 1975, Reese et al. 2011, James et al. 2015). A number of publications have provided limited state, county, or local level data and broad scale maps of *D. variabilis*, but have not been updated for many years (Banks 1908, Hooker 1909, Bishopp and Trembley 1945).

In this study, we aimed to use the Dennis et al. (1998) county classification criteria to generate an updated map showing the reported distribution of *D. variabilis*. Our findings suggest that relative to the range in suitable habitat for this tick (James et al. 2015), *D. variabilis* is currently underreported in the peer- reviewed literature, highlighting a need for improved surveillance and reporting.

Materials and Methods

To identify records of the American dog tick within specific counties in the contiguous United States, we conducted a literature review using the Scopus database with search terms '*Dermacentor*' and '*variabilis*' to identify articles published from 1913 through 13 November 2018. To expand our county records of *D. variabilis*, we obtained collection

records from the U.S. National Tick Collection (USNTC), spanning 1907–2018, and from the National Ecological Observatory Network (NEON), spanning 2014–2018. Additional records were obtained from specific monographs, state publications on the ticks of a state, and from studies conducted at localities where the county level was clearly evident. One additional source of unpublished data was provided to us opportunistically from the California Department of Health (CDPH).

Using records obtained from these data sources, we classified counties into those with 'established', 'reported', or 'no records' of *D. variabilis*. To do this, we used two different sets of inclusion criteria termed 'strict' and 'expanded'. The strict inclusion criteria follows Dennis et al. (1998) and Eisen et al. (2016) definitions. Specifically, we categorized counties as 'established' if at least six individual *D. variabilis* ticks or at least two of the three host-seeking life stages were collected within a 1-yr time period. We categorized counties as 'reported' if they failed to meet the criteria for established and if at least one *D. variabilis* tick of any life stage was identified at any time in the county or if the county had records of the tick that failed to detail the number or life stage collected. Although these criteria were originally developed in reference to *I. scapularis* and *I. pacificus*, given the similarities in life cycles of these three-host non-nidicolous ticks, the same criteria were applied in this and a previous survey of the distribution of *A. americanum* (Springer et al. 2014). Using our strict criteria, we included in our database articles including county-level data on ticks collected from vegetation or from hosts with limited home ranges (e.g., <5–10 km^2) as these hosts' limited ranges presumably do not extend beyond a single county. Unless travel histories were accounted for, we excluded ticks collected from mobile hosts such as humans, companion animals, livestock, or zoo animals owing to the frequency of their transport outside of a single county. That is, because ticks can remain attached to a host for 7–10 d, if the host traveled outside of the county of record in the previous 10 d the county of exposure cannot be clearly ascertained (CDC 2018a).

In an effort to recognize counties for which there was compelling evidence that *D. variabilis* is present, but that did not meet the strict inclusion criteria, our expanded criteria included county records from long-term programs that collected ticks found on humans. We included articles reporting results of such programs if the majority (>50%) of counties in the state of interest reported records of *D. variabilis*; this is assuming that if the majority of counties in the state have records of *D. variabilis* from humans, then human exposure to the tick within the reporting county is plausible. In addition to adhering to the strict criteria for classifying counties as reported or established, using arbitrary but reasonable criteria, we classified counties as 'established' if greater than 50 records of *D. variabilis* obtained from these programs were documented in a 5-yr or greater time span and 'reported' if they did not meet the established criteria or records failed to detail the number of ticks collected. In short, the county classifications using the expanded criteria duplicate the classifications based on the strict criteria, but amount to a more extensive (cumulative) distribution of counties with reported or established records because long-term programs cataloging ticks collected from humans were included in the former. We coded all remaining counties as having 'no records'. Notably, a lack of tick records in a county does not necessarily indicate absence of the tick, only that we did not identify any tick collection records for the county.

We used the five-digit Federal Information Processing Standard (FIPS) codes to designate counties or county equivalents. The final database included state, county, FIPS code, and county status data. We joined these data with a contiguous U.S. county map based on FIPS code using ArcMap 10.5 (ERSI, Redlands, CA). Counties were shaded based on their recorded status: established, reported, or no records.

Results

In total, 765 research articles met our Scopus search criteria, of which 111 contained adequate information for us to classify counties as having reported or established *D. variabilis* populations. Additionally, seven relevant monographs and state publications were included, as well as one unpublished list of California counties that met the criteria defined herein (California Department of Health, unpublished data). The USNTC database contained 2,040 records, of which 156 were included; the remainder were excluded primarily because they were collected from a mobile host. Of the 463 records from the NEON data set 20 records were retained, with the remainder largely representing repeat sampling in counties.

Based on the strict inclusion criteria, *D. variabilis* has been recorded in a total of 516 counties (16.6% of 3,109 FIPS codes in the contiguous United States) across 44 states (Tables 1 and 2; Fig. 1A). In total, 249 (8.0%) counties distributed across 41 states were classified as established and 267 counties (8.6%) across 37 states were classified as reported.

When using our expanded inclusion criteria, *D. variabilis* has been recorded in a total of 928 counties (29.8%) (Tables 1 and 2; Fig. 1B); three states in the contiguous 48 states do not have records of the tick, these include: Arizona, Nevada, and Utah. In total, 316 counties (10.2%) distributed across 42 states (Tables 1 and 2; Fig. 1B) met the criteria to be classified as established. The majority of these counties are east of the Rocky Mountains although states west of the Rockies including California, Oregon, Washington, and Idaho have documented established populations. *Dermacentor variabilis* is now classified as reported in 612 (19.7%) counties, distributed across 41 states (Tables 1 and 2; Fig. 1B).

Discussion

Among medically important ticks in the contiguous United States, *D. variabilis* has one of the broadest geographic ranges (Hooker 1909, Bishopp and Trembley 1945, James et al. 2015). Our data show widespread, yet sporadic county records for this tick and suggest it is currently underreported, perhaps in part because of a lack of systematic active surveillance efforts focused on this tick species. Whether based on statistical modeling or expert opinion guided by collection records, what we refer to herein as ‘species range maps’ represent areas where, hypothetically, the tick could survive and reproduce if introduced; such maps can be useful for targeting surveillance efforts that reveal whether or not the tick is present within specific parts of the tick’s range. In contrast to range maps, maps showing the reported distribution of a species depict areas where the tick has been collected. In general, information on tick abundance, rather than simple measures of tick presence or estimated ranges provides better information on the likelihood of human encounters with ticks. However, accurately estimating tick abundance over large geographic areas is

time-consuming, costly, and rarely done. In this study, we used the Dennis et al. (1998) classification criteria to categorize counties based on where 1) tick records are lacking, 2) the tick has been found (reported), but not necessarily established, and 3) the tick is established, and likely able to survive and reproduce.

In addition to species range maps, accurate distribution maps of medically important ticks are increasingly important as tick-borne disease incidence increases and cases are reported over expanded geographic areas (Dantas-Torres 2007, Piesman and Eisen 2008, Nicholson et al. 2010, Dantas-Torres et al. 2012, Eisen et al. 2017, Rosenberg et al. 2018). Such information can be useful in implicating ticks as potential vectors of newly discovered human pathogens (e.g., Heartland virus, Bourbon virus, *Borrelia miyamotoi*, and *Borrelia mayonii*), for identifying risk for potential exposure to tick-borne pathogens across regions, and for raising public awareness of which ticks and potentially which tick-borne pathogens are in the area and the importance of practicing tick bite prevention strategies. Long-term systematic active surveillance of ticks is important as species distributions shift due to a variety of factors including changes in land use, habitat and host availability, and climate (Childs and Paddock 2003, Estrada-Peña et al. 2006, Gray et al. 2009, James et al. 2015, Eisen et al. 2016).

James et al. (2015) used statistical modeling to predict the range in suitable habitat for *D. variabilis* in the United States, based largely on elevation and temperature. Highly suitable habitat included areas in: coastal California, the Pacific Northwest, the Midwest, the Gulf Coast, Florida, and the Atlantic seaboard (James et al. 2015). Regions of low suitability included much of the Western United States, areas in the South, and northwestern inland regions of New England. The distribution map we present here is comparable to the James et al. (2015) species range map.

Our distribution map using the strict criteria (Fig. 1A) shows records of the American dog tick throughout the United States particularly along the West, Gulf, and East coasts and in areas of low elevation in the central regions of the country; these records generally align with the suitable habitats delineated in the James et al. (2015) species range map. Additionally, the range map indicates low suitability in the Rocky Mountain Region (James et al. 2015), where our distribution map shows a noticeable lack of records. There is discordance between the maps where we report records in medium–low suitable habitats (James et al. 2015), such as in parts of Oklahoma and Wisconsin. However, what appears most telling is the lack of records in our distribution map in areas that James et al. (2015) note as highly suitable habitat. For example, we report only two counties in Iowa with records of *D. variabilis* even though most of Iowa is classified by the model as moderately or highly suitable habitat (James et al. 2015) for the tick. Additionally, we report no records in eastern Michigan which is classified as highly suitable (James et al. 2015), the same is true for portions of the Atlantic seaboard and Gulf Coast.

Using our expanded criteria to include counties for which there was compelling evidence that *D. variabilis* is present we created our expanded distribution map (Fig. 1B). This map includes the addition of county records from the following states: Georgia, Iowa, Maine, Michigan, Nebraska, Ohio, and Pennsylvania (Tables 1 and 2; Fig. 1B). Compared to the

strict distribution map, the expanded map displays greater concordance with the species range map (James et al. 2015) as we add records in highly suitable habitats including: Iowa, eastern Michigan, and northern Ohio. However, we still observe areas of high to medium habitat suitability (James et al. 2015) with few collection records such as along the Atlantic seaboard from New Jersey down through the Carolinas.

The variation between our distribution maps and the species range map (James et al. 2015) may arise from a lack of systematic active sampling efforts specifically targeting collection of *D. variabilis* in vegetation where it is most commonly found, such as low-elevation grasslands and boundaries of forests and trails (Wilkinson 1967, Sonenshine 1979b, McDade and Newhouse 1986, Dergousoff et al. 2013). Approximately one third of *D. variabilis* records used here originated from sources in which *D. variabilis* collections were incidental during collections focused largely on woodland-associated ticks, namely *I. scapularis* and *A. americanum*. Consequently, although tick sampling was conducted in numerous counties throughout the United States, efforts targeting *I. scapularis* and *A. americanum* may underestimate the number of established *D. variabilis* populations either because incidental species are not reported in publications, or because tick abundance is generally lower in woodlands where *I. scapularis* and *A. americanum* are common compared with grasslands where *D. variabilis* is more abundant. Additionally, by limiting our records primarily to those in the peer-reviewed literature it is quite likely that records of this tick being established in more counties is likely. In an effort to disseminate current and accurate tick distribution maps, the U.S. Centers for Disease Control and Prevention recently issued guidance on tick surveillance methods and have started to collect tick distribution and abundance records from state health departments through the ArboNET database (CDC 2018a; https://wwwn.cdc.gov/arbonet/).

Species distribution maps, developed based on spatial modeling, collection records and expert knowledge are powerful tools for assessing risk for human exposure to medically important ticks. We recognize the increasing need for accurate distribution maps of medically important ticks as tick-borne disease incidence increases, cases are reported over expanded geographic areas, and increasing numbers of people are exposed to potentially infectious tick bites. Importantly, there is a need to enhance 1) active and passive tick surveillance, particularly at the county level, 2) reporting of medically important ticks in peer-reviewed literature and through public health databases such as ArboNET, and 3) use of common classification criteria such as the Dennis et al. (1998) criteria.

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References Cited

Ammerman NC, Swanson KI, Anderson JM, Schwartz TR, Seaberg EC, Glass GE, and Norris DE. 2004. Spotted-fever group Rickettsia in *Dermacentor variabilis*, Maryland. Emerg. Infect. Dis 10: 1478–1481. [PubMed: 15496254]

Anderson JF, and Magnarelli LA. 1980. Vertebrate host relationships and distribution of ixodid ticks (Acari: Ixodidae) in Connecticut, USA. J. Med. Entomol 17: 314–323. [PubMed: 7420362]

Apperson CS, Levine JF, Evans TL, Braswell A, and Heller J. 1993. Relative utilization of reptiles and rodents as hosts by immature *Ixodes scapularis* (Acari: Ixodidae) in the coastal plain of North Carolina, USA. Exp. Appl. Acarol 17: 719–731. [PubMed: 7628223]

Apperson CS, Engber B, Nicholson WL, Mead DG, Engel J, Yabsley MJ, Dail K, Johnson J, and Watson DW. 2008. Tick-borne diseases in North Carolina: is "*Rickettsia amblyommii*" a possible cause of rickettsiosis reported as Rocky Mountain spotted fever? Vector Borne Zoonotic Dis 8: 597–606. [PubMed: 18447622]

Araya-Anchetta A, Scoles G, Giles J, Busch J, and Wagner DM. 2013. Hybridization in natural sympatric populations of *Dermacentor* ticks in northwestern North America. Ecol. Evol 3: 714–724. [PubMed: 23531531]

Banks N 1908. A revision of the Ixodidae, or ticks, of the United States US Government Printing Office, Washington, DC.

Barlough JE, Madigan JE, Kramer VL, Clover JR, Hui LT, Webb JP, and Vredevoe LK. 1997. *Ehrlichia phagocytophila* genogroup rickettsiae in ixodid ticks from California collected in 1995 and 1996. J. Clin. Microbiol 35: 2018–2021. [PubMed: 9230373]

Barrett A, Little SE, and Shaw E. 2014. "*Rickettsia amblyommii*" and *R. montanensis* infection in dogs following natural exposure to ticks. Vector Borne Zoonotic Dis 14: 20–25. [PubMed: 24359419]

Benach JL, White DJ, Burgdorfer W, Keelan T, Guirgis S, and Altieri RH. 1977. Changing patterns in the incidence of Rocky Mountain spotted fever on Long Island (1971–1976). Am. J. Epidemiol 106: 380–387. [PubMed: 920726]

Bishopp F, and Trembley HL. 1945. Distribution and hosts of certain North American ticks. J. Parasitol 31: 1–54.

Blanton LS, Walker DH, and Bouyer DH. 2014. Rickettsiae and ehrlichiae within a city park: is the urban dweller at risk? Vector Borne Zoonotic Dis 14: 168–170. [PubMed: 24528097]

Brackney DE, Nofchissey RA, Fitzpatrick KA, Brown IK, and Ebel GD. 2008. Stable prevalence of Powassan virus in *Ixodes scapularis* in a northern Wisconsin focus. Am. J. Trop. Med. Hyg 79: 971–973. [PubMed: 19052313]

Brown HE, Yates KF, Dietrich G, MacMillan K, Graham CB, Reese SM, Helterbrand WS, Nicholson WL, Blount K, Mead PS, et al. 2011. An acarologic survey and *Amblyomma americanum* distribution map with implications for tularemia risk in Missouri. Am. J. Trop. Med. Hyg 84: 411–419. [PubMed: 21363979]

Buchholz MJ, Davis C, Rowland NS, and Dick CW. 2018. *Borrelia burgdorferi* in small mammal reservoirs in Kentucky, a traditionally non-endemic state for Lyme disease. Parasitol. Res 117: 1159–1167. [PubMed: 29417273]

Burg JG 2001. Seasonal activity and spatial distribution of host-seeking adults of the tick *Dermacentor variabilis*. Med. Vet. Entomol 15: 413–421. [PubMed: 11776460]

Burgdorfer W 1975. A review of Rocky Mountain spotted fever (tick-borne typhus), its agent, and its tick vectors in the United States. J. Med. Entomol 12: 269–278. [PubMed: 810584]

Burgdorfer W, Adkins TR Jr., and Priester LE. 1975. Rocky Mountain spotted fever (tick-borne typhus) in South Carolina: an educational program and tick/rickettsial survey in 1973 and 1974. Am. J. Trop. Med. Hyg 24: 866–872. [PubMed: 811127]

Carroll JF, Schmidtmann ET, and Rice RM. 1989. White-footed mice: tick burdens and role in the epizootiology of Potomac horse fever in Maryland. J. Wildl. Dis 25: 397–400. [PubMed: 2668569]

CDC. 2018a. Surveillance for *Ixodes scapularis* and pathogens found in this tick species in the United States. Available at: https://www.cdc.gov/ticks/surveillance/index.html (Accessed 11 July 2019).

CDC. 2018b. Geographic distribution of ticks that bite humans Available at: https://www.cdc.gov/ticks/surveillance/index.html (Accessed 11 July 2019).

Chang CC, Hayashidani H, Pusterla N, Kasten RW, Madigan JE, and Chomel BB. 2002. Investigation of *Bartonella* infection in ixodid ticks from California. Comp. Immunol. Microbiol. Infect. Dis 25: 229–236. [PubMed: 12135237]

Childs JE, and Paddock CD. 2003. The ascendancy of *Amblyomma americanum* as a vector of pathogens affecting humans in the United States. Annu. Rev. Entomol 48: 307–337. [PubMed: 12414740]

Cilek JE, and Olson MA. 2000. Seasonal distribution and abundance of ticks (Acari: Ixodidae) in northwestern Florida. J. Med. Entomol 37: 439–444. [PubMed: 15535590]

Civitello DJ, Flory SL, and Clay K. 2008. Exotic grass invasion reduces survival of *Amblyomma americanum* and *Dermacentor variabilis* ticks (Acari: Ixodidae). J. Med. Entomol 45: 867–872. [PubMed: 18826028]

Clark KL, Oliver JH Jr., McKechnie DB, and Williams DC. 1998. Distribution, abundance, and seasonal activities of ticks collected from rodents and vegetation in South Carolina. J. Vector Ecol 23: 89–105. [PubMed: 9673934]

Clemons C, Rickard LG, Keirans JE, and Botzler RG. 2000. Evaluation of host preferences by helminths and ectoparasites among black-tailed jackrabbits in northern California. J. Wildl. Dis 36: 555–558. [PubMed: 10941744]

Cohen SB, Freye JD, Dunlap BG, Dunn JR, Jones TF, and Moncayo AC. 2010. Host associations of *Dermacentor, Amblyomma*, and *Ixodes* (Acari: Ixodidae) ticks in Tennessee. J. Med. Entomol 47: 415–420. [PubMed: 20496589]

Coher E, and Shaw F. 1951. The distribution of *Dermacentor variabilis*. J. Econ. Entomol 44: 998.

Conlon JM, and Rockett CL. 1982. Ecological investigations of the American dog tick, *Dermacentor variabilis* (Say), in northwest Ohio (Acari: Ixodidae). Int. J. Aracol 8: 125–131.

Cooney JC, and Burgdorfer W. 1974. Zoonotic potential (Rocky Mountain spotted fever and tularemia) in the Tennessee Valley region. I. Ecologic studies of ticks infesting mammals in Land Between the Lakes. Am. J. Trop. Med. Hyg 23: 99–108. [PubMed: 4204030]

Corn JL, Duhaime RA, Alfred JT, Mertins JW, Leland BR, Sramek RL, Moczygemba JD, and Shaw DW. 2016. Survey for ticks on feral swine within a cattle fever tick-infested landscape in Texas, U.S.A. Syst. Appl. Acarol 21: 1564–1570.

Cortinas R, and Spomer SM. 2014. Occurrence and county-level distribution of ticks (Acari: Ixodoidea) in Nebraska using passive surveillance. J. Med. Entomol 51: 352–359. [PubMed: 24724283]

Coultrip RL, Emmons RW, Legters LJ, Marshall JD Jr., and Murray KF. 1973. Survey for the arthropod vectors and mammalian hosts of Ricky Mountain spotted fever and plague at Fort Ord, California. J. Med. Entomol 10: 303–309. [PubMed: 4719297]

Dallas TA, Foré SA, and Kim HJ. 2012. Modeling the influence of *Peromyscus leucopus* body mass, sex, and habitat on immature *Dermacentor variabilis* burden. J. Vector Ecol 37: 338–341. [PubMed: 23181857]

Dantas-Torres F 2007. Rocky Mountain spotted fever. Lancet Infect. Dis 7: 724–732. [PubMed: 17961858]

Dantas-Torres F, Chomel BB, and Otranto D. 2012. Ticks and tick-borne diseases: a One Health perspective. Trends Parasitol 28: 437–446. [PubMed: 22902521]

Dennis DT, Nekomoto TS, Victor JC, Paul WS, and Piesman J. 1998. Reported distribution of *Ixodes scapularis* and *Ixodes pacificus* (Acari: Ixodidae) in the United States. J. Med. Entomol 35: 629–638. [PubMed: 9775584]

Dergousoff SJ, Galloway TD, Lindsay LR, Curry PS, and Chilton NB. 2013. Range expansion of *Dermacentor variabilis* and *Dermacentor andersoni* (Acari: Ixodidae) near their northern distributional limits. J. Med. Entomol 50: 510–520. [PubMed: 23802445]

Durden LA 1992. Parasitic arthropods of sympatric meadow voles and white-footed mice at Fort Detrick, Maryland. J. Med. Entomol 29: 761–766. [PubMed: 1404254]

Durden LA, and Richardson DJ. 2013. Ectoparasites of the Virginia opossum (*Didelphis virginiana*), raccoon (*Procyon lotor*), and striped skunk (*Mephitis mephitis*) from Keith County, Nebraska. Trans. Nebr. Acad. Sci. Affil. Soc 33: 21–24.

Durden LA, and Wilson N. 1990. Ectoparasitic and phoretic arthropods of Virginia opossums (*Didelphis virginiana*) in central Tennessee. J. Parasitol 76: 581–583. [PubMed: 2380870]

Durden LA, Klompen JS, and Keirans JE. 1993. Parasitic arthropods of sympatric opossums, cotton rats, and cotton mice from Merritt Island, Florida. J. Parasitol 79: 283–286. [PubMed: 8459341]

Durden LA, Hu R, Oliver JH Jr., and Cilek JE. 2000. Rodent ectoparasites from two locations in northwestern Florida. J. Vector Ecol 25: 222–228. [PubMed: 11217221]

Durden LA, Oliver JH Jr., and Kinsey AA. 2001. Ticks (Acari: Ixodidae) and spirochetes (Spirochaetaceae: Spirochaetales) recovered from birds on a Georgia Barrier Island. J. Med. Entomol 38: 231–236. [PubMed: 11296828]

Eads RB 1948. Ectoparasites from a series of Texas coyotes. J. Mammal 29: 268–271.

Eads R, Menzies G, and Hightower B. 1956. The ticks of Texas, with notes on their medical significance. Texas J. Sci 8: 7–24.

Easton E 1983. The ticks of South Dakota: an annotated checklist (Acari: Ixodoidea). Entomol. News 94: 191–195.

Easton ER, Keirans JE, Gresbrink RA, and Clifford CM. 1977. The distribution in Oregon of *Ixodes pacificus*, *Dermacentor andersoni*, and *Dermacentor occidentalis* with a note on *Dermacentor variabilis* (Acarina: Ixodidae). J. Med. Entomol 13: 501–506. [PubMed: 845890]

Eddy GW, and Joyce CR. 1944. The seasonal history and hosts of the American dog tick, *Dermacentor variabilis*, in Iowa. Iowa State College J. Sci 18: 313–324.

Eisen RJ, and Eisen L. 2018. The blacklegged tick, *Ixodes scapularis*: an increasing public health concern. Trends Parasitol 34: 295–309. [PubMed: 29336985]

Eisen L, Eisen RJ, and Lane RS. 2004. The roles of birds, lizards, and rodents as hosts for the western black-legged tick *Ixodes pacificus*. J. Vector Ecol 29: 295–308. [PubMed: 15709249]

Eisen RJ, Eisen L, and Beard CB. 2016. County-scale distribution of *Ixodes scapularis* and *Ixodes pacificus* (Acari: Ixodidae) in the continental United States. J. Med. Entomol 53: 349–386. [PubMed: 26783367]

Eisen RJ, Kugeler KJ, Eisen L, Beard CB, and Paddock CD. 2017. Tick-borne zoonoses in the United States: persistent and emerging threats to human health. Ilar J 58: 319–335. [PubMed: 28369515]

Estrada-Peña A, Corson M, Venzal JM, Mangold AJ, and Guglielmone A. 2006. Changes in climate and habitat suitability for the cattle tick *Boophilus microplus* in its southern Neotropical distribution range. J. Vector Ecol 31: 158–167. [PubMed: 16859105]

Feng WC, Murray ES, Burgdorfer W, Spielman JM, Rosenberg G, Dang K, Smith C, Spickert C, and Waner JL. 1980. Spotted fever group rickettsiae in *Dermacentor variabilis* from Cape Cod, Massachusetts. Am. J. Trop. Med. Hyg 29: 691–694. [PubMed: 6773430]

Fish D, and Dowler RC. 1989. Host associations of ticks (Acari: Ixodidae) parasitizing medium-sized mammals in a Lyme disease endemic area of southern New York. J. Med. Entomol 26: 200–209. [PubMed: 2724317]

Forrester DJ, McLaughlin GS, Telford SR Jr., Foster GW, and McCown JW. 1996. Ectoparasites (Acari, Mallophaga, Anoplura, Diptera) of white-tailed deer, *Odocoileus virginianus*, from southern Florida. J. Med. Entomol 33: 96–101. [PubMed: 8906911]

Furman DP, and Loomis EC. 1984. The ticks of California (Acari: Ixodida), University of California Publications, Bulletin of the California Insect Survey, vol. 25. University of California Press, Berkeley, CA.

Gabriel MW, Brown RN, Foley JE, Higley JM, and Botzler RG. 2009. Ecology of *Anaplasma phagocytophilum* infection in gray foxes (*Urocyon cinereoargenteus*) in northwestern California. J. Wildl. Dis 45: 344–354. [PubMed: 19395744]

Gage KL, Hopla CE, and Schwan TG. 1992. Cotton rats and other small mammals as hosts for immature *Dermacentor variabilis* (Acari: Ixodidae) in central Oklahoma. J. Med. Entomol 29: 832–842. [PubMed: 1404263]

Gleim ER, Garrison LE, Vello MS, Savage MY, Lopez G, Berghaus RD, and Yabsley MJ. 2016. Factors associated with tick bites and pathogen prevalence in ticks parasitizing humans in Georgia, USA. Parasit. Vectors 9: 125. [PubMed: 26935205]

Goddard J, and Bircham L. 2010. Parasitism of the carpenter bee, *Xylocopa virginica* (L.) (Hymenoptera: Apidae), by larval *Dermacentor variabilis* (Say) (Acari: Ixodidae). J. Syst. Appl. Acarol 15: 195–196.

Goddard J, Sumner JW, Nicholson WL, Paddock CD, Shen J, and Piesman J. 2003. Survey of ticks collected in Mississippi for *Rickettsia*, *Ehrlichia*, and *Borrelia* species. J. Vector Ecol 28: 184–189. [PubMed: 14714667]

Goddard J, Bircham L, and Robbins RG. 2011. New tick-host records (Acari: Ixodidae) from Mississippi, U.S.A. Syst. Appl. Acarol 16: 212–214.

Goethert HK, and Telford SR 3rd. 2005. A new *Francisella* (Beggiatiales: Francisellaceae) inquiline within *Dermacentor variabilis* Say (Acari: Ixodidae). J. Med. Entomol 42: 502–505. [PubMed: 15962806]

Goethert HK, Shani I, and Telford SR 3rd. 2004. Genotypic diversity of *Francisella tularensis* infecting *Dermacentor variabilis* ticks on Martha's Vineyard, Massachusetts. J. Clin. Microbiol 42: 4968–4973. [PubMed: 15528681]

Gray J, Dautel H, Estrada-Peña A, Kahl O, and Lindgren E. 2009. Effects of climate change on ticks and tick-borne diseases in Europe. Interdiscip. Perspect. Infect. Dis 2009. doi:10.1155/2009/593232

Greiner EC, Humphrey PP, Belden RC, Frankenberger WB, Austin DH, and Gibbs EP. 1984. Ixodid ticks on feral swine in Florida. J. Wildl. Dis 20: 114–119. [PubMed: 6737605]

Harlan HJ, and Foster WA. 1990. Micrometeorologic factors affecting field host-seeking activity of adult *Dermacentor variabilis* (Acari: Ixodidae). J. Med. Entomol 27: 471–479. [PubMed: 2388223]

Harman DM, Willner GR, and Chapman JA. 1984. Frequency and distribution of the American dog tick on the nutria in Maryland. Am. Midl. Nat 111: 81–85.

Henning TC, Orr JM, Smith JD, Arias JR, and Norris DE. 2014. Spotted fever group rickettsiae in multiple hard tick species from Fairfax County, Virginia. Vector Borne Zoonotic Dis 14: 482–485. [PubMed: 24978651]

Hertz JC, Ferree Clemons BC, Lord CC, Allan SA, and Kaufman PE. 2017. Distribution and host associations of ixodid ticks collected from wildlife in Florida, USA. Exp. Appl. Acarol 73: 223–236. [PubMed: 29110170]

Holden K, Boothby JT, Anand S, and Massung RF. 2003. Detection of *Borrelia burgdorferi, Ehrlichia chaffeensis*, and *Anaplasma phagocytophilum* in ticks (Acari: Ixodidae) from a coastal region of California. J. Med. Entomol 40: 534–539. [PubMed: 14680123]

Hooker WA 1909. The geographical distribution of American ticks. J. Econ. Entomol 2: 403–428.

Hudman DA, and Sargentini NJ. 2016. Detection of *Borrelia, Ehrlichia*, and *Rickettsia* spp. in ticks in northeast Missouri. Ticks Tick Borne Dis 7: 915–921. [PubMed: 27133163]

Jackson JO, and DeFoliart GR. 1975. Relationships of immature *Dermacentor variabilis* (Say) (Acari: Ixodidae) with the white-footed mouse, *Peromyscus leucopus*, in southwestern Wisconsin. J. Med. Entomol 12: 409–412. [PubMed: 1195285]

James AM, Freier JE, Keirans JE, Durden LA, Mertins JW, and Schlater JL. 2006. Distribution, seasonality, and hosts of the Rocky Mountain wood tick in the United States. J. Med. Entomol 43: 17–24. [PubMed: 16506443]

James AM, Burdett C, McCool MJ, Fox A, and Riggs P. 2015. The geographic distribution and ecological preferences of the American dog tick, *Dermacentor variabilis* (Say), in the U.S.A. Med. Vet. Entomol 29: 178–188. [PubMed: 25684582]

Johnson TL, Graham CB, Boegler KA, Cherry CC, Maes SE, Pilgard MA, Hojgaard A, Buttke DE, and Eisen RJ. 2017. Prevalence and diversity of tick-borne pathogens in nymphal *Ixodes scapularis* (Acari: Ixodidae) in Eastern National Parks. J. Med. Entomol 54: 742–751. [PubMed: 28028138]

Joy JE, and Briscoe NJ. 1994. Parasitic arthropods of white-footed mice at McClintic Wildlife Station, West Virginia. J. Am. Mosq. Control Assoc 10: 108–111. [PubMed: 8014620]

Kakumanu ML, Ponnusamy L, Sutton H, Meshnick SR, Nicholson WL, and Apperson CS. 2018. Prevalence of rickettsia species (Rickettsiales: Rickettsiaceae) in *Dermacentor variabilis* ticks (Acari: Ixodidae) in North Carolina. J. Med. Entomol 55: 1284–1291. [PubMed: 29771344]

Kaufman EL, Stone NE, Scoles GA, Hepp CM, Busch JD, and Wagner DM. 2018. Range-wide genetic analysis of *Dermacentor variabilis* and its Francisella-like endosymbionts demonstrates phylogeographic concordance between both taxa. Parasit. Vectors 11: 306. [PubMed: 29776375]

Koch H, and Dunn J. 1980. Ticks collected from small and medium-sized wildlife hosts in Leflore County, Oklahoma. Southwest. Entomol 5: 214–221.

Kollars TM Jr. 1993. Ticks (Acari: Ixodidae) infesting medium-sized wild mammals in southwestern Tennessee. J. Med. Entomol 30: 896–900. [PubMed: 8254637]

Kollars TM Jr. 1996. Interspecific differences between small mammals as hosts of immature *Dermacentor variabilis* (Acari: Ixodidae) and a model for detection of high risk areas of Rocky Mountain spotted fever. J. Parasitol 82: 707–710. [PubMed: 8885876]

Kollars TM Jr., and Kengluecha A. 2001. Spotted fever group Rickettsia in *Dermacentor variabilis* (Acari: Ixodidae) infesting raccoons (Carnivora: Procyonidae) and opossums (Marsupialia: Didelphimorphidae) in Tennessee. J. Med. Entomol 38: 601–602. [PubMed: 11476343]

Kollars TM Jr., and Ladine TA. 1999. Patterns of infestation by adult *Dermacentor variabilis* (Acari: Ixodidae) in a mark-recapture study of raccoons (Mammalia: Carnivora) and Virginia opossums (Mammalia: Didelphimorphia) in Tennessee. J. Med. Entomol 36: 263–267. [PubMed: 10337094]

Kramer VL, Randolph MP, Hui LT, Irwin WE, Gutierrez AG, and Vugia DJ. 1999. Detection of the agents of human ehrlichioses in ixodid ticks from California. Am. J. Trop. Med. Hyg 60: 62–65. [PubMed: 9988324]

Lane RS, and Lavoie PE. 1988. Lyme borreliosis in California. Acarological, clinical, and epidemiological studies. Ann. N. Y. Acad. Sci 539: 192–203. [PubMed: 3263826]

Lang JD 1999. Ixodid ticks (Acari, Ixodidae) found in San Diego County, California. J. Vector Ecol 24: 61–69. [PubMed: 10436879]

Lavender DR, and Oliver JH Jr. 1996. Ticks (Acari: Ixodidae) in Bulloch County, Georgia. J. Med. Entomol 33: 224–231. [PubMed: 8742526]

Lin T, Gao L, Seyfang A, and Oliver JH Jr. 2005. '*Candidatus* Borrelia texasensis', from the American dog tick *Dermacentor variabilis*. Int. J. Syst. Evol. Microbiol 55: 685–693. [PubMed: 15774644]

Lingren M, Rowley WA, Thompson C, and Gilchrist M. 2005. Geographic distribution of ticks (Acari: Ixodidae) in Iowa with emphasis on *Ixodes scapularis* and their infection with *Borrelia burgdorferi*. Vector Borne Zoonotic Dis 5: 219–226. [PubMed: 16187889]

Luckhart S, Mullen GR, and Wright JC. 1991. Etiologic agent of Lyme disease, *Borrelia burgdorferi*, detected in ticks (Acari: Ixodidae) collected at a focus in Alabama. J. Med. Entomol 28: 652–657. [PubMed: 1941933]

Lyon SM, Van Driesche R, and Edman JD. 1998. Ecology of *Hunterellus hookeri* (Hymenoptera: Encyrtidae) and evaluation of its impact on *Ixodes scapularis* (Acari: Ixodidae) on Nonamesset Island in Massachusetts. Environ. Entomol 27: 463–468.

MacCreary D 1945. Ticks of Delaware with special reference to *Dermacentor variabilis* (Say) vector of Rocky Mountain spotted fever. Bull. Delaware Univ. Agric. Exp. Stat 252: 1–22.

MacDonald AJ 2018. Abiotic and habitat drivers of tick vector abundance, diversity, phenology and human encounter risk in southern California. PLoS One 13: e0201665. [PubMed: 30063752]

Magnarelli LA, and Anderson JF. 1988. Ticks and biting insects infected with the etiologic agent of Lyme disease, *Borrelia burgdorferi*. J. Clin. Microbiol 26: 1482–1486. [PubMed: 3170711]

Magnarelli LA, Anderson JF, Philip RN, Burgdorfer W, and Chappell WA. 1983. Rickettsiae-infected ticks (Acari: Ixodidae) and seropositive mammals at a focus for Rocky Mountain spotted fever in Connecticut, USA. J. Med. Entomol 20: 151–156. [PubMed: 6405035]

Magnarelli LA, Andreadis TG, Stafford KC 3rd, and Holland CJ. 1991. Rickettsiae and *Borrelia burgdorferi* in ixodid ticks. J. Clin. Microbiol 29: 2798–2804. [PubMed: 1757551]

Manville AM 2nd. 1978. Ecto- and endoparasites of the black bear in northern Wisconsin. J. Wildl. Dis 14: 97–101. [PubMed: 633522]

Mather TN, and Mather ME. 1990. Intrinsic competence of three ixodid ticks (Acari) as vectors of the Lyme disease spirochete. J. Med. Entomol 27: 646–650. [PubMed: 2388239]

Mays SE, Houston AE, and Trout Fryxell RT. 2016. Comparison of novel and conventional methods of trapping ixodid ticks in the south-eastern U.S.A. Med. Vet. Entomol 30: 123–134. [PubMed: 26801319]

McAllister C, Connior M, and Durden L. 2013. Ectoparasites of sciurid rodents in Arkansas, including new state records for *Neohaematopinus* spp. (Phthiraptera: Anoplura: Polyplacidae). J. Ark. Acad. Sci 67: 197–199.

McDade JE, and Newhouse VF. 1986. Natural history of *Rickettsia rickettsii*. Annu. Rev. Microbiol 40: 287–309. [PubMed: 3096192]

McLean RG, Francy DB, Monath TP, Calisher CH, and Trent DW. 1985. Isolation of St. Louis encephalitis virus from adult *Dermacentor variabilis* (Acari: Ixodidae). J. Med. Entomol 22: 232–233. [PubMed: 2984423]

McNemee RB Jr., Sames WJ 4th, and Maloney FA Jr. 2003. Occurrence of *Dermacentor variabilis* (Acari: Ixodidae) around a porcupine (Rodentia: Erthethizontidae) carcass at Camp Ripley, Minnesota. J. Med. Entomol 40: 108–111. [PubMed: 12597663]

Merrill MM, Boughton RK, Lord CC, Sayler KA, Wight B, Anderson WM, and Wisely SM. 2018. Wild pigs as sentinels for hard ticks: a case study from south-central Florida. Int. J. Parasitol. Parasites Wildl 7: 161–170. [PubMed: 29988828]

Merten HA, and Durden LA. 2000. A state-by-state survey of ticks recorded from humans in the United States. J. Vector Ecol 25: 102–113. [PubMed: 10925803]

Miller MK, Jiang J, Truong M, Yarina T, Evans H, Christensen TP, and Richards AL. 2016. Emerging tick-borne *Rickettsia* and *Ehrlichia* at Joint Base Langley-Eustis, Fort Eustis, Virginia. U.S. Army. Med. Dep. J (3–16): 22–28.

Mitcham JR, Barrett AW, Gruntmeir JM, Holland T, Martin JE, Johnson EM, Little SE, and Noden BH. 2017. Active surveillance to update county scale distribution of four tick species of medical and veterinary importance in Oklahoma. J. Vector Ecol 42: 60–73. [PubMed: 28504425]

Nelson TA, Grubb KY, and Woolf A. 1984. Ticks on white-tailed deer fawns from southern Illinois. J. Wildl. Dis 20: 300–302. [PubMed: 6530716]

Newhouse VF 1983. Variations in population density, movement, and rickettsial infection rates in a local population of *Dermacentor variabilis* (Acarina: Ixodidae) ticks in the Piedmont of Georgia. Environ. Entomol 12: 1737–1746.

Nicholson WL, Allen KE, McQuiston JH, Breitschwerdt EB, and Little SE. 2010. The increasing recognition of rickettsial pathogens in dogs and people. Trends Parasitol 26: 205–212. [PubMed: 20207197]

Nims TN, and Durden LA. 2011. Ticks and lice of the black bear, *Ursus americanus* Pallas, in northern Georgia, USA, including a new state record for the chewing louse, *Trichodectes euarctidos* (Phthiraptera: Trichodectidae). J. Entomol. Sci 46: 345–347.

Nims TN, Durden LA, Chandler CR, and Pung OJ. 2008. Parasitic and phoretic arthropods of the oldfield mouse (*Peromyscus polionotus*) from burned habitats with additional ectoparasite records from the eastern harvest mouse (*Reithrodontomys humulis*) and southern short-tailed shrew (*Blarina carolinensis*). Comp. Parasitol 75: 102–106.

Noden BH, Loss SR, Maichak C, and Williams F. 2017. Risk of encountering ticks and tick-borne pathogens in a rapidly growing metropolitan area in the U.S. Great Plains. Ticks Tick Borne Dis 8: 119–124. [PubMed: 27773826]

Oliver JH Jr., Magnarelli LA, Hutcheson HJ, and Anderson JF. 1999. Ticks and antibodies to *Borrelia burgdorferi* from mammals at Cape Hatteras, NC and Assateague Island, MD and VA. J. Med. Entomol 36: 578–587. [PubMed: 10534951]

Orr JM, Smith JD, Zawada SG, and Arias JR. 2013. Diel and seasonal activity and trapping of ticks (Acari: Ixodidae) in Northern Virginia, USA. Syst. Appl. Acarol 18: 105–111.

Ouellette J, Apperson CS, Howard P, Evans TL, and Levine JF. 1997. Tick-raccoon associations and the potential for Lyme disease spirochete transmission in the coastal plain of North Carolina. J. Wildl. Dis 33: 28–39. [PubMed: 9027688]

Pagac BB, Miller MK, Mazzei MC, Nielsen DH, Jiang J, and Richards AL. 2014. *Rickettsia parkeri* and *Rickettsia montanensis*, Kentucky and Tennessee, USA. Emerg. Infect. Dis 20: 1750–1752. [PubMed: 25271771]

Perla RJ, and Thomas HH. 2001. Ixodid ticks recovered from vegetation in north-central Massachusetts. Wildl. Soc. Bull 29: 387–389.

Philip RN, Lane RS, and Casper EA. 1981. Serotypes of tick-borne spotted fever group rickettsiae from western California. Am. J. Trop. Med. Hyg 30: 722–727. [PubMed: 6789691]

Piesman J, and Eisen L. 2008. Prevention of tick-borne diseases. Annu. Rev. Entomol 53: 323–343. [PubMed: 17877457]

Pompo K, Mays S, Wesselman C, Paulsen DJ, and Fryxell RT. 2016. Survey of ticks collected from Tennessee cattle and their pastures for *Anaplasma* and *Ehrlichia* species. J. Parasitol 102: 54–59. [PubMed: 26348980]

Pretzman C, Daugherty N, Poetter K, and Ralph D. 1990. The distribution and dynamics of *Rickettsia* in the tick population of Ohio. Ann. N. Y. Acad. Sci 590: 227–236. [PubMed: 2378449]

Rand PW, Lacombe EH, Dearborn R, Cahill B, Elias S, Lubelczyk CB, Beckett GA, and Smith RP Jr. 2007. Passive surveillance in Maine, an area emergent for tick-borne diseases. J. Med. Entomol 44: 1118–1129. [PubMed: 18047214]

Reese SM, Petersen JM, Sheldon SW, Dolan MC, Dietrich G, Piesman J, and Eisen RJ. 2011. Transmission efficiency of *Francisella tularensis* by adult American dog ticks (Acari: Ixodidae). J. Med. Entomol 48: 884–890. [PubMed: 21845949]

Rosenberg R, Lindsey NP, Fischer M, Gregory CJ, Hinckley AF, Mead PS, Paz-Bailey G, Waterman SH, Drexler NA, Kersh GJ, et al. 2018. Vital signs: trends in reported vectorborne disease cases - United States and Territories, 2004–2016. MMWR. Morb. Mortal. Wkly. Rep 67: 496–501. [PubMed: 29723166]

Russart NM, Dougherty MW, and Vaughan JA. 2014. Survey of ticks (Acari: Ixodidae) and tick-borne pathogens in North Dakota. J. Med. Entomol 51: 1087–1090. [PubMed: 25276942]

Rydzewski J, Mateus-Pinilla N, Warner RE, Nelson JA, and Velat TC. 2012. *Ixodes scapularis* (Acari: Ixodidae) distribution surveys in the Chicago metropolitan region. J. Med. Entomol 49: 955–959. [PubMed: 22897059]

Rynkiewicz EC, and Clay K. 2014. Tick community composition in Midwestern US habitats in relation to sampling method and environmental conditions. Exp. Appl. Acarol 64: 109–119. [PubMed: 24705853]

Salgo MP, Telzak EE, Currie B, Perlman DC, Litman N, Levi M, Nathenson G, Benach JL, Al-Hafidh R, and Casey J. 1988. A focus of Rocky Mountain spotted fever within New York City. N. Engl. J. Med 318: 1345–1348. [PubMed: 3130574]

Sanders DM, Schuster AL, McCardle PW, Strey OF, Blankenship TL, and Teel PD. 2013. Ixodid ticks associated with feral swine in Texas. J. Vector Ecol 38: 361–373. [PubMed: 24581367]

Santanello C, Barwari R, and Troyo A. 2018. Spotted fever group Rickettsiae in Ticks from Missouri. Ticks Tick Borne Dis 9: 1395–1399. [PubMed: 29960871]

Savage HM, Godsey MS, Lambert A, Panella NA, Burkhalter KL, Harmon JR, Lash RR, Ashley DC, and Nicholson WL. 2013. First detection of heartland virus (Bunyaviridae: Phlebovirus) from field collected arthropods. Am. J. Trop. Med. Hyg 89: 445–452. [PubMed: 23878186]

Savage HM, Godsey MS Jr., Panella NA, Burkhalter KL, Ashley DC, Lash RR, Ramsay B, Patterson T, and Nicholson WL. 2016. Surveillance for Heartland virus (Bunyaviridae: Phlebovirus) in Missouri during 2013: first detection of virus in adults of *Amblyomma americanum* (Acari: Ixodidae). J. Med. Entomol 53: 607–612. [PubMed: 27032416]

Savage HM, Godsey MS Jr., Tatman J, Burkhalter KL, Hamm A, Panella NA, Ghosh A, and Raghavan RK. 2018a. Surveillance for Heartland and Bourbon viruses in Eastern Kansas, June 2016. J. Med. Entomol 55: 1613–1616. [PubMed: 29947778]

Savage HM, Godsey MS Jr., Panella NA, Burkhalter KL, Manford J, Trevino-Garrison IC, Straily A, Wilson S, Bowen J, and Raghavan RK. 2018b. Surveillance for tick-borne viruses near the location of a fatal human case of bourbon virus (Family Orthomyxoviridae: Genus *Thogotovirus*) in Eastern Kansas, 2015. J. Med. Entomol 55: 701–705. [PubMed: 29365128]

Sayler K, Rowland J, Boyce C, and Weeks E. 2017. *Borrelia burgdorferi* DNA absent, multiple *Rickettsia* spp. DNA present in ticks collected from a teaching forest in North Central Florida. Ticks Tick Borne Dis 8: 53–59. [PubMed: 27720381]

Scoles GA 2004. Phylogenetic analysis of the *Francisella*-like endosymbionts of *Dermacentor* ticks. J. Med. Entomol 41: 277–286. [PubMed: 15185926]

Semtner PJ, and Hair JA. 1975. Evaluation of CO2-baited traps for survey of *Amblyomma maculatum* Koch and *Dermacentor variabilis* Say (Acarina: Ixodidae). J. Med. Entomol 12: 137–138. [PubMed: 1159725]

Serra AC, Warden PS, Fricker CR, and Giese AR. 2013. Distribution of ticks and prevalence of *Borrelia burgdorferi* in the upper Connecticut river valley of Vermont. Northeast. Nat. (Steuben) 20: 197–204. [PubMed: 25473255]

Smart DL, and Caccamise DF. 1988. Population dynamics of the American dog tick (Acari: Ixodidae) in relation to small mammal hosts. J. Med. Entomol 25: 515–522. [PubMed: 3204629]

Smith RP Jr., Lacombe EH, Rand PW, and Dearborn R. 1992. Diversity of tick species biting humans in an emerging area for Lyme disease. Am. J. Public Health 82: 66–69. [PubMed: 1536337]

Smith MP, Ponnusamy L, Jiang J, Ayyash LA, Richards AL, and Apperson CS. 2010. Bacterial pathogens in ixodid ticks from a Piedmont County in North Carolina: prevalence of rickettsial organisms. Vector Borne Zoonotic Dis 10: 939–952. [PubMed: 20455778]

Snetsinger R, Jacobs SB, Kim KC, and Tavris D. 1993. Extension of the range of *Dermacentor variabilis* (Acari: Ixodidae) in Pennsylvania. J. Med. Entomol 30: 795–798. [PubMed: 8360904]

Solberg VB, Olson JG, Boobar LR, Burge JR, and Lawyer PG. 1996. Prevalence of *Ehrlichia chaffeensis*, spotted fever group rickettsia, and *Borrelia* spp. infections in ticks and rodents at Fort Bragg, North Carolina. J. Vector Ecol 21: 81–84.

Sonenshine DE 1979a. Ticks of Virginia (Acari: Mestastigmata). Virginia polytechnic institute and State University: Blacksburg, VA. Insects of Viginia Series No. 13. Res. Div. Bull 139: 1–45.

Sonenshine DE 1979b. Insects of Virginia No. 13. Ticks of Virginia (Acari: Metastigmata). Virginia Polytech. Inst. Res. Div. Bull 139: 44p.

Sonenshine DE, and Atwood EL. 1967. Dynamics of feeding of the American dog tick, *Dermacentor variabilis* (Acarina: Ixodidae). Ann. Entomol. Soc. Am 60: 362–373. [PubMed: 6044892]

Spielman A 1976. Human babesiosis on Nantucket Island: transmission by nymphal *Ixodes* ticks. Am. J. Trop. Med. Hyg 25: 784–787. [PubMed: 1008124]

Springer YP, Eisen L, Beati L, James AM, and Eisen RJ. 2014. Spatial distribution of counties in the continental United States with records of occurrence of *Amblyomma americanum* (Ixodida: Ixodidae). J. Med. Entomol 51: 342–351. [PubMed: 24724282]

Steiert JG, and Gilfoy F. 2002. Infection rates of *Amblyomma americanum* and *Dermacentor variabilis* by *Ehrlichia chaffeensis* and *Ehrlichia ewingii* in southwest Missouri. Vector Borne Zoonotic Dis 2: 53–60. [PubMed: 12653298]

Stein KJ, Waterman M, and Waldon JL. 2008. The effects of vegetation density and habitat disturbance on the spatial distribution of ixodid ticks (Acari: Ixodidae). Geospat. Health 2: 241–252. [PubMed: 18686272]

Stephenson N, Blaney A, Clifford D, Gabriel M, Wengert G, Foley P, Brown RN, Higley M, Buckenberger-Mantovani S, and Foley J. 2017. Diversity of rickettsiae in a rural community in northern California. Ticks Tick Borne Dis 8: 526–531. [PubMed: 28274808]

Storm JJ, and Ritzi CM. 2008. Ectoparasites of small mammals in Western Iowa. Northeast. Nat 15: 283–292.

Stout IJ, Clifford CM, Keirans JE, and Portman RW. 1971. *Dermacentor variabilis* (Say) (Acarina: Ixodidae) established in south-eastern Washington and northern Idaho. J. Med. Entomol 8: 143–147. [PubMed: 5157834]

Teel PD, Ketchum HR, Mock DE, Wright RE, and Strey OF. 2010. The Gulf Coast tick: a review of the life history, ecology, distribution, and emergence as an arthropod of medical and veterinary importance. J. Med. Entomol 47: 707–722. [PubMed: 20939363]

Tokarz R, Sameroff S, Tagliafierro T, Jain K, Williams SH, Cucura DM, Rochlin I, Monzon J, Carpi G, Tufts D, et al. 2018. Identification of novel viruses in *Amblyomma americanum, Dermacentor variabilis*, and *Ixodes scapularis* ticks. mSphere 3: e00614–617. [PubMed: 29564401]

Trout Fryxell RT, Hendricks BM, Pompo K, Mays SE, Paulsen DJ, Operario DJ, and Houston AE. 2017. Investigating the adult ixodid tick populations and their associated *Anaplasma*, *Ehrlichia*,

and *Rickettsia* bacteria at a Rocky Mountain spotted fever hotspot in Western Tennessee. Vector Borne Zoonotic Dis 17: 527–538. [PubMed: 28598270]

Trout R, and Steelman C. 2010. Ticks (Acari: Ixodidae) parasitizing canines and deer in Arkansas. J. Entomol. Sci 45: 140–149.

Walker ED, Stobierski MG, Poplar ML, Smith TW, Murphy AJ, Smith PC, Schmitt SM, Cooley TM, and Kramer CM. 1998. Geographic distribution of ticks (Acari: Ixodidae) in Michigan, with emphasis on *Ixodes scapularis* and *Borrelia burgdorferi*. J. Med. Entomol 35: 872–882. [PubMed: 9775623]

Wehinger KA, Roelke ME, and Greiner EC. 1995. Ixodid ticks from panthers and bobcats in Florida. J. Wildl. Dis 31: 480–485. [PubMed: 8592378]

Wikswo ME, Hu R, Dasch GA, Krueger L, Arugay A, Jones K, Hess B, Bennett S, Kramer V, and Eremeeva ME. 2014. Detection and identification of spotted fever group rickettsiae in *Dermacentor* species from southern California. J. Med. Entomol 45: 509–516.

Wilkinson PR 1967. The distribution of *Dermacentor* ticks in Canada in relation to bioclimatic zones. Can. J. Zool 45: 517–537. [PubMed: 6070627]

Wilson N, and Baker WW. 1972. Ticks of Georgia (Acarina: Metastigmata). Bull. Tall Timbers Res. Sta 10: 1–29.

Wilson N, and Kale HW. 1972. Ticks collected from Indian River County, Florida (Acari: Metastigmata: Ixodidae). J. Florida Entomol 55: 53–57.

Wilson NA, Telford SR Jr., and Forrester DJ. 1991. Ectoparasites of a population of urban gray squirrels in northern Florida. J. Med. Entomol 28: 461–464. [PubMed: 1875375]

Zieman EA, Jiménez FA, and Nielsen CK. 2017. Concurrent examination of bobcats and ticks reveals high prevalence of *Cytauxzoon felis* in southern Illinois. J. Parasitol 103: 343–348. [PubMed: 28355128]

Zimmerman RH, McWherter GR, and Bloemer SR. 1987. Role of small mammals in population dynamics and dissemination of *Amblyomma americanum* and *Dermacentor variabilis* (Acari: Ixodidae) at Land Between the Lakes, Tennessee. J. Med. Entomol 24: 370–375. [PubMed: 3295243]

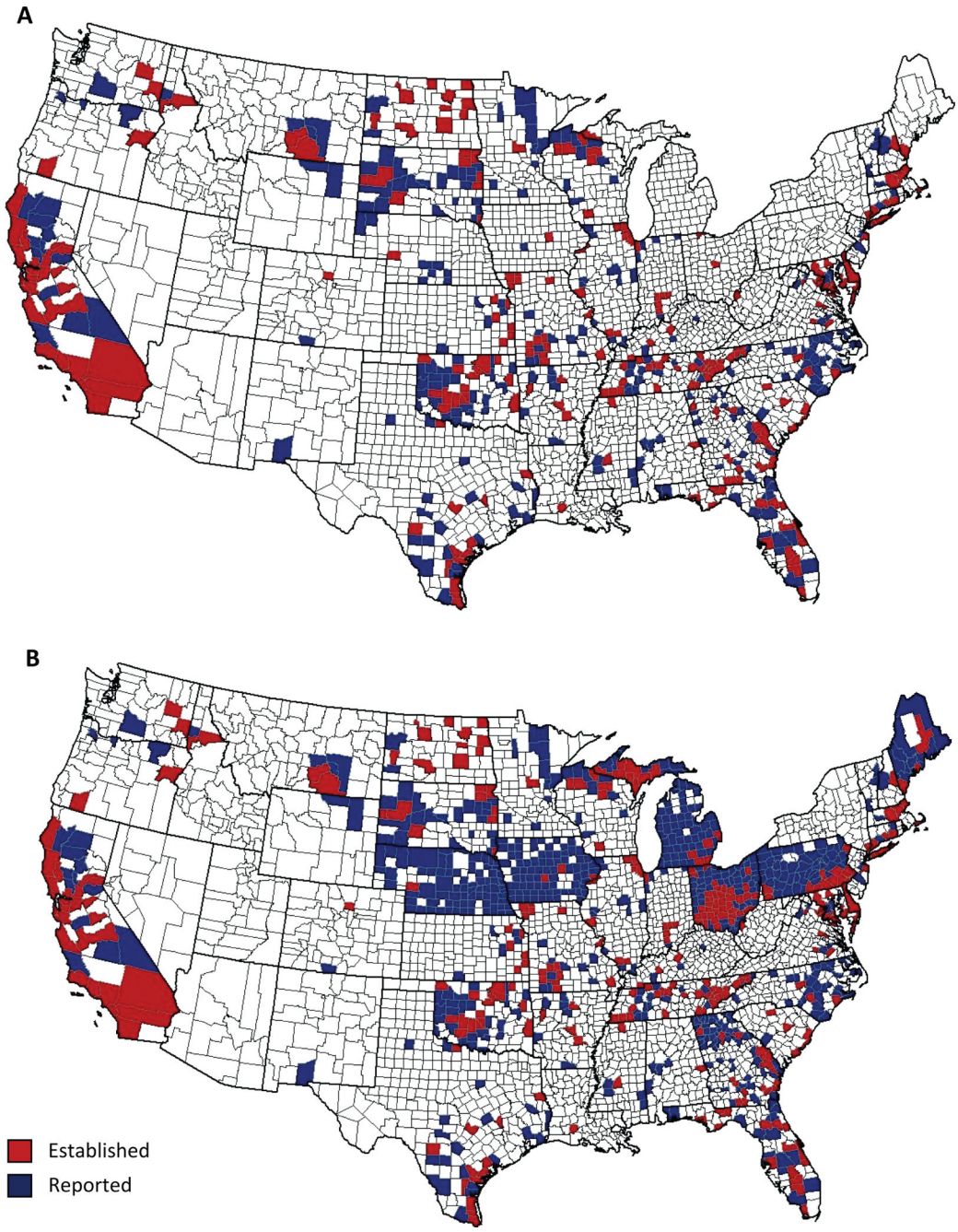

Fig. 1.

Distribution by county of recorded presence of *D. variabilis* in the contiguous United States based on strict (A) or expanded (B) inclusion criteria. Established counties (in red) have records of six or more ticks or two or more life stages recorded in 1 yr, or using the expanded criteria ≥50 ticks recorded over ≥5 yr if from a state-wide surveillance program. Reported counties (in blue) have records of fewer than six ticks in 1 yr, no documentation of number of ticks, or using the expanded criteria <50 ticks over ≥5 yr if a state-wide surveillance program. Counties shown in white indicate 'no records'. Notably, an absence

of records derived through our review is not indicative of the tick's absence in a particular county.

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Table 1.

Number (%) of contiguous U.S. counties in which *D. variabilis* is classified as reported or established as of November 2018 using the strict and expanded criteria.

State	Strict criteria		Expanded criteria	
	No. (%) counties with reported status	No. (%) counties with established status	No. (%) counties with reported status	No. (%) counties with established status
Alabama	4 (6.0)	1 (1.5)	4 (6.0)	1 (1.5)
Arkansas	6 (8.0)	4 (5.3)	6 (8.0)	4 (5.3)
California	13 (22.4)	26 (44.8)	13 (22.4)	26 (44.8)
Colorado	1 (1.6)	1 (1.6)	1 (1.6)	1 (1.6)
Connecticut	2 (25.0)	3 (37.5)	2 (25.0)	3 (37.5)
Delaware	0 (0)	3 (100.0)	0 (0)	3 (100.0)
Florida	17 (25.4)	15 (22.4)	17 (25.4)	15 (22.4)
Georgia[a]	19 (11.9)	21 (13.2)	54 (34.0)	21 (13.2)
Idaho	1 (2.3)	2 (4.5)	1 (2.3)	2 (4.5)
Illinois	11 (10.8)	8 (7.8)	11 (10.8)	8 (7.8)
Indiana	5 (5.4)	6 (6.5)	5 (5.4)	6 (6.5)
Iowa[a]	1 (1.0)	1 (1.0)	75 (75.8)	3 (3.0)
Kansas	5 (4.8)	6 (5.7)	5 (4.8)	6 (5.7)
Kentucky	3 (2.5)	3 (2.5)	3 (2.5)	3 (2.5)
Louisiana	0 (0)	1 (1.6)	0 (0)	1 (1.6)
Maine[a]	0 (0)	1 (6.3)	11 (68.8)	4 (25.0)
Maryland	3 (12.5)	9 (37.5)	3 (12.5)	9 (37.5)
Massachusetts	1 (7.1)	6 (42.9)	1 (7.1)	6 (42.9)
Michigan[a]	0 (0)	1 (1.2)	61 (73.5)	13 (15.7)
Minnesota	9 (10.3)	1 (1.1)	9 (10.3)	1 (1.1)
Mississippi	4 (4.9)	2 (2.4)	4 (4.9)	2 (2.4)
Missouri	9 (7.8)	14 (12.2)	9 (7.8)	14 (12.2)
Montana	3 (5.4)	2 (3.6)	3 (5.4)	2 (3.6)
Nebraska[a]	8 (8.6)	1 (1.1)	73 (78.5)	1 (1.1)
New Hampshire	1 (10.0)	1 (10.0)	1 (10.0)	1 (10.0)

State	Strict criteria		Expanded criteria	
	No. (%) counties with reported status	No. (%) counties with established status	No. (%) counties with reported status	No. (%) counties with established status
New Jersey	2 (9.5)	1 (4.8)	2 (9.5)	1 (4.8)
New Mexico	1 (3.0)	0 (0)	1 (3.0)	0 (0)
New York	1 (1.6)	4 (6.5)	1 (1.6)	4 (6.5)
North Carolina	31 (31.0)	3 (3.0)	31 (31.0)	3 (3.0)
North Dakota	2 (3.8)	10 (18.9)	2 (3.8)	10 (18.9)
Ohio[a]	0 (0)	2 (2.3)	50 (56.8)	38 (43.2)
Oklahoma	25 (32.5)	15 (19.5)	25 (32.5)	15 (19.5)
Oregon	3 (8.3)	2 (5.6)	3 (8.3)	2 (5.6)
Pennsylvania[a]	—	—	49 (73.1)	14 (20.9)
Rhode Island	0 (0)	1 (20.0)	0 (0)	1 (20.0)
South Carolina	1 (2.2)	4 (8.7)	1 (2.2)	4 (8.7)
South Dakota	21 (31.8)	9 (13.6)	21 (31.8)	9 (13.6)
Tennessee	15 (15.8)	28 (29.5)	15 (15.8)	28 (29.5)
Texas	20 (7.9)	13 (5.1)	20 (7.9)	13 (5.1)
Vermont	3 (21.4)	0 (0)	3 (21.4)	0 (0)
Virginia	4 (3.0)	9 (6.7)	4 (3.0)	9 (6.7)
Washington	1 (2.6)	2 (5.1)	1 (2.6)	2 (5.1)
West Virginia	0 (0)	1 (1.8)	0 (0)	1 (1.8)
Wisconsin	9 (12.5)	6 (8.3)	9 (12.5)	6 (8.3)
Wyoming	2 (8.7)	0 (0)	2 (8.7)	0 (0)
Total	267 (8.6)	249 (8.0)	612 (19.7)	316 (10.2)

[a]States with additional county records when inclusion criteria expanded.

Table 2.

Status of *D. variabilis* by county in the contiguous United States

State and county		Status by November 2018	Source for status
Alabama			
	Bibb	Reported	NEON
	Choctaw	Reported	NEON
	Greene	Reported	NEON
	Hale	Reported	NEON
	Lee	Established	(Luckhart et al. 1991)
Arkansas			
	Franklin	Established	USNTC
	Jefferson	Established	USNTC
	Madison	Reported	(Trout and Steelman 2010)
	Marion	Reported	(McAllister et al. 2013)
	Polk	Reported	USNTC; (Trout and Steelman 2010)
	Pulaski	Established	(Blanton et al. 2014)
	Searcy	Reported	USNTC
	Stone	Established	USNTC
	Union	Reported	(McAllister et al. 2013)
	Van Buren	Reported	USNTC
California			
	Alameda	Established	CDPH; (Kramer et al. 1999)
	Butte	Reported	CDPH
	Calaveras	Established	CDPH
	Colusa	Reported	CDPH
	Contra Costa	Reported	(Lane and Voie 1988, Dennis et al. 1998)
	El Dorado	Reported	CDPH
	Fresno	Established	USNTC
	Humboldt	Established	(Clemons et al. 2000, Gabriel et al. 2009, Stephenson et al. 2017)
	Inyo	Reported	CDPH
	Lake	Established	CDPH; (Kaufman et al. 2018)

State and county	Status by November 2018	Source for status
Los Angeles	Established	USNTC; CDPH
Marin	Established	CDPH
Mariposa	Established	CDPH
Mendocino	Established	CDPH
Merced	Reported	CDPH
Monterey	Established	CDPH; (Coultrip et al. 1973, Philip et al. 1981)
Nevada	Established	CDPH
Orange	Established	CDPH; (Barlough et al. 1997, Chang et al. 2002)
Placer	Established	CDPH
Riverside	Established	CDPH
Sacramento	Established	CDPH
San Bernardino	Established	CDPH
San Diego	Established	CDPH (Lang 1999)
San Francisco	Reported	CDPH
San Joaquin	Established	CDPH
San Diego	Established	CDPH; (Lang 1999)
San Francisco	Reported	CDPH
San Joaquin	Established	CDPH
San Luis Obispo	Reported	CDPH; USNTC
San Mateo	Established	CDPH
Santa Barbara	Established	CDPH; (Wikswo et al. 2014, MacDonald 2018)
Santa Clara	Established	CDPH
Santa Cruz	Established	CDPH; (Kramer et al. 1999, Holden et al. 2003)
Shasta	Reported	CDPH
Solano	Established	CDPH
Sonoma	Established	CDPH
Sutter	Reported	CDPH
Tehama	Reported	CDPH
Trinity	Reported	CDPH
Tulare	Reported	CDPH; (Furman and Loomis 1984)
Ventura	Established	CDPH

State and county	Status by November 2018	Source for status
Yolo	Reported	CDPH; (Kaufman et al. 2018)
Colorado		
Boulder	Established	USNTC
Conejos	Reported	USNTC
Connecticut		
Fairfield	Established	(Magnarelli et al. 1983)
Middlesex	Established	(Magnarelli et al. 1991)
New Haven	Reported	USNTC; (Anderson and Magnarelli 1980)
New London	Established	(Magnarelli and Anderson 1988, Magnarelli et al. 1991)
Windham	Reported	(Anderson and Magnarelli 1980)
Delaware		
Kent	Established	(MacCreary 1945)
New Castle	Established	(MacCreary 1945)
Sussex	Established	(MacCreary 1945)
Florida		
Alachua	Established	(Sayler et al. 2017)
Bay	Established	(Cilek and Olson 2000)
Bradford	Reported	USNTC; (Hertz et al. 2017)
Brevard	Established	(Durden et al. 1993)
Clay	Reported	(Hertz et al. 2017)
Collier	Reported	(Forrester et al. 1996, Hertz et al. 2017)
Duval	Reported	(Wilson et al. 1991)
Escambia	Reported	(Hertz et al. 2017)
Flagler	Established	USNTC
Franklin	Established	USNTC
Gadsden	Established	USNTC
Glades	Established	(Greiner et al. 1984)
Hardee	Reported	USNTC
Hendry	Established	USNTC
Highlands	Established	(Durden et al. 2000)
Hillsborough	Established	USNTC

State and county	Status by November 2018	Source for status
Indian River	Established	(Wilson and Kale 1972)
Leon	Established	(Durden et al. 2000)
Levy	Reported	USNTC
Marion	Reported	(Hertz et al. 2017)
Miami-Dade	Reported	(Wehinger et al. 1995)
Monroe	Established	USNTC
Nassau	Reported	USNTC
Orange	Established	USNTC
Osceola	Reported	NEON
Palm Beach	Reported	USNTC
Pasco	Reported	(Hertz et al. 2017)
Pinellas	Reported	USNTC
Polk	Reported	NEON; (Hertz et al. 2017)
Putnam	Established	USNTC
Santa Rosa	Reported	(Hertz et al. 2017)
Taylor	Reported	(Hertz et al. 2017)
Georgia		
Barrow	Reported[a]	(Gleim et al. 2016)
Bartow	Reported[a]	(Gleim et al. 2016)
Berrien	Established	USNTC
Bibb	Reported[a]	(Gleim et al. 2016)
Brantley	Established	(Wilson and Baker 1972)
Brooks	Established	(Wilson and Baker 1972)
Bryan	Established	USNTC
Bulloch	Established	(Lavender and Oliver 1996)
Burke	Established	(Wilson and Baker 1972)
Camden	Reported[a]	(Gleim et al. 2016)
Candler	Established	(Nims et al. 2008)
Carroll	Reported	(Wilson and Baker 1972)
Catoosa	Reported[a]	(Gleim et al. 2016)

State and county	Status by November 2018	Source for status
Chatham	Reported[a]	(Gleim et al. 2016)
Chattooga	Reported[a]	(Gleim et al. 2016)
Cherokee	Reported[a]	(Gleim et al. 2016)
Clarke	Established	(Wilson and Baker 1972)
Clay	Reported[a]	(Gleim et al. 2016)
Clayton	Reported[a]	(Gleim et al. 2016)
Clinch	Reported	USNTC
Cobb	Reported[a]	(Gleim et al. 2016)
Coffee	Reported[a]	(Gleim et al. 2016)
Crisp	Established	(Wilson and Baker 1972)
Dade	Reported[a]	(Gleim et al. 2016)
Dawson	Reported	(Nims and Durden 2011, Gleim et al. 2016)
DeKalb	Reported[a]	(Gleim et al. 2016)
Dougherty	Reported	(Wilson and Baker 1972)
Effingham	Reported[a]	(Gleim et al. 2016)
Emanuel	Reported	USNTC
Fannin	Reported[a]	(Gleim et al. 2016)
Fayette	Reported[a]	(Gleim et al. 2016)
Floyd	Established	(Wilson and Baker 1972)
Forsyth	Reported[a]	(Gleim et al. 2016)
Fulton	Reported[a]	(Gleim et al. 2016)
Gilmer	Reported[a]	(Gleim et al. 2016)
Glynn	Established	(Wilson and Baker 1972)
Gordon	Reported[a]	(Gleim et al. 2016)
Greene	Reported[a]	(Wilson and Baker 1972)
Gwinnett	Established	(Nims and Durden 2011)

State and county	Status by November 2018	Source for status
Habersham	Reported	(Wilson and Baker 1972, Gleim et al. 2016)
Hall	Reported[a]	(Gleim et al. 2016)
Haralson	Reported[a]	(Gleim et al. 2016)
Harris	Reported	(Wilson and Baker 1972)
Houston	Reported	(Wilson and Baker 1972)
Irwin	Reported	(Wilson and Baker 1972)
Jackson	Reported	(Wilson and Baker 1972, Gleim et al. 2016)
Jefferson	Reported	(Wilson and Baker 1972)
Jenkins	Established	(Wilson and Baker 1972)
Liberty	Reported	(Durden et al. 2001)
Lincoln	Reported[a]	(Gleim et al. 2016)
Lowndes	Established	(Wilson and Baker 1972)
Lumpkin	Reported	(Wilson and Baker 1972)
Madison	Reported[a]	(Gleim et al. 2016)
McIntosh	Established	(Wilson and Baker 1972)
Murray	Reported[a]	(Gleim et al. 2016)
Oconee	Reported[a]	(Gleim et al. 2016)
Oglethorpe	Established	(Wilson and Baker 1972, Gleim et al. 2016)
Paulding	Reported[a]	(Gleim et al. 2016)
Pierce	Established	(Wilson and Baker 1972)
Polk	Reported	(Wilson and Baker 1972, Gleim et al. 2016)
Rabun	Reported[a]	(Gleim et al. 2016)
Rockdale	Established	(Newhouse 1983)
Screven	Established	(Wilson and Baker 1972)
Stephens	Reported[a]	(Gleim et al. 2016)
Tattnall	Reported[a]	(Gleim et al. 2016)
Telfair	Reported	(Wilson and Baker 1972)
Thomas	Established	(Wilson and Baker 1972)

State and county		Status by November 2018	Source for status
	Tift	Reported[a]	(Gleim et al. 2016)
	Towns	Reported	(Nims and Durden 2011)
	Turner	Established	(Wilson and Baker 1972)
	Upson	Reported[a]	(Gleim et al. 2016)
	Walker	Reported	(Wilson and Baker 1972, Gleim et al. 2016)
	Walton	Reported[a]	(Gleim et al. 2016)
	Whitfield	Reported[a]	(Gleim et al. 2016)
	Wilkes	Reported	(Wilson and Baker 1972)
Idaho			
	Clearwater	Established	(Stout et al. 1971)
	Latah	Reported	(Stout et al. 1971)
	Nez Perce	Established	(Stout et al. 1971, Scoles 2004)
Illinois			
	Brown	Reported	USNTC
	Carroll	Reported	USNTC
	Cook	Established	(Rydzewski et al. 2012)
	DuPage	Established	(Rydzewski et al. 2012)
	Jackson	Established	(Zieman et al. 2017)
	Jo Daviess	Reported	USNTC
	Lake	Established	(Rydzewski et al. 2012)
	Massac	Reported	USNTC
	McHenry	Established	(Rydzewski et al. 2012)
	McLean	Reported	USNTC
	Monroe	Reported	USNTC
	Piatt	Reported	USNTC
	Pike	Established	USNTC
	Pope	Reported	USNTC
	Rock Island	Established	USNTC
	Schuyler	Reported	USNTC
	Union	Reported	USNTC

State and county		Status by November 2018	Source for status
	Vermilion	Reported	USNTC
	Williamson	Established	(Nelson et al. 1984)
Indiana			
	Bartholomew	Established	(Rynkiewicz and Clay 2014)
	Brown	Established	(Rynkiewicz and Clay 2014)
	Crawford	Reported	USNTC
	Lake	Established	USNTC
	Lawrence	Established	USNTC
	Monroe	Established	(Rynkiewicz and Clay 2014)
	Newton	Reported	USNTC
	Orange	Established	(Civitello et al. 2008)
	Porter	Reported	USNTC
	St. Joseph	Reported	USNTC
	Steuben	Reported	USNTC
Iowa			
	Adair	Reported[a]	(Lingren et al. 2005)
	Adams	Reported[a]	(Lingren et al. 2005)
	Appanoose	Reported[a]	(Lingren et al. 2005)
	Audubon	Reported[a]	(Lingren et al. 2005)
	Benton	Reported[a]	(Lingren et al. 2005)
	Black Hawk	Reported[a]	(Lingren et al. 2005)
	Boone	Reported[a]	(Lingren et al. 2005)
	Bremer	Reported[a]	(Lingren et al. 2005)
	Buena Vista	Reported[a]	(Lingren et al. 2005)
	Butler	Reported[a]	(Lingren et al. 2005)
	Calhoun	Reported[a]	(Lingren et al. 2005)
	Carroll	Reported[a]	(Lingren et al. 2005)

State and county	Status by November 2018	Source for status
Cass	Reported[a]	(Lingren et al. 2005)
Cedar	Reported[a]	(Lingren et al. 2005)
Cerro Gordo	Reported[a]	(Lingren et al. 2005)
Cherokee	Reported[a]	(Lingren et al. 2005)
Chickasaw	Reported[a]	(Lingren et al. 2005)
Clarke	Reported[a]	(Lingren et al. 2005)
Clay	Reported[a]	(Lingren et al. 2005)
Clayton	Reported[a]	(Lingren et al. 2005)
Clinton	Reported[a]	(Lingren et al. 2005)
Crawford	Reported[a]	(Lingren et al. 2005)
Dallas	Reported	(Storm and Ritzi 2008)
Decatur	Reported[a]	(Lingren et al. 2005)
Delaware	Reported[a]	(Lingren et al. 2005)
Des Moines	Reported[a]	(Lingren et al. 2005)
Dickinson	Reported[a]	(Lingren et al. 2005)
Dubuque	Reported[a]	(Lingren et al. 2005)
Fayette	Reported[a]	(Lingren et al. 2005)
Franklin	Reported[a]	(Lingren et al. 2005)
Fremont	Reported[a]	(Lingren et al. 2005)
Greene	Reported[a]	(Lingren et al. 2005)
Grundy	Reported[a]	(Lingren et al. 2005)
Guthrie	Reported[a]	(Lingren et al. 2005)
Hamilton	Reported[a]	(Lingren et al. 2005)
Hardin	Reported[a]	(Lingren et al. 2005)

State and county	Status by November 2018	Source for status
Henry	Reported[a]	(Lingren et al. 2005)
Jackson	Reported[a]	(Lingren et al. 2005)
Jasper	Reported[a]	(Lingren et al. 2005)
Jefferson	Reported[a]	(Lingren et al. 2005)
Johnson	Reported[a]	(Lingren et al. 2005)
Jones	Reported[a]	(Lingren et al. 2005)
Kossuth	Reported[a]	(Lingren et al. 2005)
Lee	Reported[a]	(Lingren et al. 2005)
Linn	Reported[a]	(Lingren et al. 2005)
Louisa	Reported[a]	(Lingren et al. 2005)
Lucas	Reported[a]	(Lingren et al. 2005)
Lyon	Reported[a]	(Lingren et al. 2005)
Madison	Reported[a]	(Lingren et al. 2005)
Marion	Reported[a]	(Lingren et al. 2005)
Marshall	Reported[a]	(Lingren et al. 2005)
Mills	Reported[a]	(Lingren et al. 2005)
Mitchell	Reported[a]	(Lingren et al. 2005)
Monroe	Reported[a]	(Lingren et al. 2005)
Montgomery	Reported[a]	(Lingren et al. 2005)
Muscatine	Reported[a]	(Lingren et al. 2005)
O'Brien	Reported[a]	(Lingren et al. 2005)
Page	Reported[a]	(Lingren et al. 2005)
Polk	Established[a]	(Lingren et al. 2005)
Pottawattamie	Reported[a]	(Lingren et al. 2005)

State and county		Status by November 2018	Source for status
	Ringgold	Reported[a]	(Lingren et al. 2005)
	Sac	Reported[a]	(Lingren et al. 2005)
	Scott	Established[a]	(Lingren et al. 2005)
	Shelby	Reported[a]	(Lingren et al. 2005)
	Sioux	Reported[a]	(Lingren et al. 2005)
	Story	Reported[a]	(Lingren et al. 2005)
	Tama	Established	(Eddy and Joyce 1944)
	Taylor	Reported[a]	(Lingren et al. 2005)
	Union	Reported[a]	(Lingren et al. 2005)
	Wapello	Reported[a]	(Lingren et al. 2005)
	Warren	Reported[a]	(Lingren et al. 2005)
	Washington	Reported[a]	(Lingren et al. 2005)
	Wayne	Reported[a]	(Lingren et al. 2005)
	Webster	Reported[a]	(Lingren et al. 2005)
	Winnebago	Reported[a]	(Lingren et al. 2005)
	Winneshiek	Reported[a]	(Lingren et al. 2005)
	Woodbury	Reported[a]	(Lingren et al. 2005)
	Wright	Reported[a]	(Lingren et al. 2005)
Kansas			
	Barber	Reported	USNTC
	Bourbon	Established	(Savage et al. 2018a,b)
	Douglas	Reported	NEON; USNTC
	Jackson	Established	USNTC
	Jefferson	Reported	NEON
	Leavenworth	Established	USNTC
	Linn	Established	(Savage et al. 2018a,b)

State and county	Status by November 2018	Source for status
Kentucky		
Lyon	Reported	USNTC
Neosho	Established	USNTC
Osage	Established	USNTC
Riley	Reported	NEON
Calloway	Established	USNTC
Christian	Reported	USNTC
Fayette	Reported	(Burg 2001)
Hardin	Established	(Pagac et al. 2014)
Hart	Reported	(Buchholz et al. 2018)
Muhlenberg	Established	(Pagac et al. 2014)
Louisiana		
Acadia	Established	(Goddard and Bircham 2010)
Maine		
Androscoggin	Reported[a]	(Smith et al. 1992, Rand et al. 2007)
Aroostook	Reported[a]	(Rand et al. 2007)
Cumberland	Established[a]	(Rand et al. 2007)
Franklin	Reported[a]	(Smith et al. 1992, Rand et al. 2007)
Hancock	Reported[a]	(Rand et al. 2007)
Kennebec	Reported[a]	(Smith et al. 1992, Rand et al. 2007)
Knox	Reported[a]	(Smith et al. 1992, Rand et al. 2007)
Lincoln	Established[a]	(Rand et al. 2007)
Oxford	Reported[a]	(Smith et al. 1992, Rand et al. 2007)
Penobscot	Established[a]	(Rand et al. 2007)
Sagadahoc	Reported[a]	(Smith et al. 1992, Rand et al. 2007)
Somerset	Reported[a]	(Smith et al. 1992)
Waldo	Reported[a]	(Rand et al. 2007)

State and county		Status by November 2018	Source for status
Maryland	Washington	Reported[a]	(Smith et al. 1992, Rand et al. 2007)
	York	Established	(Rand et al. 2007, Kaufman et al. 2018)
	Anne Arundel	Reported	NEON
	Baltimore	Established	(Ammerman et al. 2004)
	Calvert	Established	(Ammerman et al. 2004)
	Charles	Established	(Ammerman et al. 2004)
	Dorchester	Established	(Harman et al. 1984)
	Frederick	Established	(Durden 1992)
	Kent	Reported	USNTC
	Montgomery	Established	(Carroll et al. 1989)
	Prince George's	Reported	(Ammerman et al. 2004)
	St. Mary's	Established	(Ammerman et al. 2004)
	Talbot	Established	USNTC
	Worcester	Established	(Oliver et al. 1999)
Massachusetts	Barnstable	Established	(Feng et al. 1980)
	Dukes	Established	(Lyon et al. 1998, Goethert et al. 2004)
	Essex	Established	(Goethert and Telford 2005)
	Hampshire	Reported	(Coher and Shaw 1951)
	Middlesex	Established	USNTC
	Nantucket	Established	(Spielman 1976)
	Worcester	Established	(Perla and Thomas 2001)
Michigan	Alger	Reported[a]	(Walker et al. 1998)
	Allegan	Reported[a]	(Walker et al. 1998)
	Alpena	Reported[a]	(Walker et al. 1998)
	Baraga	Established[a]	(Walker et al. 1998)
	Barry	Reported[a]	(Walker et al. 1998)

State and county	Status by November 2018	Source for status
Bay	Reported[a]	(Walker et al. 1998)
Berrien	Reported[a]	(Walker et al. 1998)
Branch	Reported[a]	(Walker et al. 1998)
Calhoun	Reported[a]	(Walker et al. 1998)
Cass	Reported[a]	(Walker et al. 1998)
Charlevoix	Reported[a]	(Walker et al. 1998)
Cheboygan	Reported[a]	(Walker et al. 1998)
Chippewa	Reported[a]	(Walker et al. 1998)
Clare	Reported[a]	(Walker et al. 1998)
Clinton	Reported[a]	(Walker et al. 1998)
Crawford	Reported[a]	(Walker et al. 1998)
Delta	Established[a]	(Walker et al. 1998)
Dickinson	Established[a]	(Walker et al. 1998)
Eaton	Reported[a]	(Walker et al. 1998)
Emmet	Reported[a]	(Walker et al. 1998)
Grand Traverse	Reported[a]	(Walker et al. 1998)
Gladwin	Reported[a]	(Walker et al. 1998)
Gogebic	Established	NEON
Grand Traverse	Reported[a]	(Walker et al. 1998)
Hillsdale	Reported[a]	(Walker et al. 1998)
Houghton	Reported[a]	(Walker et al. 1998)
Huron	Reported[a]	(Walker et al. 1998)
Ingham	Reported[a]	(Walker et al. 1998)
Ionia	Reported[a]	(Walker et al. 1998)

State and county	Status by November 2018	Source for status
Iosco	Reported[a]	(Walker et al. 1998)
Iron	Established[a]	(Walker et al. 1998)
Isabella	Reported[a]	(Walker et al. 1998)
Jackson	Established[a]	(Walker et al. 1998)
Kalamazoo	Reported[a]	(Walker et al. 1998)
Kent	Reported[a]	(Walker et al. 1998)
Leelanau	Reported[a]	(Walker et al. 1998)
Lake	Reported[a]	(Walker et al. 1998)
Lapeer	Reported[a]	(Walker et al. 1998)
Leelanau	Reported[a]	(Walker et al. 1998)
Lenawee	Established[a]	(Walker et al. 1998)
Livingston	Reported[a]	(Walker et al. 1998)
Luce	Reported[a]	(Walker et al. 1998)
Mackinac	Reported[a]	(Walker et al. 1998)
Macomb	Reported[a]	(Walker et al. 1998)
Manistee	Reported[a]	(Walker et al. 1998)
Marquette	Established[a]	(Walker et al. 1998)
Mason	Reported[a]	(Walker et al. 1998)
Mecosta	Reported[a]	(Walker et al. 1998)
Menominee	Established[a]	(Walker et al. 1998)
Midland	Reported[a]	(Walker et al. 1998)
Monroe	Established[a]	(Walker et al. 1998)
Montcalm	Reported[a]	(Walker et al. 1998)
Muskegon	Reported[a]	(Walker et al. 1998)

State and county	Status by November 2018	Source for status
Newaygo	Reported[a]	(Walker et al. 1998)
Oakland	Established[a]	(Walker et al. 1998)
Oceana	Reported[a]	(Walker et al. 1998)
Ogemaw	Reported[a]	(Walker et al. 1998)
Ontonagon	Reported[a]	(Walker et al. 1998)
Osceola	Reported[a]	(Walker et al. 1998)
Otsego	Reported[a]	(Walker et al. 1998)
Ottawa	Reported[a]	(Walker et al. 1998)
Presque Isle	Reported[a]	(Walker et al. 1998)
Roscommon	Reported[a]	(Walker et al. 1998)
Saginaw	Reported[a]	(Walker et al. 1998)
St. Clair	Reported[a]	(Walker et al. 1998)
St. Joseph	Established[a]	(Walker et al. 1998)
Sanilac	Reported[a]	(Walker et al. 1998)
Schoolcraft	Established[a]	(Walker et al. 1998)
Shiawassee	Reported[a]	(Walker et al. 1998)
Tuscola	Reported[a]	(Walker et al. 1998)
Van Buren	Reported[a]	(Walker et al. 1998)
Washtenaw	Reported[a]	(Walker et al. 1998)
Wayne	Reported[a]	(Walker et al. 1998)
Wexford	Reported[a]	(Walker et al. 1998)
Minnesota		
Aitkin	Reported	USNTC
Anoka	Reported	USNTC
Blue Earth	Reported	USNTC

State and county		Status by November 2018	Source for status
	Clearwater	Reported	USNTC
	Itasca	Reported	USNTC
	Kanabec	Reported	USNTC
	Koochiching	Reported	USNTC
	Lyon	Reported	USNTC
	Morrison	Established	(Mcnemee et al. 2003)
	Pine	Reported	USNTC
Mississippi			
	Copiah	Reported	(Goddard et al. 2003)
	Greene	Reported	USNTC
	Hinds	Reported	(Goddard et al. 2003)
	Marshall	Established	(Goddard et al. 2003)
	Rankin	Established	(Goddard et al. 2011)
	Wayne	Reported	(Goddard et al. 2003)
Missouri			
	Adair	Established	(Dallas et al. 2012, Hudman and Sargentini 2016)
	Andrew	Established	(Savage et al. 2013, 2016)
	Barry	Reported	(Steiert and Gilfoy 2002)
	Carter	Reported	(Brown et al. 2011)
	Christian	Established	(Steiert and Gilfoy 2002)
	Dade	Established	(Steiert and Gilfoy 2002)
	Dallas	Established	(Steiert and Gilfoy 2002)
	Dent	Reported	(Brown et al. 2011)
	Gentry	Established	(Brown et al. 2011)
	Greene	Reported	(Steiert and Gilfoy 2002)
	Hickory	Reported	(Brown et al. 2011)
	Johnson	Reported	(Brown et al. 2011)
	Laclede	Reported	(Brown et al. 2011)
	Lawrence	Established	(Steiert and Gilfoy 2002)
	Nodaway	Established	(Savage et al. 2013, 2016)
	Polk	Established	(Steiert and Gilfoy 2002)

State and county	Status by November 2018	Source for status
St. Louis	Established	(Santanello et al. 2018)
Stoddard	Established	USNTC
Stone	Reported	(Steiert and Gilfoy 2002)
Taney	Established	USNTC
Washington	Reported	USNTC
Webster	Established	(Steiert and Gilfoy 2002)
Worth	Established	(Savage et al. 2013)
Montana		
Big Horn	Established	USNTC
Musselshell	Reported	USNTC
Rosebud	Reported	USNTC
Treasure	Reported	USNTC
Yellowstone	Established	(Araya-Anchetta et al. 2013)
Nebraska		
Adams	Reported	(Cortinas and Spomer 2014, Kaufman et al. 2018)
Antelope	Reported[a]	(Cortinas and Spomer 2014)
Blaine	Reported[a]	(Cortinas and Spomer 2014)
Boyd	Reported[a]	(Cortinas and Spomer 2014)
Brown	Reported[a]	(Cortinas and Spomer 2014)
Buffalo	Reported	(Cortinas and Spomer 2014, Kaufman et al. 2018)
Burt	Reported[a]	(Cortinas and Spomer 2014)
Butler	Reported[a]	(Cortinas and Spomer 2014)
Cass	Reported[a]	(Cortinas and Spomer 2014)
Cedar	Reported[a]	(Cortinas and Spomer 2014)
Chase	Reported[a]	(Cortinas and Spomer 2014)
Cherry	Reported[a]	(Cortinas and Spomer 2014)
Cheyenne	Reported[a]	(Cortinas and Spomer 2014)
Clay	Reported[a]	(Cortinas and Spomer 2014)

State and county	Status by November 2018	Source for status
Colfax	Reported[a]	(Cortinas and Spomer 2014)
Cuming	Reported[a]	(Cortinas and Spomer 2014)
Custer	Reported[a]	(Cortinas and Spomer 2014)
Dakota	Reported[a]	(Cortinas and Spomer 2014)
Dawes	Reported	(Cortinas and Spomer 2014, Kaufman et al. 2018)
Dawson	Reported	(Cortinas and Spomer 2014, Kaufman et al. 2018)
Dixon	Reported[a]	(Cortinas and Spomer 2014)
Dodge	Reported[a]	(Cortinas and Spomer 2014)
Douglas	Reported[a]	(Cortinas and Spomer 2014)
Dundy	Reported[a]	(Cortinas and Spomer 2014)
Franklin	Reported[a]	(Cortinas and Spomer 2014)
Frontier	Reported[a]	(Cortinas and Spomer 2014)
Furnas	Reported	(Cortinas and Spomer 2014, Kaufman et al. 2018)
Gage	Reported[a]	(Cortinas and Spomer 2014)
Garfield	Reported[a]	(Cortinas and Spomer 2014)
Greeley	Reported[a]	(Cortinas and Spomer 2014)
Hall	Reported[a]	(Cortinas and Spomer 2014)
Hamilton	Reported[a]	(Cortinas and Spomer 2014)
Harlan	Reported[a]	(Cortinas and Spomer 2014)
Hitchcock	Reported[a]	(Cortinas and Spomer 2014)
Hooker	Reported[a]	(Cortinas and Spomer 2014)
Howard	Reported[a]	(Cortinas and Spomer 2014)
Jefferson	Reported[a]	(Durden and Richardson 2013, Cortinas and Spomer 2014)
Johnson	Reported[a]	(Cortinas and Spomer 2014)
Kearney	Reported[a]	(Cortinas and Spomer 2014)

State and county	Status by November 2018	Source for status
Keith	Reported	(Durden and Richardson 2013, Cortinas and Spomer 2014)
Keya Paha	Reported[a]	(Cortinas and Spomer 2014)
Knox	Reported[a]	(Cortinas and Spomer 2014)
Lancaster	Reported[a]	(Cortinas and Spomer 2014)
Lincoln	Reported[a]	(Cortinas and Spomer 2014)
Loup	Reported[a]	(Cortinas and Spomer 2014)
Madison	Reported[a]	(Cortinas and Spomer 2014)
Merrick	Reported[a]	(Cortinas and Spomer 2014)
Morrill	Reported[a]	(Cortinas and Spomer 2014)
Nance	Reported[a]	(Cortinas and Spomer 2014)
Nemaha	Reported[a]	(Cortinas and Spomer 2014)
Nuckolls	Reported[a]	(Cortinas and Spomer 2014)
Otoe	Reported[a]	(Cortinas and Spomer 2014)
Pawnee	Reported[a]	(Cortinas and Spomer 2014)
Perkins	Reported[a]	(Cortinas and Spomer 2014
Phelps	Reported	(Cortinas and Spomer 2014, Kaufman et al. 2018)
Platte	Reported[a]	(Cortinas and Spomer 2014)
Polk	Reported[a]	(Cortinas and Spomer 2014)
Red Willow	Reported[a]	(Cortinas and Spomer 2014)
Richardson	Reported[a]	(Cortinas and Spomer 2014)
Rock	Reported[a]	(Cortinas and Spomer 2014)
Saline	Reported[a]	(Cortinas and Spomer 2014)
Sarpy	Reported[a]	(Cortinas and Spomer 2014)
Saunders	Reported[a]	(Cortinas and Spomer 2014)

State and county		Status by November 2018	Source for status
	Scotts Bluff	Reported[a]	(Cortinas and Spomer 2014)
	Seward	Reported[a]	(Cortinas and Spomer 2014)
	Sheridan	Reported[a]	(Cortinas and Spomer 2014)
	Sherman	Reported[a]	(Cortinas and Spomer 2014)
	Sioux	Reported	(Cortinas and Spomer 2014, Kaufman et al. 2018)
	Thomas	Reported[a]	(Cortinas and Spomer 2014)
	Thurston	Reported[a]	(Cortinas and Spomer 2014)
	Washington	Reported[a]	(Cortinas and Spomer 2014)
	Wayne	Reported[a]	(Cortinas and Spomer 2014)
	Webster	Reported	(Cortinas and Spomer 2014, Kaufman et al. 2018)
	York	Reported[a]	(Cortinas and Spomer 2014)
New Hampshire			
	Carroll	Established	NEON
	Grafton	Reported	USNTC
New Jersey			
	Burlington	Reported	USNTC
	Middlesex	Reported	USNTC
	Monmouth	Established	(Smart and Caccamise 1988)
New Mexico			
	Dona Ana	Reported	USNTC
New York			
	Bronx	Established	(Salgo et al. 1988)
	Nassau	Established	(Benach et al. 1977)
	Queens	Reported	USNTC
	Suffolk	Established	(Benach et al. 1977, Tokarz et al. 2018)
	Westchester	Established	(Fish and Dowler 1989)
North Carolina			

State and county	Status by November 2018	Source for status
Alamance	Reported	(Kakumanu et al. 2018)
Anson	Reported	(Kakumanu et al. 2018)
Bladen	Reported	(Kakumanu et al. 2018)
Brunswick	Reported	(Kakumanu et al. 2018)
Camden	Reported	(Kakumanu et al. 2018)
Carteret	Reported	(Kakumanu et al. 2018)
Chatham	Established	(Apperson et al. 2008, Smith et al. 2010)
Columbus	Reported	(Kakumanu et al. 2018)
Craven	Reported	(Kakumanu et al. 2018)
Cumberland	Established	(Solberg et al. 1996)
Dare	Reported	USNTC
Durham	Reported	USNTC
Franklin	Reported	(Kakumanu et al. 2018)
Gates	Reported	(Kakumanu et al. 2018)
Greene	Reported	(Kakumanu et al. 2018)
Guilford	Reported	(Kakumanu et al. 2018)
Halifax	Reported	(Kakumanu et al. 2018)
Harnett	Reported	(Kakumanu et al. 2018)
Haywood	Reported	USNTC
Hoke	Reported	(Kakumanu et al. 2018)
Johnston	Reported	(Kakumanu et al. 2018)
Jones	Reported	(Kakumanu et al. 2018)
Martin	Reported	(Kakumanu et al. 2018)
Northampton	Reported	(Kakumanu et al. 2018)
Onslow	Established	(Apperson et al. 1993, Ouellette et al. 1997)
Perquimans	Reported	(Kakumanu et al. 2018)
Sampson	Reported	(Kakumanu et al. 2018)
Scotland	Reported	(Kakumanu et al. 2018)
Surry	Reported	(Kakumanu et al. 2018)
Tyrrell	Reported	(Kakumanu et al. 2018)
Vance	Reported	(Kakumanu et al. 2018)

State and county		Status by November 2018	Source for status
	Wake	Reported	(Kakumanu et al. 2018)
	Warren	Reported	(Kakumanu et al. 2018)
	Wayne	Reported	(Kakumanu et al. 2018)
North Dakota			
	Billings	Established	(Russart et al. 2014)
	Eddy	Established	(Russart et al. 2014)
	Grand Forks	Established	(Russart et al. 2014)
	McKenzie	Reported	(Russart et al. 2014)
	Morton	Established	NEON
	Pembina	Established	(Russart et al. 2014)
	Ramsey	Established	(Russart et al. 2014
	Rolette	Established	(Russart et al. 2014)
	Slope	Reported	USNTC
	Steele	Established	(Russart et al. 2014)
	Stutsman	Established	NEON
	Ward	Established	USNTC
Ohio			
	Adams	Established[a]	(Pretzman et al. 1990)
	Allen	Reported[a]	(Pretzman et al. 1990)
	Ashland	Reported[a]	(Pretzman et al. 1990)
	Ashtabula	Reported[a]	(Pretzman et al. 1990)
	Athens	Established[a]	(Pretzman et al. 1990)
	Auglaize	Reported[a]	(Pretzman et al. 1990)
	Belmont	Established[a]	(Pretzman et al. 1990)
	Brown	Reported[a]	(Pretzman et al. 1990)
	Butler	Established[a]	(Pretzman et al. 1990)
	Carroll	Reported[a]	(Pretzman et al. 1990)

State and county	Status by November 2018	Source for status
Champaign	Established[a]	(Pretzman et al. 1990)
Clark	Established[a]	(Pretzman et al. 1990)
Clermont	Established[a]	(Pretzman et al. 1990)
Clinton	Established[a]	(Pretzman et al. 1990)
Columbiana	Reported[a]	(Pretzman et al. 1990)
Coshocton	Reported[a]	(Pretzman et al. 1990)
Crawford	Reported[a]	(Pretzman et al. 1990)
Cuyahoga	Reported[a]	(Pretzman et al. 1990)
Darke	Reported[a]	(Pretzman et al. 1990)
Defiance	Established[a]	(Pretzman et al. 1990)
Delaware	Established	(Harlan and Foster 1990, Pretzman et al. 1990)
Erie	Reported[a]	(Pretzman et al. 1990)
Fairfield	Established[a]	(Pretzman et al. 1990)
Fayette	Established[a]	(Pretzman et al. 1990)
Franklin	Established[a]	(Pretzman et al. 1990)
Fulton	Reported[a]	(Pretzman et al. 1990)
Gallia	Reported[a]	(Pretzman et al. 1990)
Geauga	Reported[a]	(Pretzman et al. 1990)
Greene	Established[a]	(Pretzman et al. 1990)
Guernsey	Established[a]	(Pretzman et al. 1990)
Hamilton	Established[a]	(Pretzman et al. 1990)
Hancock	Reported[a]	(Pretzman et al. 1990)
Hardin	Reported[a]	(Pretzman et al. 1990)
Harrison	Reported[a]	(Pretzman et al. 1990)

State and county	Status by November 2018	Source for status
Henry	Reported[a]	(Pretzman et al. 1990)
Highland	Established[a]	(Pretzman et al. 1990)
Hocking	Established[a]	(Pretzman et al. 1990)
Holmes	Reported[a]	(Pretzman et al. 1990)
Huron	Reported[a]	(Pretzman et al. 1990)
Jackson	Established[a]	(Pretzman et al. 1990)
Jefferson	Reported[a]	(Pretzman et al. 1990)
Knox	Established[a]	(Pretzman et al. 1990)
Lake	Reported[a]	(Pretzman et al. 1990)
Lawrence	Reported[a]	(Pretzman et al. 1990)
Licking	Established[a]	(Pretzman et al. 1990)
Logan	Established[a]	(Pretzman et al. 1990)
Lorain	Reported[a]	(Pretzman et al. 1990)
Lucas	Established	(Conlon and Rockett 1982, Pretzman et al. 1990)
Madison	Established[a]	(Pretzman et al. 1990)
Mahoning	Reported[a]	(Pretzman et al. 1990)
Marion	Established[a]	(Pretzman et al. 1990)
Medina	Reported[a]	(Pretzman et al. 1990)
Meigs	Reported[a]	(Pretzman et al. 1990)
Mercer	Reported[a]	(Pretzman et al. 1990)
Miami	Reported[a]	(Pretzman et al. 1990)
Monroe	Reported[a]	(Pretzman et al. 1990)
Montgomery	Established[a]	(Pretzman et al. 1990)
Morgan	Reported[a]	(Pretzman et al. 1990)

State and county	Status by November 2018	Source for status
Morrow	Established[a]	(Pretzman et al. 1990)
Muskingum	Established[a]	(Pretzman et al. 1990)
Noble	Reported[a]	(Pretzman et al. 1990)
Ottawa	Reported[a]	(Pretzman et al. 1990)
Paulding	Reported[a]	(Pretzman et al. 1990)
Perry	Reported[a]	(Pretzman et al. 1990)
Pickaway	Established[a]	(Pretzman et al. 1990)
Pike	Reported[a]	(Pretzman et al. 1990)
Portage	Established[a]	(Pretzman et al. 1990)
Preble	Reported[a]	(Pretzman et al. 1990)
Putnam	Reported[a]	(Pretzman et al. 1990)
Richland	Reported[a]	(Pretzman et al. 1990)
Ross	Established[a]	(Pretzman et al. 1990)
Sandusky	Reported[a]	(Pretzman et al. 1990)
Scioto	Reported[a]	(Pretzman et al. 1990)
Seneca	Reported[a]	(Pretzman et al. 1990)
Shelby	Reported[a]	(Pretzman et al. 1990)
Stark	Reported[a]	(Pretzman et al. 1990)
Summit	Reported[a]	(Pretzman et al. 1990)
Trumbull	Reported[a]	(Pretzman et al. 1990)
Tuscarawas	Established[a]	(Pretzman et al. 1990)
Union	Established[a]	(Pretzman et al. 1990)
Van Wert	Reported[a]	(Pretzman et al. 1990)
Vinton	Established[a]	(Pretzman et al. 1990)

State and county		Status by November 2018	Source for status
	Warren	Established[a]	(Pretzman et al. 1990)
	Washington	Established[a]	(Pretzman et al. 1990)
	Wayne	Reported[a]	(Pretzman et al. 1990)
	Williams	Established[a]	(Pretzman et al. 1990)
	Wood	Reported[a]	(Mitcham et al. 2017)
	Wyandot	Established[a]	(Mitcham et al. 2017)
Oklahoma			
	Beckham	Reported	(Mitcham et al. 2017)
	Blaine	Reported	(Mitcham et al. 2017)
	Caddo	Established	(Mitcham et al. 2017)
	Cherokee	Established	USNTC
	Cleveland	Established	(Mitcham et al. 2017)
	Coal	Reported	(Mitcham et al. 2017)
	Comanche	Established	USNTC
	Cotton	Reported	(Mitcham et al. 2017)
	Custer	Reported	(Mitcham et al. 2017)
	Delaware	Reported	(Mitcham et al. 2017)
	Dewey	Reported	(Mitcham et al. 2017)
	Ellis	Reported	(Mitcham et al. 2017)
	Garfield	Established	(Mitcham et al. 2017)
	Garvin	Reported	(Mitcham et al. 2017)
	Grady	Established	(Mitcham et al. 2017)
	Grant	Reported	(Mitcham et al. 2017)
	Harmon	Reported	(Mitcham et al. 2017)
	Harper	Established	USNTC
	Hughes	Reported	(Mitcham et al. 2017)
	Jefferson	Reported	(Mitcham et al. 2017)
	Kingfisher	Reported	(Mitcham et al. 2017)
	Kiowa	Reported	(Mitcham et al. 2017)

State and county		Status by November 2018	Source for status
	Le Flore	Established	(Koch and Dunn 1980)
	Love	Reported	(Mitcham et al. 2017)
	Major	Reported	(Mitcham et al. 2017)
	McClain	Established	(Gage et al. 1992)
	Murray	Reported	(Noden et al. 2017)
	Muskogee	Reported	USNTC
	Nowata	Established	(Semtner and Hair 1975)
	Oklahoma	Established	(Barrett et al. 2014)
	Osage	Established	(Mitcham et al. 2017)
	Pawnee	Established	(Mitcham et al. 2017)
	Payne	Established	(Barrett et al. 2014)
	Pottawatomie	Reported	(Mitcham et al. 2017)
	Roger Mills	Reported	(Mitcham et al. 2017)
	Stephens	Reported	(Mitcham et al. 2017)
	Tulsa	Reported	USNTC
	Washington	Reported	(Mitcham et al. 2017)
	Washita	Established	NEON
	Woodward	Reported	(Mitcham et al. 2017)
Oregon			
	Baker	Established	USNTC
	Hood River	Reported	USNTC
	Jackson	Established	(Easton et al. 1977)
	Umatilla	Reported	USNTC
	Washington	Reported	USNTC
Pennsylvania			
	Adams	Established[a]	(Snetsinger et al. 1993)
	Allegheny	Reported[a]	(Snetsinger et al. 1993)
	Armstrong	Reported[a]	(Snetsinger et al. 1993)
	Beaver	Reported[a]	(Snetsinger et al. 1993)

State and county	Status by November 2018	Source for status
Bedford	Reported[a]	(Snetsinger et al. 1993)
Berks	Established[a]	(Snetsinger et al. 1993)
Blair	Reported[a]	(Snetsinger et al. 1993)
Bradford	Reported[a]	(Snetsinger et al. 1993)
Bucks	Established[a]	(Snetsinger et al. 1993)
Butler	Reported[a]	(Snetsinger et al. 1993)
Cambria	Reported[a]	(Snetsinger et al. 1993)
Carbon	Reported[a]	(Snetsinger et al. 1993)
Centre	Reported[a]	(Snetsinger et al. 1993)
Chester	Established[a]	(Snetsinger et al. 1993)
Clarion	Reported[a]	(Snetsinger et al. 1993)
Clearfield	Reported[a]	(Snetsinger et al. 1993)
Clinton	Reported[a]	(Snetsinger et al. 1993)
Columbia	Reported[a]	(Snetsinger et al. 1993)
Crawford	Reported[a]	(Snetsinger et al. 1993)
Cumberland	Reported[a]	(Snetsinger et al. 1993)
Dauphin	Established[a]	(Snetsinger et al. 1993)
Delaware	Established[a]	(Snetsinger et al. 1993)
Erie	Reported[a]	(Snetsinger et al. 1993)
Fayette	Reported[a]	(Snetsinger et al. 1993)
Forest	Reported[a]	(Snetsinger et al. 1993)
Franklin	Established[a]	(Snetsinger et al. 1993)
Fulton	Reported[a]	(Snetsinger et al. 1993)
Greene	Established[a]	(Snetsinger et al. 1993)

State and county	Status by November 2018	Source for status
Huntingdon	Reported[a]	(Snetsinger et al. 1993)
Indiana	Reported[a]	(Snetsinger et al. 1993)
Jefferson	Reported[a]	(Snetsinger et al. 1993)
Juniata	Reported[a]	(Snetsinger et al. 1993)
Lackawanna	Reported[a]	(Snetsinger et al. 1993)
Lancaster	Established[a]	(Snetsinger et al. 1993)
Luzerne	Reported[a]	(Snetsinger et al. 1993)
Lebanon	Reported[a]	(Snetsinger et al. 1993)
Lehigh	Reported[a]	(Snetsinger et al. 1993)
Luzerne	Reported[a]	(Snetsinger et al. 1993)
Lycoming	Reported[a]	(Snetsinger et al. 1993)
McKean	Reported[a]	(Snetsinger et al. 1993)
Mercer	Reported[a]	(Snetsinger et al. 1993)
Mifflin	Reported[a]	(Snetsinger et al. 1993)
Monroe	Reported[a]	(Snetsinger et al. 1993)
Montgomery	Established[a]	(Snetsinger et al. 1993)
Montour	Reported[a]	(Snetsinger et al. 1993)
Northampton	Reported[a]	(Snetsinger et al. 1993)
Northumberland	Reported[a]	(Snetsinger et al. 1993)
Perry	Reported[a]	(Snetsinger et al. 1993)
Philadelphia	Established[a]	(Snetsinger et al. 1993)
Pike	Established[a]	(Snetsinger et al. 1993)
Potter	Reported[a]	(Snetsinger et al. 1993)
Schuylkill	Reported[a]	(Snetsinger et al. 1993)

State and county	Status by November 2018	Source for status
Snyder	Reported[a]	(Snetsinger et al. 1993)
Somerset	Reported[a]	(Snetsinger et al. 1993)
Sullivan	Reported[a]	(Snetsinger et al. 1993)
Union	Reported[a]	(Snetsinger et al. 1993)
Venango	Reported[a]	(Snetsinger et al. 1993)
Warren	Reported[a]	(Snetsinger et al. 1993)
Washington	Established[a]	(Snetsinger et al. 1993)
Wayne	Reported[a]	(Snetsinger et al. 1993)
Westmoreland	Reported[a]	(Snetsinger et al. 1993)
Wyoming	Reported[a]	(Snetsinger et al. 1993)
York	Established[a]	(Snetsinger et al. 1993)
Rhode Island		
Newport	Established	(Mather and Mather 1990)
South Carolina		
Aiken	Reported	USNTC
Charleston	Established	(Burgdorfer et al. 1975)
Chester	Established	(Clark et al. 1998)
Georgetown	Established	(Clark et al. 1998)
Sumter	Established	(Clark et al. 1998)
South Dakota		
Brookings	Established	USNTC
Butte	Reported	(Easton 1983)
Clark	Reported	(Easton 1983)
Clay	Reported	(Easton 1983)
Codington	Reported	(Easton 1983)
Davison	Reported	(Easton 1983)

State and county	Status by November 2018	Source for status
Day	Established	USNTC
Deuel	Established	USNTC
Fall River	Reported	(Easton 1983)
Grant	Reported	(Easton 1983)
Gregory	Reported	(Easton 1983)
Haakon	Reported	USNTC
Hamlin	Reported	(Easton 1983)
Hand	Reported	(Easton 1983)
Hughes	Reported	(Easton 1983)
Jackson	Established	USNTC
Kingsbury	Reported	(Easton 1983)
Lawrence	Established	USNTC
Lincoln	Reported	(Easton 1983)
Marshall	Established	USNTC
Meade	Established	USNTC
Minnehaha	Reported	USNTC
Pennington	Reported	USNTC
Perkins	Reported	(Easton 1983)
Roberts	Established	USNTC
Shannon	Reported	(Easton 1983)
Spink	Reported	USNTC
Stanley	Reported	USNTC; (Easton 1983)
Union	Established	USNTC
Ziebach	Reported	USNTC; (Easton 1983)
Tennessee		
Anderson	Established	NEON
Blount	Established	(Cohen et al. 2010)
Bradley	Established	(Cohen et al. 2010)
Carroll	Reported	(Cohen et al. 2010)
Carter	Established	(Cohen et al. 2010)
Cheatham	Established	(Cohen et al. 2010)

State and county	Status by November 2018	Source for status
Chester	Reported	(Cohen et al. 2010)
Cumberland	Established	(Cohen et al. 2010)
Davidson	Established	(Durden and Wilson 1990, Cohen et al. 2010)
Decatur	Reported	(Cohen et al. 2010)
DeKalb	Established	(Cohen et al. 2010)
Dickson	Established	(Cohen et al. 2010)
Fayette	Established	(Mays et al. 2016, Pompo et al. 2016, Trout Fryxell et al. 2017)
Giles	Established	(Mays et al. 2016)
Greene	Established	(Cohen et al. 2010)
Hamilton	Established	(Cohen et al. 2010)
Hardeman	Established	(Mays et al. 2016)
Hardin	Reported	(Cohen et al. 2010)
Henry	Reported	(Cohen et al. 2010)
Humphreys	Reported	(Cohen et al. 2010)
Jefferson	Established	(Cohen et al. 2010)
Johnson	Reported	(Cohen et al. 2010)
Knox	Established	(Cohen et al. 2010)
Loudon	Established	(Cohen et al. 2010)
McMinn	Reported	(Cohen et al. 2010)
McNairy	Reported	(Cohen et al. 2010)
Madison	Established	(Cohen et al. 2010)
Monroe	Established	(Cohen et al. 2010)
Montgomery	Reported	(Cohen et al. 2010)
Morgan	Reported	(Cohen et al. 2010)
Perry	Reported	(Cohen et al. 2010)
Roane	Established	(Cohen et al. 2010)
Scott	Established	(Cohen et al. 2010)
Sevier	Established	(Cohen et al. 2010)
Shelby	Established	(McLean et al. 1985, Kollars 1993, 1996, Kollars and Ladine 1999, Kollars and Kengluecha 2001)
Smith	Reported	(Cohen et al. 2010)
Stewart	Established	(Cooney and Burgdorfer 1974, Zimmerman et al. 1987)

State and county		Status by November 2018	Source for status
	Sullivan	Established	(Cohen et al. 2010)
	Sumner	Established	(Cohen et al. 2010)
	Unicoi	Reported	(Cohen et al. 2010)
	Washington	Established	(Cohen et al. 2010)
	Weakley	Established	(Cohen et al. 2010)
	Williamson	Reported	(Cohen et al. 2010)
Texas			
	Angelina	Reported	USNTC
	Aransas	Reported	(Eads 1956)
	Bee	Established	USNTC; (Eads 1956)
	Bexar	Reported	USNTC; (Eads 1948)
	Brazos	Established	(Sanders et al. 2013)
	Cameron	Established	(Corn et al. 2016)
	Floyd	Reported	(Eads 1948)
	Frio	Reported	USNTC
	Hidalgo	Reported	USNTC
	Jackson	Reported	USNTC
	Jefferson	Reported	USNTC
	Jim Wells	Established	USNTC
	Johnson	Reported	USNTC
	Kenedy	Established	USNTC
	Kerr	Reported	USNTC
	Kleberg	Reported	USNTC
	Liberty	Reported	USNTC
	Live Oak	Reported	USNTC
	Mason	Reported	USNTC
	Milam	Reported	(Eads et al. 1956)
	Newton	Reported	(Sanders et al. 2013)
	Nueces	Reported	USNTC
	Refugio	Established	(Eads et al. 1956)
	San Patricio	Established	(Sanders et al. 2013)

State and county	Status by November 2018	Source for status
Shelby	Established	(Eads et al. 1956)
Travis	Established	(Eads et al. 1956)
Uvalde	Established	USNTC
Victoria	Established	USNTC
Webb	Reported	(Lin et al. 2005)
Wichita	Established	(Eads et al. 1956)
Wilbarger	Reported	(Eads 1948)
Willacy	Established	USNTC
Zavala	Reported	USNTC; (Eads et al. 1956)
Vermont		
Bennington	Reported	USNTC
Caledonia	Reported	Serra et al. 2013)
Orange	Reported	(Serra et al. 2013)
Virginia		
Accomack	Established	(Orr et al. 2013)
Clarke	Reported	NEON
Dinwiddie	Reported	USNTC
Fairfax	Established	(Orr et al. 2013, Henning et al. 2014)
Hanover	Established	(Sonenshine and Atwood 1967, Sonenshine 1979a)
Newport News	Established	(Miller et al. 2016)
Nottoway	Established	(Stein et al. 2008)
Prince George	Reported	USNTC
Prince William	Established	(Johnson et al. 2017)
Shenandoah	Reported	USNTC
Sussex	Established	USNTC
Warren	Established	NEON
Westmoreland	Established	USNTC
Washington		
Lincoln	Established	(Araya-Anchetta et al. 2013)
Whitman	Established	(Stout et al. 1971)
Yakima	Reported	(Stout et al. 1971)

State and county	Status by November 2018	Source for status
West Virginia		
Mason	Established	(Joy and Briscoe 1994)
Wisconsin		
Ashland	Reported	(Manville 1978)
Bayfield	Reported	(Manville 1978)
Douglas	Reported	USNTC
Iowa	Established	(Jackson and DeFoliart 1975)
Iron	Established	(Manville 1978)
Langlade	Reported	USNTC
Lincoln	Established	NEON
Oneida	Established	USNTC
Outagamie	Reported	USNTC
Price	Reported	NEON
Sawyer	Established	(Brackney et al. 2008)
Trempealeau	Reported	USNTC
Vernon	Reported	USNTC
Vilas	Reported	USNTC
Washburn	Established	(Brackney et al. 2008)
Wyoming		
Campbell	Reported	USNTC
Sheridan	Reported	USNTC

[a]Counties included using expanded inclusion criteria.