

Metropolitan Mosquito Control District
2019 *Ixodes scapularis* distribution study
report

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Metropolitan Mosquito Control District

Ixodes scapularis DISTRIBUTION STUDY

2019

Abstract

A black legged tick (*Ixodes scapularis*) distribution study designed to detect any changes in *Is* distribution over a many year period was conducted in the seven-county metropolitan area by the Metropolitan Mosquito Control District. Small mammal sampling was used to collect ticks from 100 wooded locations that have all been sampled since 1990 or 1991. Except for 2011, each year since 2007 we have collected *Is* from at least one site in all seven counties that comprise our service area. Our overall positive site total for 2019 was 63. While in eight of the past ten years we have tabulated positive site totals higher than 63, our positive site totals were lower than 63 in all years prior to 2010. Twenty-three of our positive sites in 2019 were tabulated from counties south of the Mississippi River (equal to 2018 and lower than 2014-2017). Overall, we collected a total of 826 *Is* removed from 1121 mammals for a season mean of .737 *Is* per mammal, the lowest tabulated since 2013 (.401). Since 2000 most years have had averages \geq .806, and the averages from 2014 – 2018 had ranged from 1.209 - 1.679. In 2019, 80% of our *Is* collections were obtained from our sites north of the Mississippi River. Our Washington County sites accounted for the majority (51%) of our 2019 collections, with the highest numbers collected in May Township. Anoka County accounted for another 27% of our total *Is* collections, with the highest numbers collected in Coon Rapids Township. Anoka County maintained the highest 1990-2019 overall season mean (1.162), followed by Washington County (1.039). Small mammal (Table 2) species diversity and collection success level in 2019 is comparable to past years, as *Peromyscus leucopus* was the predominant mammal species collected. While the immature tick species diversity appears comparable to past years, the yearly collection percentages of *Is* and *Dermaacentor variabilis* in Table 3 do show changes over time. In 2002 *Is* comprised 50% of our collections for the first time; *Is* has now comprised \geq 50% (70% in 2019) of our overall collections 15 times, compared to the 17 times (the last being in 2011) that *Dv* has comprised the majority. Not only has the average percentage of *Dv* collected yearly been reducing, it has been reducing at a more than 10% rate in roughly five year increments of time. As of July 2, 2019, the MN Department of Health (MDH) did not have 2019 tick-borne disease case totals prepared but there had been 950 Lyme and 496 human anaplasmosis cases in 2018. Despite what could turn out to be an off collection year in 2019, the risk of metro tick encounters is now higher than it used to be throughout our service area.

Introduction

In 1990 the Metropolitan Mosquito Control District initiated a Lyme Disease Tick Surveillance Program to determine the distribution and prevalence of *Is* and *Borrelia burgdorferi* within the Minneapolis- Saint Paul metropolitan area. District re-structuring in 1996 integrated the former tick surveillance program activities into the District's overall field processes. Small mammal trapping has been the primary sampling method used, with examination of road-killed mammals and flagging (dragging flannel cloth along vegetation) each used as secondary collection methods in the past.

A total of 545 sites were sampled from 1990 through 1992, including 100 sites that had been selected for repetitive sampling prior to the 1991 or 1992 field season. Baseline *Is* distribution data for our area was determined from the 1990 and 1991 studies with most of the ticks collected north of the Mississippi River in Anoka, Washington, and northern Ramsey counties. The 1992 study was designed to inspect areas that had not been sampled as intensely in the past, with emphasis on locations south and west of the Mississippi River, but the majority of *Is* collections continued to be obtained in the northeastern counties.

Since 1993, our distribution study has focused on the re-sampling of 100 sites to detect any changes in *Is* distribution over time. Seventy-five of these sites were re-sampled beginning in 1991 and were selected from the previous study based on three criteria: representative habitat of an area, locations that were unlikely to be developed, and areas where small mammal collections had been sufficient in the past. An additional twenty-five sites were selected from Dakota, Hennepin, Scott, and Carver counties in 1992 to increase our data collections south of the Mississippi River. We plan to monitor these sites indefinitely to track areas that have shown potential *Is* range expansion.

Periodically, additional sites have been sampled:

From 1995-1997 two additional sites were sampled; section 7 of New Market Township in Scott County (where a single adult *Is* tick had been collected in 1995) and section 19 of West Saint Paul Township in Dakota County (Dodge Nature Center- to foster improved relations through providing a general risk assessment). Sampling at these two locations was discontinued in 1998 since zero *Is* had been collected in either location in the three-year period.

From 2007-2009 several park sites were sampled and results compared to our 1990 results. Although we are still sampling a limited number of parks today, in 1990 a larger number of our sites had been selected inside metropolitan parks to provide a primitive assessment of park user risk to potential *Is* encounters. Included were Joy Park in North Saint Paul (62-08-01) and a location near Pigs Eye Lake in St Paul (62-13-02). In 1990 *Is* had not been collected at either park in three rounds of sampling. We re-sampled both parks, for two rounds only, as extra sites in 2007 and 2008. The 2007-08 Pigs Eye site was moved over one section, to section 3 while the 2007-08 Joy Park site was in the same (square mile) section, but east of our 1990 location. Unlike 1990, we detected *Is* in both parks in both years. In 2009, Joy Park and a previously unsampled Ramsey County location (Priory Preserve (62-04-24)), were both sampled for three rounds. *Is* was found again at Joy Park. Zero mammals were collected at Priory Preserve.

In 2010 Joy Park and Priory Reserve were sampled for two rounds and a new site, section 18 of Laketown Township in Carver County (a single adult *Is* had been collected in late July 2009), was sampled for all three rounds. *Is* was not found at Joy Park in 2010 but was detected at both Priory Reserve and Laketown Township.

Materials and Methods

Of the 100 repeat sites, 56 are located north of the Mississippi River in Anoka (28 sites), Washington (25 sites), and Ramsey (3 sites) counties. The 44 repeat sites located south of the Mississippi River are distributed throughout the counties of Dakota (15 sites), Hennepin (14 sites), Scott (8 sites), and Carver (7 sites).

Sampling was initiated on April 22, 2019 and ended on October 24, 2019. Small mammal trapping was used as the primary sampling method. As in past years, the twenty-seven week study was divided into three nine-week sampling periods, and all sites were sampled for twenty-one trap nights (7 traps x 3 consecutive nights) per period. Weeks of site visitation were randomly selected within each sampling period. <http://www.earth-pics.com/gallery/10most/the-most-amazing-ice-formations>

One three-hundred foot transect was established at each sampling location and Sherman live traps (H. B. Sherman Traps, Inc., Tallahassee, Fla.), baited with peanut butter and oats, were placed along these transects at fifty foot intervals. We euthanized all small mammals caught in the traps, removed any ticks found, and stored the ticks in alcohol for later identification.

Results

➤ 2019 Study (Repeat Sites):

Except for 2011, since 2007 and again in 2019 we collected *Is* from at least one site in all seven counties that comprise our service area. Specifically, we found at least one *Is* at 63 of our 100 sampling sites, with 40 of these positive sites located north of the Mississippi River in Anoka (17 sites positive of 28 sites sampled), Washington (20 sites positive of 25 sites sampled), and Ramsey (3 sites positive of 3 sites sampled) counties. Twenty-three additional positive sites were detected south of the river in Dakota (7), Hennepin (7), Scott (6), and Carver (3) counties (Figure 5A).

Overall, 1121 mammals (Figure 1 and 2019 results in Table 2) were inspected: 461 from north of the Mississippi River and 660 from south of the river. A total of 826 *Is* (Figure 2 and 2019 results in Table 3) were collected from them. In all, 80% of our 2019 *Is* collections were obtained from our sites north of the Mississippi River. Our Washington County sites accounted for the majority (51%) of our 2019 collections, with the highest numbers collected in May (170L; 39N) township. Anoka County accounted for another 27% of our total *Is* collections, with the highest numbers collected in Coon Rapids township (54L; 68N).

The overall season mean number of *Is* collected per mammal in 2019 was .737 (larvae: .575, nymphs: .162). The mean increases to 1.084 (larvae: .846, nymphs: .238) when all sites negative for *Is* are excluded (see 2019 results in Figure 6). The highest average number of *Is* per mammal was calculated for Washington (1.584) and Anoka (1.295) counties (see 2019 results in Figure 3). North of the Mississippi River, townships in Washington County averaging ≥ 1.0 *Is* per mammal in 2019 were Hugo (4.300), Afton (3.810), May (2.488), Cottage Grove (1.444), and Oakdale/Lake Elmo (1.200), in Anoka County, Coon Rapids (4.519), East Bethel (2.333), Andover (1.417), and Linwood (1.318), and

in Ramsey County, Shoreview (1.455). Averaging $\geq .500$ *Is* per mammal north of the Mississippi River in 2019 was New Scandia (.500) of Washington County, and Blaine (.940), Saint Francis (.857) and Ham Lake (.500) of Anoka County. South¹ of the Mississippi River (no figure), townships maintaining averages $\geq .500$ *Is* per mammal were, in Dakota, Burnsville (.632) and Hastings (.632) townships, in Hennepin, Hassan (.500) township, and in Scott County, Saint Lawrence (2.44) and Blakeley (.750) townships (Figure 4).

➤ **Compiled Results (Repeat Sites) from 1990 – 2019 or 1991 - 2019:**

The 1990-2019 mean number of *Is* collected per mammal is .674, with averages in some townships south of the Mississippi River becoming comparable in recent years to the consistent higher averages many of the townships from north of the river have maintained. We have tabulated an overall yearly average of > 1.0 *Is* per mammal six times; in 2005 (1.180), 2014 (1.213), 2015 (1.450), 2016 (1.679), 2017 (1.209) and 2018 (1.498) (Figures 3 and 6). Washington County maintained the highest yearly county season means from 1990-1997, 2010, 2012 and 2019, while Anoka County maintained the highest yearly county season means from 1998-2009, 2011, and 2014-2018. In 2013, Ramsey County had the highest county season mean (.842), for the first time (Figure 3). Anoka County's compiled 1990-2019 overall season mean is 1.162 and is followed by Washington County (1.039). The 1990-2019 township averages (all > 1.0), north of the Mississippi River include May, Hugo, Afton, Grant, and New Scandia of Washington County and Coon Rapids, Blaine, Ham Lake, Saint Francis, East Bethel, and Linwood of Anoka County, while the averages for Oak Grove, Andover, and Lino Lakes of Anoka County and Lakeland, Lake Elmo, and Cottage Grove townships of Washington County are $> .500$ *Is* per mammal (Figures 4A and B—inserts on Figure 4). Shoreview of Ramsey County maintained a compiled 1990-2019 average of 1.053. In compiled results from south of the Mississippi River (1991 – 2019), Burnsville (2.390), Inver Grove Heights (1.029), Vermillion (.881) and Hastings (.643) townships of Dakota County, and Bloomington township (.635) of Hennepin County maintained 1991-2019 averages $> .500$ *Is* per mammal² (no figure).

Is status at the 100 repeat sampling locations is shown on Figure 5. The status has changed at 96 of the sites since 1990 or 1991 (see 2019 results in Table 1). While the number of sites where *Is* is detected every year has decreased since 1992, we have detected *Is* at all but three of our sampling locations since 2016 (Table 1).

Our positive sites have been primarily located north of the Mississippi River in Anoka and Washington counties, with one consistently positive Ramsey County site (northern Shoreview Township). We tabulated two positive Ramsey County sites (both of our Shoreview Township sites) for the first time in 2003, and they were positive for *Is* again in 2005, 2006, 2008, 2010, 2013-2017, and 2019. Our Roseville site has been positive since 2013. South of the river from 1990 – 1999 it had been typical to tabulate a maximum total of 3-4 positive sites each season. Except for 1991 when several *Is* were collected at one site each in Scott and Carver counties, positive sites were located only in Dakota County from 1990 through 1997.

In 1998 we first detected *Is* in Hennepin and Scott counties³ and in 2000 we began to tabulate more sites south of the river than in past years. In 2014 we first tabulated 30 positive sites south of the river

¹ Prior to 2005, township averages south of the river were not tabulated. See footnote 1 (and the report text) in the 2005 report for detailed yearly averages for positive townships south of the Mississippi River through 2005. In brief, Inver Grove Heights Township first averaged $> .500$ in 1998 while Vermillion Township first averaged $> .500$ in 1991. 2005 was the first year that Hassan Township (Hennepin County) had an average $\geq .500$.

² Inver Grove Heights Township has maintained a compiled 1991-current year average of $> .500$ *Is* per mammal since 1999 while Vermillion's first compiled 1991-current year average $> .500$ *Is* per mammal occurred in 2004.

³ *Is* was collected previously in Hennepin County in a collaborative study with Dr. R. Johnson of the University of Minnesota and in very small numbers in Scott and Carver counties (one site each) in our 1991 study effort. In 1995 District staff performing pest mosquito activities inadvertently found a single *Is* adult tick in Scott County's New Market Township but no additional *Is* were detected there in a 3 year sampling effort. Staff or the public have continued to occasionally turn in adult *Is* from Scott County, especially from New Market Township, since 1995.

and we tabulated numbers equal or close to that in 2015 (30), 2016 (29), and 2017 (30). In 2019 (and 2018) we tabulated 23 positive sites south of the river (Table 1A).

The total number of ticks collected in 2019 (*Dv*, *Is*, and *Ixodes muris* combined) was 1,164, which is lower than the 1993-2019 average of 1600 ticks collected (Table 3). As Figures 3 and 6 show, our 2019 overall season mean of .737 *Is* per mammal is the lowest tabulated since 2013 (.401). Since 2000, except for 2003, 2006, 2008, 2011 and 2013 (range .389 to .644), the yearly averages have all been \geq .806.

Small mammal (Table 2) species diversity and collection success level in 2019 is comparable to past years. *P. leucopus* consistently has been the predominant mammal species collected each year, with some variability in the total percentages collected⁴ (Figure 1 and Table 2). Our compiled average small mammal collection success level per site for 1990 through 2019 is 12.37 (1991-2019 average of 11.39 for 100 repeat sites only), with results ranging from 2013's low of 5.96 mammals collected per site to the high of 20.61 (23.54 at the 100 repeat sites only) in 1991. Therefore, 2019's average number of mammals collected per site (11.21) is a typical yearly small mammal collection total (Table 2).

While the immature tick species diversity appears comparable to past years, the yearly collection percentages of *Is* and *Dv* in Table 3 do show changes over time. Starting in 2002 and including 2019, *Is* has comprised \geq 50% of our overall collections 15 times, compared to the 17 times (including for the first 12 years of this study) that *Dv* has comprised the majority. The last time *Dv* was the majority of our overall collections was in 2011. In 2019 *Is* comprised 70% of our overall collections, lower than 2018's 80% but still a high percentage; there have been only seven years with percentages \geq 70%, including 2019. The percentages of *Dv* collected yearly trends downward over time. In fact, excluding 1990-1992 which had more sampling sites and more sites in then known *Dv* habitat, the average percentage of *Dv* has been reducing at a more than 10% rate in roughly five year increments (1993-1997 an average of 74% of overall collections; 1998-2003, 58% of overall collections; 2004-2009, 49% of overall collections; 2010-2014, 34% of overall collections; 2015-2019, 22% of overall collections).

Discussion

Is populations are now established throughout our seven-county service area. Although our study was not designed to specifically answer the question of tick establishment, we feel that our relative *Is* density estimates are accurate enough for a general risk assessment. While it remains our view that the greatest Lyme disease risk continues to occur in the northern metropolitan area⁵, greater *Is* exposure opportunities and therefore higher tick-borne disease risk now occurs throughout our service area.

While our 2019 overall season mean of .737 *Is* per mammal is lower than the averages we have come to expect since 2000 (most season means have been \geq .806), the 2019 tabulation of .737 is generally within range of the .806 tabulated average. However, compared with the averages from 2014 – 2018 (range 1.209-1.679) it is definitely lower. We have had other off years before now (2003, 2006, 2008, 2011 and 2013 ranged from .389 to .644) so a few more years of data collection should clarify things as to an off year for 2019 or the beginning of a downward trend.

Likewise, and as in 2018 (64 positive sites), we tabulated a seemingly low number of positive sites in 2019 (63). As shown in Figure 3, our yearly positive site totals have been lower than 63 only twice in the last 10 years (2011 (55) and 2013 (43)). Our first positive site total in the 70's had been in 2010

⁴see the discussion sections in the 1993 (*Is* population estimates) and 1994 (graph handout-mammal density equality across sites) *Is* study report

⁵Yearly metro human exposure case totals vary from 1 case per year occurring sporadically in Scott and Carver counties to double-digit amounts (typically teens to twenties) for both Anoka and Washington counties (personal communication MN Dept Health).

and our first positive site total in the 80's in 2015. However, when comparing 2019's 63 to all of our positive site totals over the years, it is a higher total than we had tabulated for 22 of the 30 years of this study. Perhaps in a few years we will find that 2014 (75), 2015 (81), and 2016 (82) are the outliers.

While our focus remains on *I.s* and its disease potential, we do find it interesting that not only do the percentages of *D.v* collected yearly in Table 3 trend downward over time, our collection rates of *D.v* have been reducing at a more than 10% rate that seems to stabilize in roughly five year increments before reducing another 10% or more. We are not sure what to make of this observation. All we do know is that we are not sampling in prime *D.v* habitat but in prime *I.s* habitat, which *I.s* seems to be taking full advantage of and seemingly outcompeting *D.v* there.

Minnesota human tick-borne disease statewide case totals tabulated by the MDH began to rise in 2000. The median number of Lyme cases from 2000 to 2008 was 913 (range 463 - 1,239) and from 2009 - 2017 was 1,203 (range 896 - 1,431), while the median number of human anaplasmosis cases from 2000 - 2009 was 163 (range 76-322) and from 2010-2017 was 633 (range 448-788). Comparatively, statewide Lyme case totals from 1992-1999 had been roughly 250 Lyme cases per year, and statewide HA cases from 1997 to 1999 had been roughly 15 HA cases per year. Case data for 2019 as provided by the Minnesota Department of Health (MDH) is not yet available (as of July 1, 2019) but in 2018 there had been 950 Lyme and 496 human anaplasmosis (HA) cases, both of which were down from 2017.

During the time the MDH had been separating metro residents from people who reside elsewhere in the state for their statewide data tallies, they had consistently documented that metro residents comprised roughly half of the Lyme cases tallied⁶ in their state-wide and metro-wide data. And, although HA had been detected in MMCD collaborative research in metro-collected small mammals beginning in 1995⁷, locally acquired human HA cases were not documented by MDH until 2000. From 2000 – 2007 the MDH had typically tabulated a few metro-exposed HA cases each year (range 0-9).

Metro residents north of the Mississippi River have been used to encounters with *I.s* but south of the river these encounters changed over time from extremely infrequent to commonplace. The risk of metro tick encounters is higher than it used to be throughout our service area and is based both on our higher collections of *I.s* in recent years compared to the early years as well as that we are collecting ticks from a broader geographic area now than in years past.

⁶Slide 37 www.health.state.mn.us/divs/idepc/diseases/lyme/lymeslide.ppt CHANGE TO 7

⁷Several serology studies have been performed since 1995 using both distribution-study collected small mammals and small mammals collected at different sites. A map showing the results of our 1995 and 1997 efforts is available on our website (http://www.mmcd.org/tick_links.html). The 1995 work has been published--Walls, J. J., B. Greig, et al. (1997). "Natural Infection of Small Mammal Species in Minnesota with the Agent of Human Granulocytic Ehrlichiosis." *Journal of Clinical Microbiology* **35**(4): 853-855. Additional unpublished studies have been performed in collaboration with Dr. Russell Johnson, UM Microbiologist. Serology results of the later distribution study serology efforts are similar overall to the 1995 and 1997 work shown on the website map.

ADDITIONAL UPDATES/RESEARCH:

STUDIES/PROJECT UPDATES AND PLANS FOR 2020.

- *Ixodes scapularis* distribution study (sites unchanged from 1993).
- **Publication in progress.** In 2014 MMCD had provided *I. scapularis* nymphs from 1990 - 2014 to Steve Bennett (UM-St Paul), for testing. Steve is preparing a paper for publication. His dissertation was titled “The Complex Eco-Epidemiology of Tick Borne Disease: Ticks, Hosts and Pathobiomes in an Urbanizing Environment”.

AMBLYOMMA AMERICANUM

Aa (lone star tick) records are significant because these ticks vector human monocytic ehrlichiosis, they are an aggressive human biter, and their range is known to be moving northward. Though found here since 1990 on a rare, sporadic basis, Minnesota is not within their historic range. In 2009 there were several *Aa* collections in one year (one adult, submitted to the MDH, one nymph, submitted to MMCD); an unusual event. This trend continued in 2010, with *Aa* submitted to MMCD from Eagan, Mound, and the Orono/Lake Minnetonka areas of the metro. Either agency has continued to receive and identify *Aa* on a yearly basis, as shown in Table 4.

Table 4. *Amblyomma americanum* collections by MMCD and the MN Dept Health, 2009 -2019.

Year	Stage and sex	Location	Agency
2009	1 female	?	MDH
	1 nymph	?	MMCD
2010	3 females	Eagan, Mound, Orono/Lk Mtka area	MMCD
2011	3 females	Shakopee, Lindstrom, Hennepin Co.	MDH
2012	3 females	Eden Prairie or Burnsville, Bloomington, Rice Co.	MDH
2013	3 females	Afton, Scandia, Western WI- sent to WDH	MMCD
2014	1 female	Zumbrota	MDH
2015	1 male, 1 nymph	Elk River area	MMCD
	1 female	? – collected by Jordan dog groomer	
2016	2 nymphs	Florida travel history	MMCD
	3 females (pictures)	Scott Co., Ramsey Co., on a dog – loc ?	MDH
	2 females (reported)	Wabasha Co., Dakota Co.	MDH
2017	1 male (dragging) May 6	Cold Spring (Stearns Co.)	MDH
	1 female (picture)	Ottertail Co. found on child	
	1 female (reported) June 27	Chippewa Co	
	1 female July 6	Stillwater, Washington Co.	
	1 female July 7	Golden Valley, Hennepin Co.	
2018	1 adult (reported) before June 29	Itasca State Park	MDH
	1 female (dragging) June 29	Near same area as above tick, at Itasca State Park	
2019	1 female July 12	Shakopee (1 mi from PetSmart)	MMCD
	1 female roughly July 16	Lives in Wayzata, found right after Woodbury	MDH
TOTAL	27 female, 2 male, 4 nymph 1 unknown adult	34 <i>Amblyomma americanum</i> 2009-2019	

HAEMAPHYSALIS LONGICORNIS

The Asian longhorned tick (*H. longicornus*, also known as the bush tick/cattle tick) was first detected in New Jersey in the fall of 2017 and is now known to have been in the United States since at least 2010. It has been found mostly on the eastern seaboard but has been found in Arkansas, too. It has the potential to spread various diseases. Its principle host is cattle, and in the United States is known to have fed on domestic animals including cattle, sheep, goats, horses, and wildlife including raccoon, opossum, and deer. It has the potential to feed on humans as well. There are several ways this tick species can reproduce, and the type introduced into the U.S. is parthenogenetic. Therefore, an introduction of a single female tick into an area could potentially cause it to become established.

There is some question as to temperatures and survivability of this parthenogenetic form of tick in Minnesota. The lowest temperatures that the parthenogenetic version is known to be able to withstand is 14°F. Whether it can survive in lower temperatures is unknown. Higher temperatures (≥ 81 °F – 86°F) are detrimental to egg development.

MMCD is in a good position to detect introductions of *Hl*. While it seems that our tick surveillance is not as likely to pick up the immature stages, we have a lot of staff walking around in nature on a daily basis, and our staff turns in any unusual adult ticks for identification. We also have had our tick identification service in place for many years and will continue to utilize Facebook to keep the public informed and to enlist their help to turn in unusual ticks.

We are partnering with other Minnesota agencies, including the MDH. All agencies will keep each other informed of any Asian longhorned ticks found, and all ticks will be sent to Dr. Ulrike Munderloh, UM – St Paul, for confirmation of identifications.

No *Hl* are known to have been introduced into Minnesota since our statewide partnership began in the spring of 2018.

POSTING AT DOG PARKS.

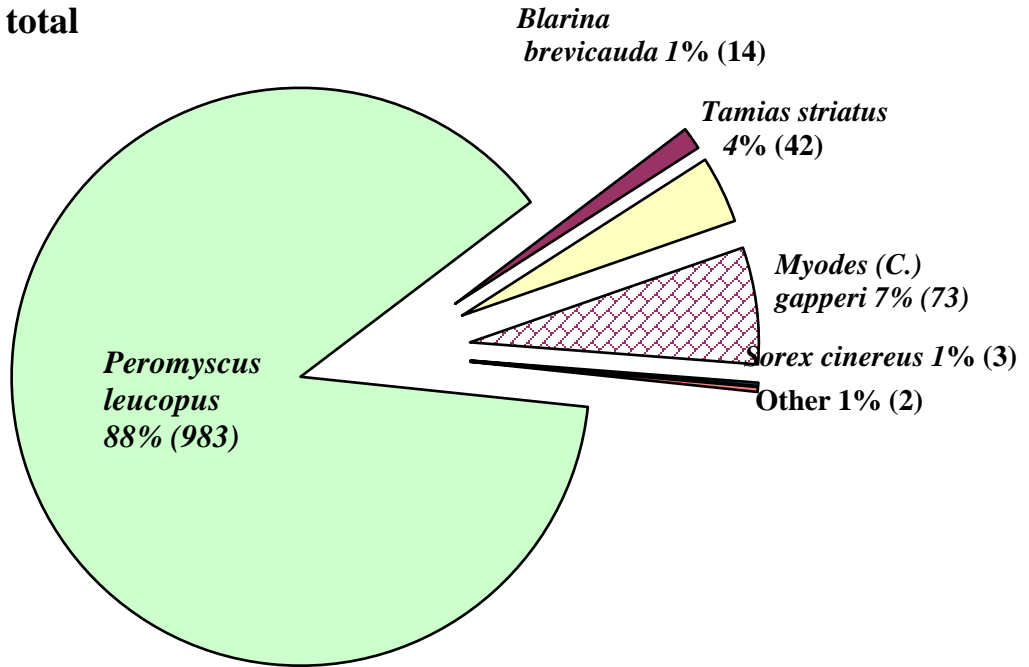
Since the initial suggestion of the Technical Advisory Board (TAB) in 2010, we have visited dog parks and vet offices as part of our outreach. Signs have been posted in at least 21 parks with additional signs posted in active dog walking areas. In 2019 we had posted a total of 41 signs at over 36 locations throughout the metro with most signs removed in winter. Signs were re-posted in spring 2019.

DISTRIBUTING MATERIALS TO TARGETED AREAS

In 2019 brochures, tick cards, double-sided lone star/Asian longhorned tick cards, and/or posters were dropped at roughly 292 locations (city halls, libraries, schools, child care centers, retail establishments, vet clinics, parks) across the metro as well as distributed at fair booths and city events, with many more mailed upon request. We began materials distribution in spring 2019.

**Small Mammals Collected
2019: 1121 total**

Figure 1



**Ticks, by Species and Stage,
Removed from Small Mammals
2019: 1,164 total**

Figure 2

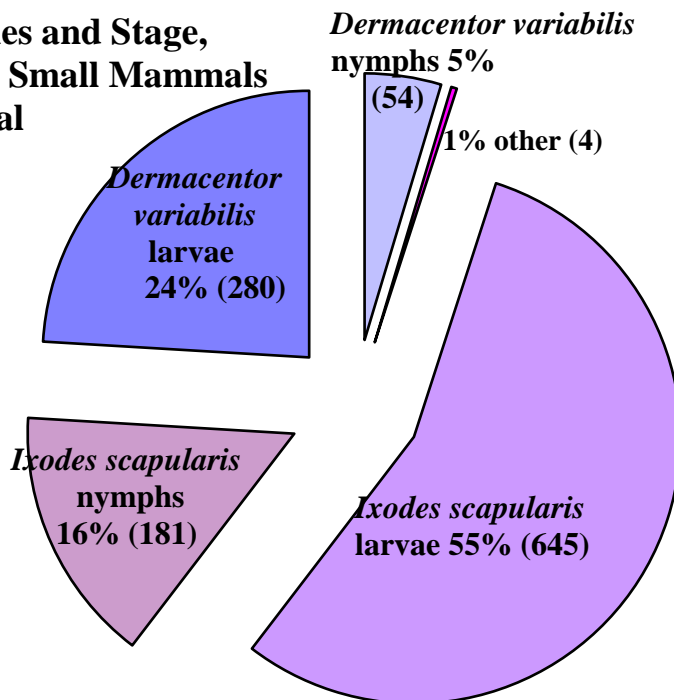


Figure 3

Average number of *I. scapularis* collected per mammal at 100 sampling locations in Anoka, Washington, and Ramsey counties: 1990 - 2019
(white box shows the total number of sites where at least one *I. scapularis* was found: by year)

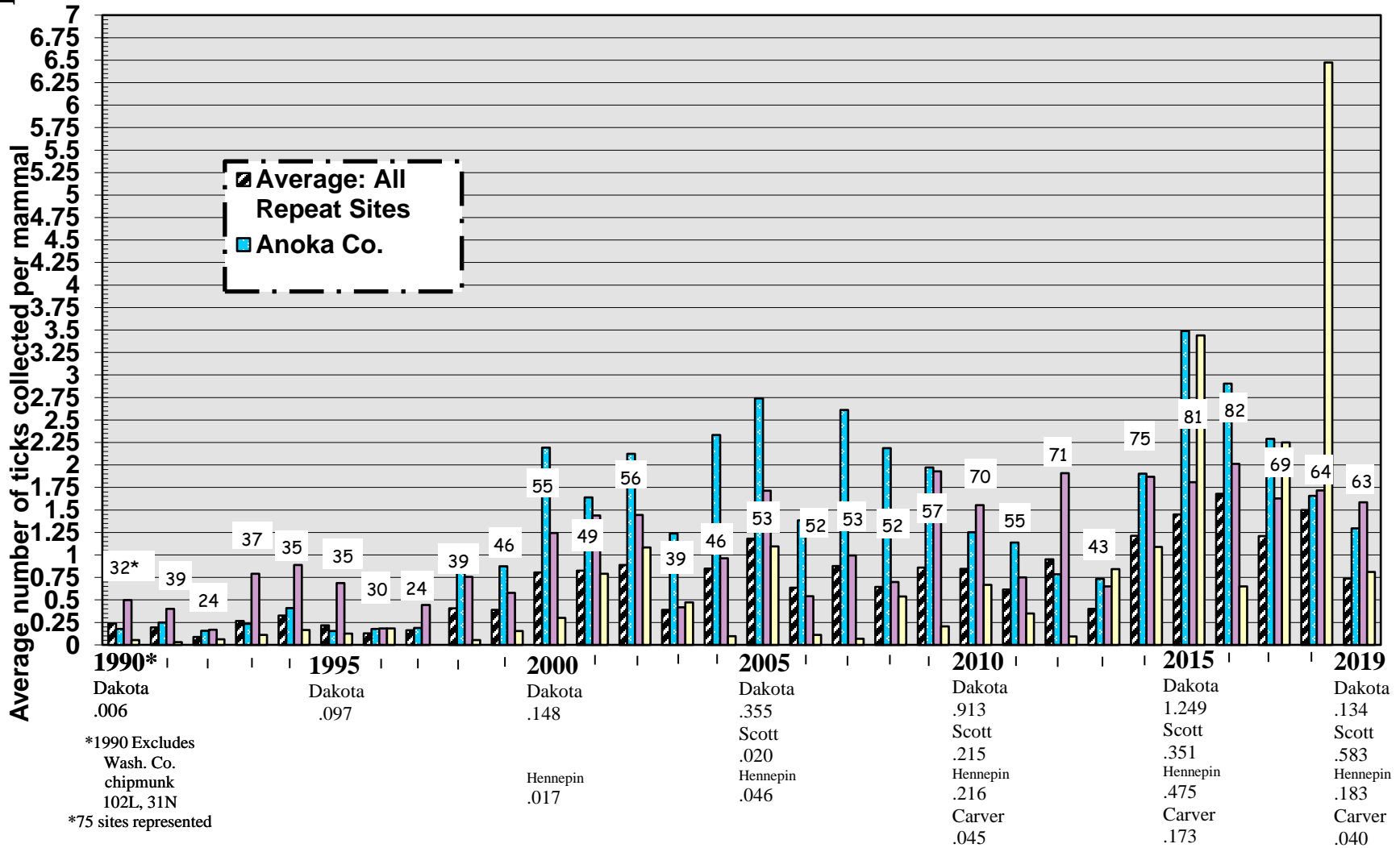
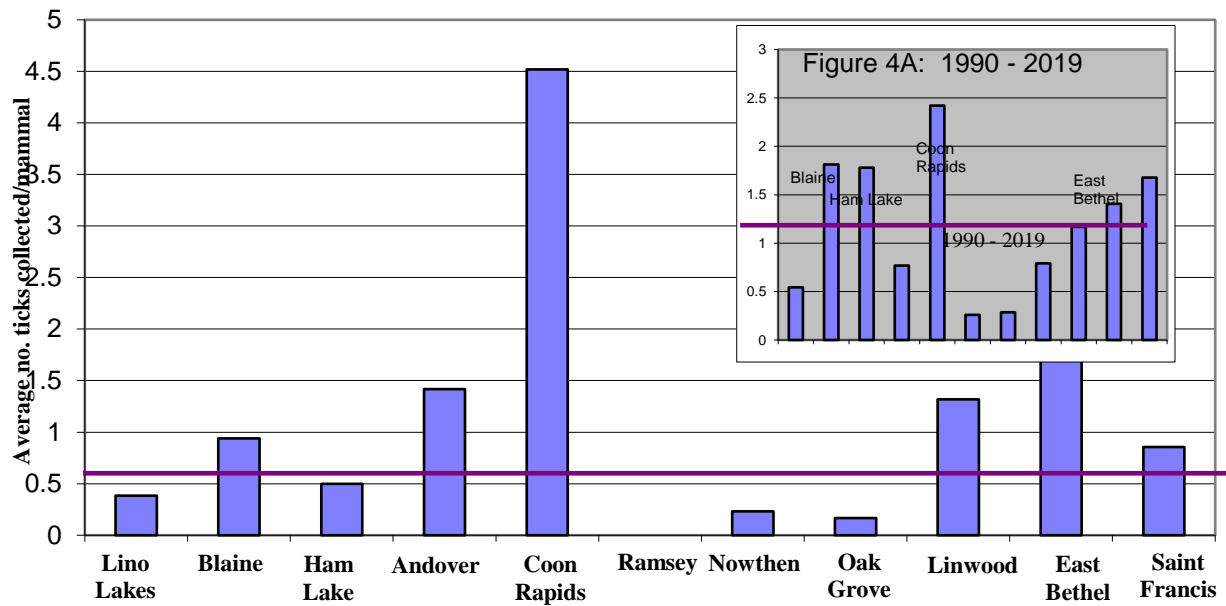


Figure 4

Average number of *I. scapularis* collected per mammal in Anoka county (by township): 2019 results



Average number of *I. scapularis* collected per mammal in Washington county (by township): 2019 results

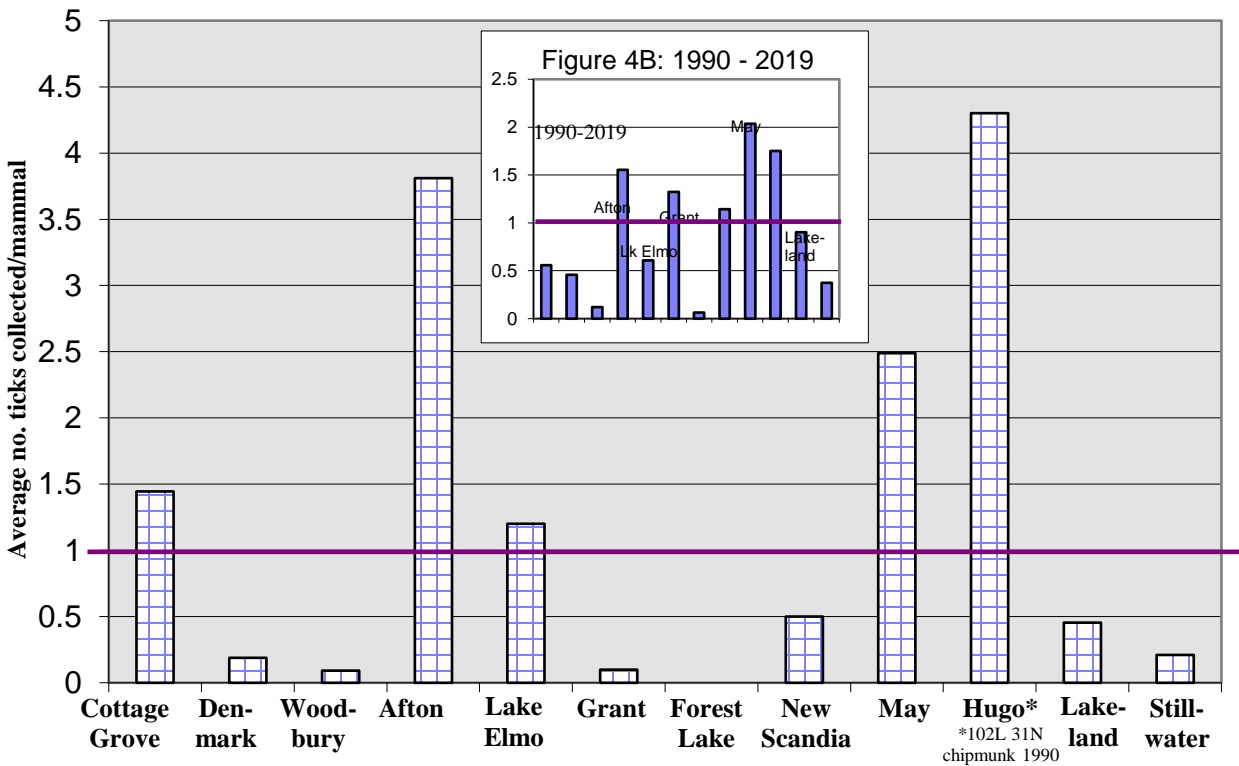
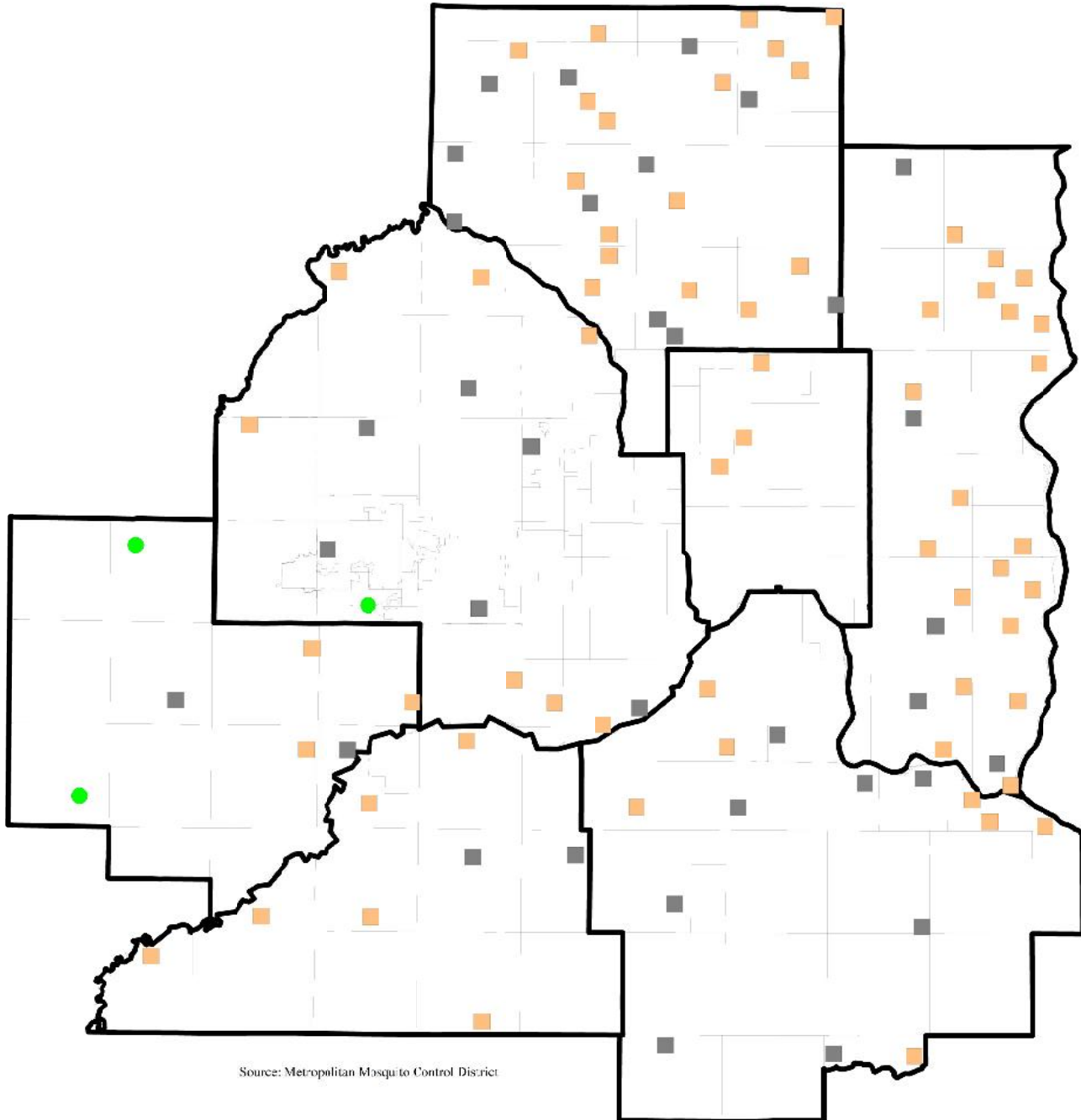


Figure 5A

Ixodes scapularis Presence/Absence 2019
present if at least one Is was detected during the year



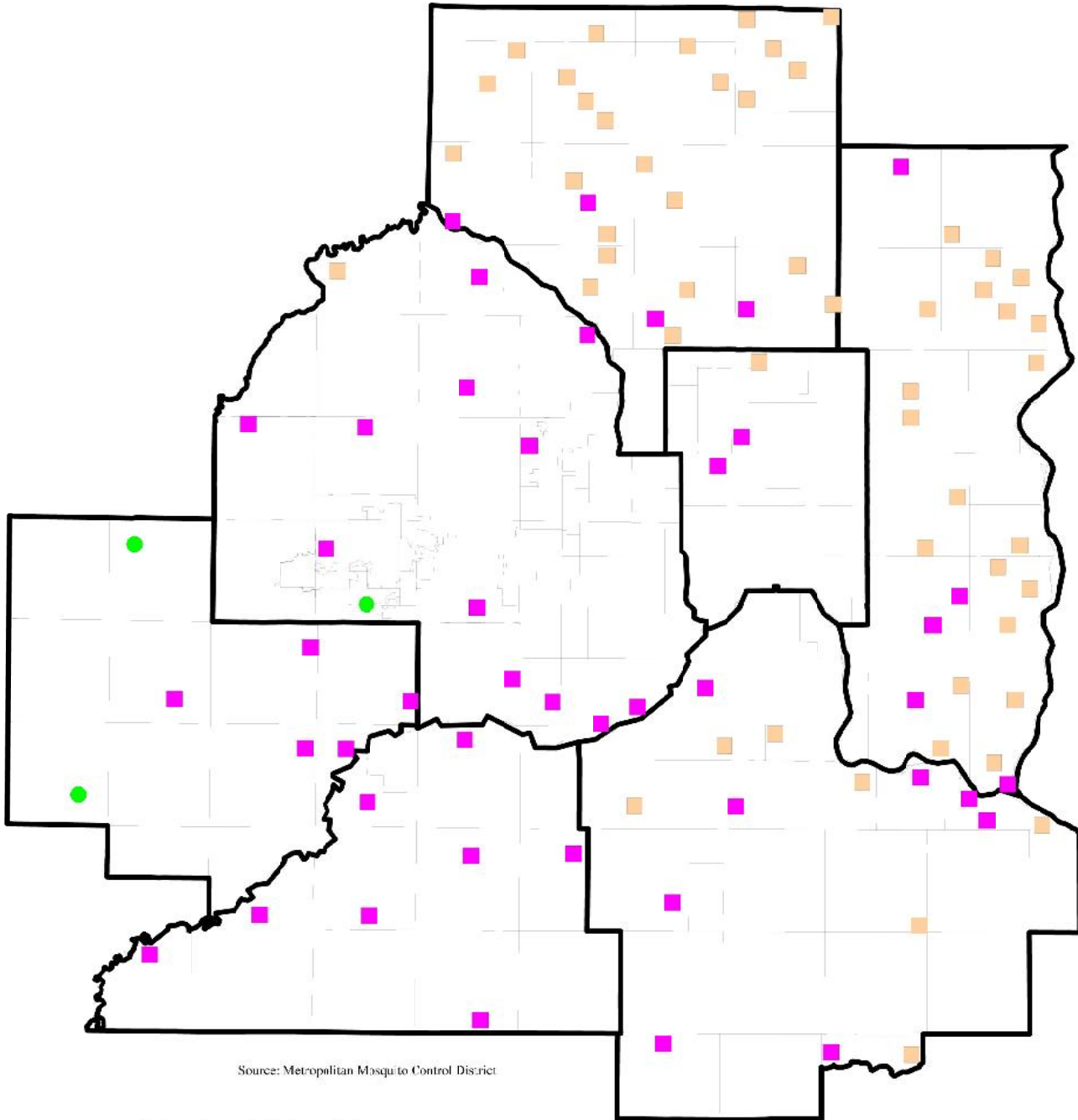
Status 2019

- present (63)
- absent this year (34)
- not found 1990-2019 (3)

*2019 Ixodes scapularis distribution study report
Metropolitan Mosquito Control District*

Figure 5

Ixodes scapularis Presence/Absence: 1990-2019
present if at least one Is was detected during the year



Source: Metropolitan Mosquito Control District

- At least one tick found during:
- all/most years (53)
 - at least one year (44)

Figure 6

Average number of *I. scapularis* collected per mammal at 100 repeat sampling locations 1990-2019 overall vs. sites where at least one *I. scapularis* was collected (positive sites)

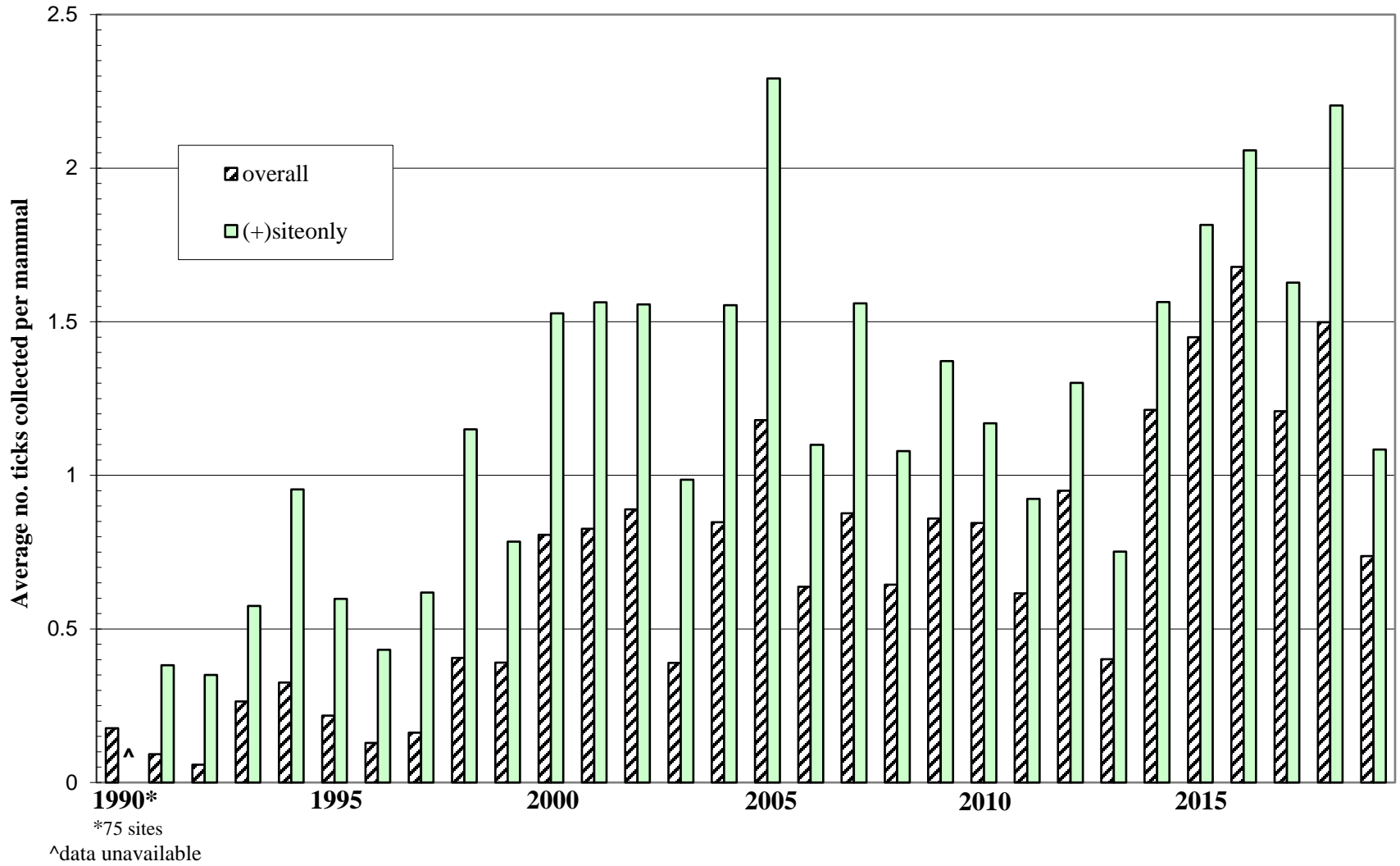


Table 1: Comparison of *I. scapularis* Presence/Absence Status at 100 Repeat Sampling Locations

	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2013	2014	2015	2016	2017	2018	2019
No. sites changing status	26	38	47	58	61	69	75	78	81	88	91	92	94	95	96	96	96	96
Ticks found:																		
all years	21	17	11	5	5	4	1	1	1	1	1	1	1	1	1	1	1	1
most years	5	15	19	27	31	35	38	41	42	44	45	45	45	48	45	51	50	52
least	21	23	28	31	30	34	37	37	39	44	46	47	49	47	51	45	46	44
(not found)	53	45	42	37	34	27	24	21	18	11	8	7	5	4	3	3	3	3

Table 1A: Number of Sites South of the Mississippi River Positive for *I. scapularis*

	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2013	2014	2015	2016	2017	2018	2019
Total sites south of river	*1	2	4	4	7	12	9	12	19	24	27	15	30	30	29	30	23	23
By county:																		
Dakota	*1	2	4	2	6	8	8	9	12	10	13	9	11	13	11	12	9	7
Hennepin	*0	0	0	1	1	3	0	2	3	6	7	4	8	8	9	7	8	7
Scott	*0	0	0	1	0	1	1	1	2	6	4	1	7	6	7	8	5	6
Carver	*0	0	0	0	0	0	0	0	2	2	3	1	4	3	2	3	1	3

*This count includes only our current site network. However, despite our intensive 1992 effort, the overall total was only 2 (both Dakota County).

Table 2. Numbers and Percentages of Small Mammals Collected by Year

Year	No. sites	Total mammals collected	Avg collected per site and [100 repeat sites only]	<i>Peromyscus leucopus</i> percent (n)	<i>Tamias striatus</i> percent (n)	<i>Myodes (Clethrionomys) gapperi</i> percent (n)	<i>Blarina brevicauda</i> percent (n)	Other* percent (n)
^a 1990	250	3651	14.6 [17.15 @75 sites]	80% (2921)	6% (224)	7% (240)	4% (155)	3% (111)
1991	270	5566	20.61 [23.54]	77% (4308)	7% (395)	5% (264)	7% (402)	4% (197)
1992	200	2544	12.72 [12.68]	71% (1804)	9% (223)	4% (103)	13% (329)	3% (85)
1993	100	1543	[15.43]	81% (1243)	4% (69)	7% (101)	7% (107)	1% (23)
1994	100	1672	[16.72]	78% (1309)	10% (171)	5% (79)	5% (76)	2% (37)
1995	100	1406	[14.06]	79% (1114)	11% (156)	4% (56)	4% (61)	1% (19)
1996	100	791	[7.91]	79% (628)	11% (84)	3.5% (29)	3.5% (28)	3% (22)
1997	100	728	[7.28]	71% (515)	13% (98)	3% (24)	10% (71)	3% (20)
1998	100	1246	[12.46]	84% (1041)	4% (51)	3% (42)	6% (72)	3% (40)
1999	100	1627	[16.27]	85% (1376)	7% (108)	3% (46)	4% (63)	2% (34)
2000	100	1173	[11.73]	83% (968)	7% (86)	5% (55)	2% (28)	3% (36)
2001	100	897	[8.97]	80% (719)	6% (58)	7% (63)	4% (39)	2% (18)
2002	100	1236	[12.36]	87% (1074)	6% (73)	3% (42)	2% (27)	2% (20)
2003	100	1226	[12.26]	88% (1081)	6% (72)	3% (36)	1% (16)	2% (21)
2004	100	1152	[11.52]	87% (1007)	6% (71)	3% (40)	2% (20)	1% (14)
2005	100	965	[9.65]	87% (841)	6% (54)	4% (37)	2% (16)	2% (17)
2006	100	1241	[12.41]	85% (1056)	4% (54)	8% (94)	0% (2)	3% (35)
2007	100	849	[8.49]	85% (721)	8% (71)	5% (42)	1% (5)	1% (10)
2008	100	702	[7.02]	80% (560)	8% (53)	6% (45)	4% (29)	2% (15)
2009	100	941	[9.41]	86% (809)	4% (40)	5% (47)	1% (14)	3% (31)
2010	100	1320	[13.20]	82% (1084)	4% (55)	6% (78)	5% (70)	3% (33)
2011	100	756	[7.56]	73% (549)	8% (62)	11% (81)	6% (43)	3% (21)
2012	100	1537	[15.37]	86% (1322)	3% (49)	7% (103)	2% (31)	2% (32)
2013	100	596	[5.96]	80% (474)	5% (31)	9% (56)	3% (18)	3% (17)
2014	100	1396	[13.96]	85% (1192)	5% (69)	7% (101)	2% (23)	1% (11)
2015	100	1195	[11.95]	84% (1006)	5% (62)	7% (83)	2% (22)	2% (22)
2016	100	1374	[13.74]	84% (1149)	5% (67)	6% (86)	3% (46)	2% (26)
2017	100	1079	[10.79]	83% (894)	5% (56)	8% (88)	2% (25)	1% (16)
2018	100	765	[7.65]	83% (637)	3% (26)	9% (69)	3% (23)	1% (10)
2019	100	1121	[11.21]	88% (984)	4% (42)	6% (73)	1% (14)	1% (8)

*Other includes *Microtus pennsylvanicus*, *Spermophilus tridecemlineatus*, *Zapus hudsonius*, *Mustela erminea*, *Tamiasciurus hudsonicus*, *Glaucomys volans*, *Sorex arcticus*, *Sorex cinereus*, *Mus musculus* and several ground-feeding bird species.

Table 3. Numbers and Percentages of Tick Species Collected by Stage and Year

Year	No. sites	Total ticks collected	<i>Dermacentor variabilis</i> L ^b percent (n)	<i>Dermacentor variabilis</i> N ^c percent (n)	<i>Ixodes scapularis</i> L ^b percent (n)	<i>Ixodes scapularis</i> N ^c percent (n)	Other species ^d percent (n)
^a 1990	250	9957	83% (8289)	10% (994)	6% (573)	1% (74)	0% (27)
1991	270	8452	81% (6807)	13% (1094)	5% (441)	1% (73)	0% (37)
1992	200	4130	79% (3259)	17% (703)	3% (114)	1% (34)	0% (20)
1993	100	1785	64% (1136)	12% (221)	22% (388)	1% (21)	1% (19)
1994	100	1514	53% (797)	11% (163)	31% (476)	4% (67)	1% (11)
1995	100	1196	54% (650)	19% (232)	22% (258)	4% (48)	1% (8)
1996	100	724	64% (466)	20% (146)	11% (82)	3% (20)	1% (10)
1997	100	693	73% (506)	10% (66)	14% (96)	3% (22)	0% (3)
1998	100	1389	56% (779)	7% (100)	32% (439)	5% (67)	0% (4)
1999	100	1594	51% (820)	8% (128)	36% (570)	4% (64)	1% (12)
2000	100	2207	47% (1030)	10% (228)	31% (688)	12% (257)	0% (4)
2001	100	1957	54% (1054)	8% (159)	36% (697)	2% (44)	0% (3)
2002	100	2185	36% (797)	13% (280)	42% (922)	8% (177)	0% (9)
2003	100	1293	52% (676)	11% (139)	26% (337)	11% (140)	0% (1)
2004	100	1773	37% (653)	8% (136)	51% (901)	4% (75)	0% (8)
2005	100	1974	36% (708)	6% (120)	53% (1054)	4% (85)	0% (7)
2006	100	1353	30% (411)	10% (140)	54% (733)	4% (58)	1% (11)
2007	100	1700	47% (807)	8% (136)	33% (566)	10% (178)	1% (13)
2008	100	1005	48% (485)	6% (61)	34% (340)	11% (112)	1% (7)
2009	100	1897	48% (916)	9% (170)	39% (747)	3% (61)	0% (3)
2010	100	1553	21% (330)	7% (101)	65% (1009)	7% (107)	0% (6)
2011	100	938	40% (373)	10% (97)	28% (261)	22% (205)	0% (2)
2012	100	2223	25% (547)	9% (211)	59% (1321)	6% (139)	0% (5)
2013	100	370	24% (88)	11% (42)	40% (147)	25% (92)	0% (1)
2014	100	2427	24% (580)	6% (149)	67% (1620)	3% (74)	0% (4)
2015	100	2217	15% (390)	4% (91)	65% (1442)	13% (291)	0% (3)
2016	100	3038	19% (576)	5% (153)	68% (2055)	8% (252)	0% (2)
2017	100	1609	16% (253)	3% (45)	68% (1101)	13% (204)	0% (6)
2018	100	1430	15% (219)	4% (63)	70% (1007)	10% (139)	1% (2)
2019	100	1164	24% (280)	5% (54)	55% (645)	15% (181)	1% (4)

^a 1990 data excludes one *Tamias striatus* with 102 larval & 31 nymphal *I. scapularis*

^b L = larvae

^c N = nymphs

^d Other species mostly *Ixodes muris* 1999-2nd adult *I. muris* collected 2007-collected 7 *I. marxi* nymphs

mean