

Metropolitan Mosquito Control District

Ixodes scapularis DISTRIBUTION STUDY

2014

Abstract

A black legged tick (*Ixodes scapularis*) distribution study designed to detect any changes in *I. scapularis* 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, since 2007 we have collected *I. scapularis* from at least one site in all seven counties that comprise our service area. Our overall positive site total for 2014 was a record high 75, compared with a yearly positive site total typically in the 50s since 2000. Our previous high of 71 sites was tabulated for 2012 and we tabulated 70 sites in 2010. From counties south of the Mississippi River, our 2014 positive site total of 30 (11 Dakota, 8 Hennepin, 7 Scott and 4 Carver) is a new record high, surpassing our previous highs recorded for 2010, 2011, and 2012 (24, 26, 27 respectively). We collected a total of 1694 *I. scapularis* removed from 1396 mammals for an overall season mean of 1.214 *I. scapularis* per mammal; a new record but comparable to the averages we have come to expect in recent years (2000 to 2002, 2004, 2005, 2007, 2009, 2010, 2012 and 2014 were all $\geq .806$). Our Washington county sites accounted for the majority (39%) of our 2014 collections with an additional 23% obtained from Anoka County. Dakota County accounted for another 22% of our overall collections. Townships maintaining *I. scapularis* per mammal averages ≥ 1.0 included Afton, Stillwater, Grant, May, Cottage Grove, and Lakeland of Washington County (range 1.083 to 7.548), Coon Rapids, Lino Lakes, Linwood, Andover, Ham Lake, and Blaine of Anoka County (range 1.412 to 10.538), Shoreview (4.500) of Ramsey County, Burnsville, Vermillion, and Hastings (range 1.455 to 6.0) of Dakota County, and Bloomington (2.167) of Hennepin County. Denmark, Hugo (Washington), Oak Grove, East Bethel, Saint Francis (Anoka), Inver Grove Heights (Dakota), Saint Lawrence, Blakely, Credit River (Scott) townships all averaged $\geq .500$ *I. scapularis* per mammal. Anoka County maintained the highest 1990-2014 overall season mean (.978), followed by Washington County (.915). Our compiled 1990-2014 township averages (all > 1.0) north of the Mississippi River include May, Hugo, Afton, New Scandia, and Grant of Washington County and Coon Rapids, Blaine, Saint Francis, Ham Lake, and East Bethel of Anoka County. Shoreview of Ramsey County maintained a compiled 1990-2014 average of .553. South of the river, the highest 1991-2014 averages ($> .500$ *I. scapularis* per mammal) occurred in Burnsville, Inver Grove Heights, Vermillion and Ravenna townships of Dakota County (range .510 to 1.435) and Saint Lawrence Township (1.364) of Scott County. Both small mammal and immature tick species diversity in 2014 appeared comparable to past years. As in past years, *Peromyscus leucopus* was the predominant mammal species collected. As for ticks, since 2002 and including 2014 *I. scapularis* has comprised $\geq 50\%$ of our overall collections nine times while *Dermacentor variabilis* has comprised the majority 16 times, including for the first 12 years of this study. As of April 14, 2015 the MN Dept Health (MDH) anticipated the statewide tallies for 2014 to be lower than 2013's Lyme (1,431) and human anaplasmosis (627) tallies. We did tabulate new record highs in several categories in 2014 and overall, our results continue to indicate that a Twin Cities resident's risk of encountering *I. scapularis* locally is now greater than it once was and that this risk has risen from insignificant to high over time for people who reside in counties south of the Mississippi River.

Introduction

In 1990 the Metropolitan Mosquito Control District initiated a Lyme Disease Tick Surveillance Program to determine the distribution and prevalence of *I. scapularis* 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 *I. scapularis* 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 *I. scapularis* 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 potential changes in *I. scapularis* 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 *I. scapularis* 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 *I. scapularis* 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 *I. scapularis* 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 *I. scapularis* 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 *I. scapularis* 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 *I. scapularis* 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 and *I. scapularis* 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 *I. scapularis* had been collected in late July 2009), was sampled for all three rounds. *I. scapularis* 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 21, 2014 and ended on October 23, 2014. 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.

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

➤ 2014 Study (Repeat Sites):

Except for 2011, since 2007 and again in 2014 we collected *I. scapularis* from at least one site in all seven counties that comprise our service area. Specifically, we found at least one *I. scapularis* at 75 of our 100 sampling sites, with 45 of these positive sites located north of the Mississippi River in Anoka (21 sites positive/28 sites sampled), Washington (21 sites positive/25 sites sampled), and Ramsey (3 sites positive/3 sites sampled) counties. Thirty additional positive sites were detected south of the river in Dakota (11), Hennepin (8), Scott (7) and Carver (4) counties (Figure 5A).

Overall, 1396 mammals (Figure 1 and 2014 results in Table 2) were inspected: 590 from north of the Mississippi River and 806 from south of the river and a total of 1694 *I. scapularis* (Figure 2 and 2014 results in Table 3) were collected from them. The Washington County sites accounted for 39% of the total *I. scapularis* collections (627L; 37N) with the highest numbers collected in Oakdale/Lake Elmo (146L; 62N), Afton (226L; 8N), and May (188L; 14N) townships. Anoka County accounted for another 23% of our total *I. scapularis* collections (374L; 18N), with the highest numbers collected in Coon Rapids (133L; 4N) Township. An additional 22% of the total (372L; 9N) were collected from our Dakota County sites, with the highest collections occurring in Burnsville (229L; 5N) Township.

The overall season mean number of *I. scapularis* collected per mammal in 2014 was 1.213 (larvae: 1.160, nymphs: .053). The mean increases to 1.564 (larvae: 1.496, nymphs: .068) when all sites negative for *I. scapularis* are excluded (see 2014 results in Figure 6). The highest average number of *I. scapularis* per mammal was calculated for Anoka County (1.903), followed by Washington (1.870), Dakota (1.225), Ramsey (1.090) and Hennepin (.522) counties (see 2014 results in Figure 3). North of the Mississippi River, townships in Washington County averaging ≥ 1.0 *I. scapularis* per mammal in 2014 were Afton (7.548), Stillwater (2.833), Grant (2.538), May (2.658), Cottage Grove (1.244), and Lakeland (1.083), in Anoka, Coon Rapids (10.538), Lino Lakes (2.950), Linwood (1.969), Andover (1.533), Ham Lake (1.429), and Blaine (1.412) townships, and in Ramsey County, Shoreview Township (4.500). Averaging $\geq .500$ *I. scapularis* per mammal were Denmark (.509) and Hugo (.500) of Washington County and Oak Grove (.947), East Bethel (.900), and Saint Francis (.545) townships of Anoka County (Figure 4). South¹ of the Mississippi River (no figure), townships maintaining averages $\geq .500$ *I. scapularis* per mammal were Burnsville (6.0), Vermillion (4.273), Hastings (1.455), and Inver Grove Heights (.632) of Dakota County, Saint Lawrence (.600), Blakely (.533), and Credit River (.526) of Scott County, and Bloomington (2.167) of Hennepin County.

➤ **Compiled Results (Repeat Sites) from 1990 - 2014 or 1991 - 2014:**

The 1990-2014 mean number of *I. scapularis* collected per mammal is .555, with the highest averages continuing to occur north of the Mississippi River. Washington County maintained the highest yearly county season means from 1990-1997, 2010 and 2012 while Anoka County maintained the highest yearly county season means from 1998-2009, 2011 and 2014. In 2013, Ramsey County had the highest county season mean (.842) for the first time (Figure 3). Anoka County's compiled 1990-2014 overall season mean is .978 and is followed closely by Washington County (.915). The 1990-2014 township averages (all > 1.0), north of the Mississippi River include May, Hugo, Afton, New Scandia, and Grant of Washington County and Coon Rapids, Blaine, Ham Lake, Saint Francis, and East Bethel of Anoka County, while the averages for Linwood, Andover, Oak Grove and Lino Lakes of Anoka County and Lakeland and Lake Elmo townships of Washington County are $> .500$ *I. scapularis* per mammal (Figures 4A and B's inserts on Figure 4). Shoreview of Ramsey County maintained a compiled 1990-2014 average of .553. In compiled results from south of the Mississippi River (1991 to 2014), Burnsville (1.435), Inver Grove Heights (.968), Vermillion (.545), and Ravenna (.510) townships of Dakota County and Saint Lawrence Township (1.364) of Scott County maintained 1991-2014 averages $> .500$ *I. scapularis* per mammal² (no figure).

I. scapularis status at the 100 repeat sampling locations is shown on Figure 5. The status has changed at 94 of the sites since 1990 or 1991 (see 2014 results in Table 1). While the number of sites where *I. scapularis* is detected every year has decreased since 1992, we continue to detect *I. scapularis* at several new sampling locations each year (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. These two sites were positive for *I. scapularis* again in 2005, 2006, 2008, 2010, 2013 and 2014. In fact, in 2013 and again in 2014 our Roseville site was also positive, making 2014 the second consecutive year that all three of our Ramsey County sites were positive. South of the river from 1990 to 1999 it had been typical to tabulate a maximum total of 3-4 positive sites each season. Except for

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 $> .500$ *I. scapularis* per mammal since 1999 while Vermillion's first compiled 1991-current year average $> .500$ *I. scapularis* per mammal occurred in 2004.

1991 when several *I. scapularis* 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 *I. scapularis* 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 tabulated 30 positive sites south of the river; a new record, surpassing the former record high of 27 positive sites in 2012 (Table 1A).

Comparing our 2014 small mammal and immature *I. scapularis* collection results with past study efforts, small mammal (Table 2) and immature tick (Table 3) species diversity appears comparable to past years. As in past years, *Peromyscus leucopus* was the predominant mammal species collected. In our tick collections, since 2002 and including 2014 *I. scapularis* has comprised $\geq 50\%$ of our overall collections nine times. This compares to the 16 times that *Dermacentor variabilis* has comprised the majority, including for the first 12 years of this study. The total number of ticks collected in 2014 (*D. variabilis*, *I. scapularis*, and *I. muris* combined) was 2,427, an all time high for our 100 site sampling network (Table 3). As Figures 3 and 6 show, our 2014 overall season mean of 1.213 *I. scapularis* per mammal is a new record high, it is similar to the averages we have come to expect in recent years (2000 to 2002, 2004, 2005, 2007, 2009 and 2010 were all $\geq .806$). *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). The 2014 average number of mammals collected per site (13.96) is a higher than average yearly small mammal collection total (Table 2). Our compiled average small mammal collection success level per site for 1990 through 2014 is 12.59 (1991-2013 average of 11.93 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.

Discussion

Our results seem to indicate that *I. scapularis* populations are established within Anoka and Washington counties and are now established or establishing themselves south of the Mississippi River. Although our study was not designed to specifically answer the question of tick establishment, we feel that our relative *I. scapularis* density estimates are accurate enough for a general risk assessment. While we believe that the greatest Lyme disease risk continues to occur in the northern metropolitan area⁵, we believe via greater *I. scapularis* exposure opportunities and therefore higher tick-borne disease risk is occurring now across our seven county service area.

Our average number of *I. scapularis* collected per mammal (1.213) in 2014 is a new record high but it is comparable to the averages we have come to expect in recent years (2000 to 2002, 2004, 2005, 2007, 2009, 2010, and 2012 were all $\geq .806$). Our 75 positive site total for 2014 is also a new record high, surpassing the 71 sites tabulated in 2012. The first time we ever tabulated a positive site total in the 70's (70 exactly) was in 2010 (Figure 3).

Case data for 2015 is not yet available (as of April 14, 2015) but will likely be lower than the 1,431 Lyme (record high) and 627 human anaplasmosis (HA) cases of 2013 (pers. comm. Dave Neitzel MDH). The 2012 Lyme total was 911; HA 512. In 2011 there were 1,201 Lyme cases and 782 HA cases- the current record high for HA. Their 2010 Lyme (1,293) and HA (720) totals had both been

³ *I. scapularis* 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 adult tick in Scott County's New Market Township but no additional *I. scapularis* were detected there in a 3 year sampling effort. Staff or the public have continued to occasionally turn in adult *I. scapularis* from Scott County, especially from New Market Township, since 1995.

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

⁵ Yearly 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).

new record highs at the time, and the 2009 (Lyme roughly 1,065; HA 317), 2008 (Lyme 1,050; HA 278) and 2007 totals (Lyme 1,239; HA 322) were similar. The Lyme case total for 2002 was 867, with the Lyme case totals of 2004 (1,023), 2005 (918), and 2006 (914), also at very high levels compared to other years. For reference, compared with roughly 250 Lyme cases per year through 1999, the statewide Lyme case total in 2000 was 463 cases, with the 2001 (465) and 2003 (473) case totals being similar. As for statewide human anaplasmosis cases, through 1999 the MDH had only been compiling an average of roughly 15 HA cases per year. From 2000-2004 HA case totals ranged from 78 to 152. The 2005 HA case total was 186 and they recorded 177 HA cases for 2006, making the then record 322 HA cases for 2007 that much more impressive at the time.

The Twin Cities metro-exposed tick-borne disease case totals have also risen over time, but not as dramatically as the statewide totals. Although metro-exposed case tallies have not been available since 2008, the 2007 totals had been at all-time highs (80 Lyme, 9 HA). Comparatively, the range for metro-exposed Lyme cases for all seven counties combined was 15 to 43 from 1991 to 1999 and 40 to 69 from 2000 to 2006. Although HA had been detected in metro-collected small mammals beginning in 1995⁶ in MMCD collaborative research, locally acquired human HA cases were not documented by MDH until 2000. From 2000 to 2007 the MDH typically tabulated a few metro-exposed HA cases each year (range 0-9). If discussion is expanded to case numbers for metro residents as a whole and not just those who were exposed in the metro, the case totals obviously would be higher. During the time when the MDH separated metro residents from people who reside elsewhere in the state for their statewide data, they had consistently documented that metro residents comprised roughly half of the Lyme cases tallied⁷.

While we did tabulate new record highs in several categories in our tick surveillance work in 2014, they are not extraordinarily higher than prior tabulations. However, we do continue to believe that the risk of metro tick encounters is higher than it used to be based on our collections of more *I. scapularis* overall as well as from a broader geographic area, specifically south of the Mississippi River. Metro residents north of the river have been used to encounters with *I. scapularis* but south of the river these encounters have changed from extremely infrequent to commonplace now, in some areas.

⁶Several 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.

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

ADDITIONAL UPDATES/RESEARCH:

STUDIES/PROJECT UPDATES AND PLANS FOR 2015.

- ***Ixodes scapularis* distribution study** (sites unchanged from 1993).
- **Additional projects: Bot Flies.** As we have since 2009, MMCD will provide samples to Dr. Roger Moon (UM ó St Paul), to further the knowledge of the rodent bot fly (Genus *Cuterebra*). Since 2013 we have also collected pupae to be reared out to the adult stage. Dr. Moon has managed to successfully induce adults to emerge, at least some of them after having been in forced diapause (frozen). We will collect pupae for Dr. Moon again in 2015.
NEW. Collecting ticks from grooming shops. Dogs make great tick collectors and some dogs get groomed. A sub-set of these dogs have ticks on them that the groomer removes and tick vials are kept at a lot of shops. We plan to receive an affirmation from a minimum of one shop per facility in 2015 and identify and document the number and species of ticks found. This idea originated with Dr. Moon but we fully embrace it.

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 2014 we had posted a total of 41 signs at over 36 locations throughout the metro with most signs removed in winter. Sign posting will resume in spring 2015.

DISTRIBUTING MATERIALS TO TARGETED AREAS

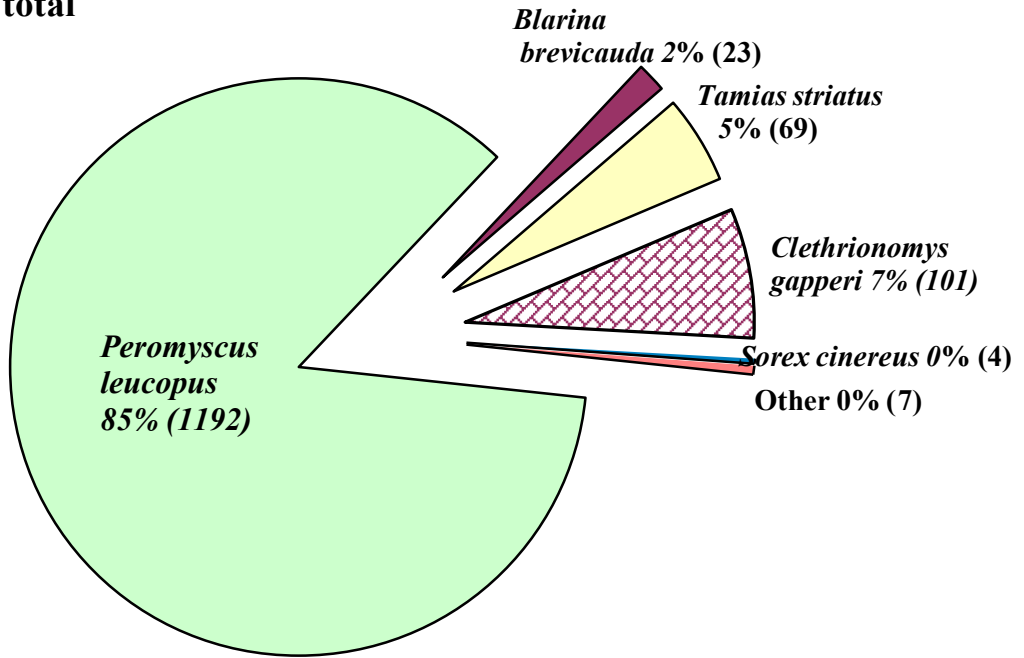
In 2014 brochures, tick cards, and/or posters were dropped at roughly 292 locations (city halls, libraries, schools, child care centers, retail establishments, vet clinics, parks) across the metro as well as distributed at fair booths and city events, with many more mailed upon request. We will continue materials distribution in spring 2015.

AMBLYOMMA AMERICANUM

Amblyomma americanum (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 *Amblyomma* collections (one adult, submitted to the MDH, one nymph, submitted to MMCD) in one year; an unusual event. This trend continued in 2010, with *Amblyomma* submitted to MMCD from Eagan, Mound, and the Orono/Lake Minnetonka areas of the metro. In 2011 the MDH had submissions of adults from Shakopee, Lindstrom, and Hennepin Co (unconfirmed location) and in 2012, three more *Amblyomma* were submitted to the MDH: Eden Prairie or Burnsville, Bloomington, and Rice County. MMCD did not receive any *Amblyomma* in 2011 or 2012. In 2013, the MDH did not receive any reports but MMCD received 3 *Amblyomma* (Afton, Scandia and Western Wisconsin). We notified the Wisconsin Department of Health of the Western Wisconsin detection and mailed the tick to them per their request. In 2014 MMCD did not receive any reports but the MDH received one report from the Zumbrota, MN area.

**Small Mammals Collected
2014: 1396 total**

Figure 1



**Ticks, by Species and Stage,
Removed from Small Mammals
2014: 2427 total**

Figure 2

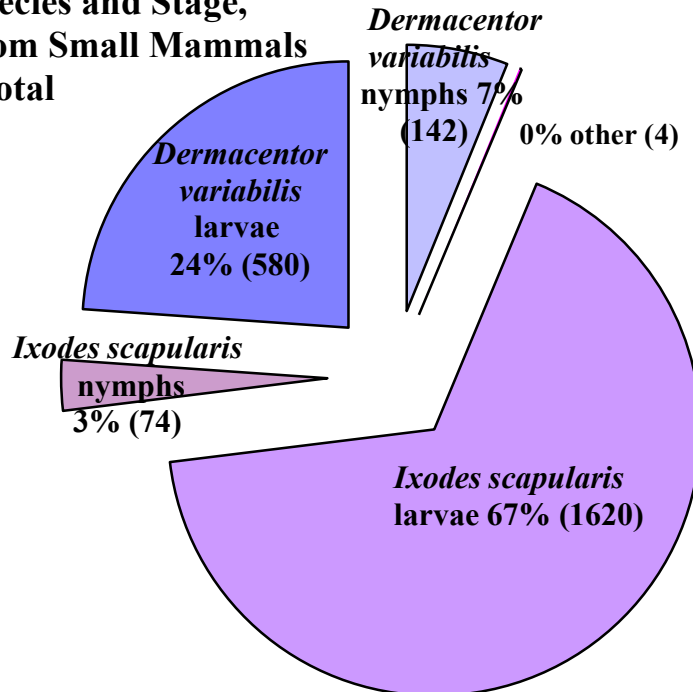


Figure 3 Average number of *I. scapularis* collected per mammal at 100 sampling locations in Anoka, Washington, and Ramsey counties: 1990 - 2014
 (white box shows the total number of sites where at least one *I. scapularis* was found: by year)

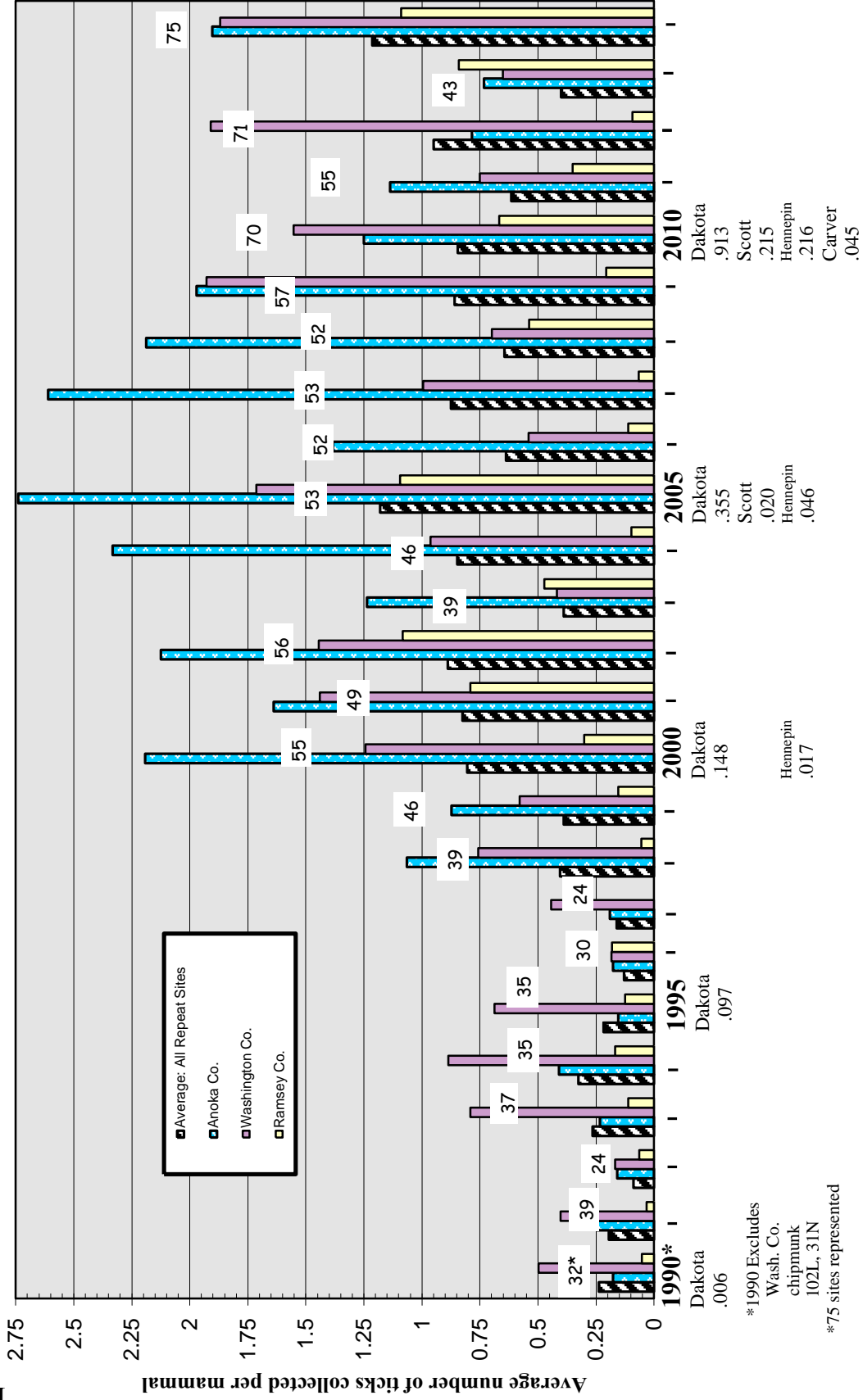
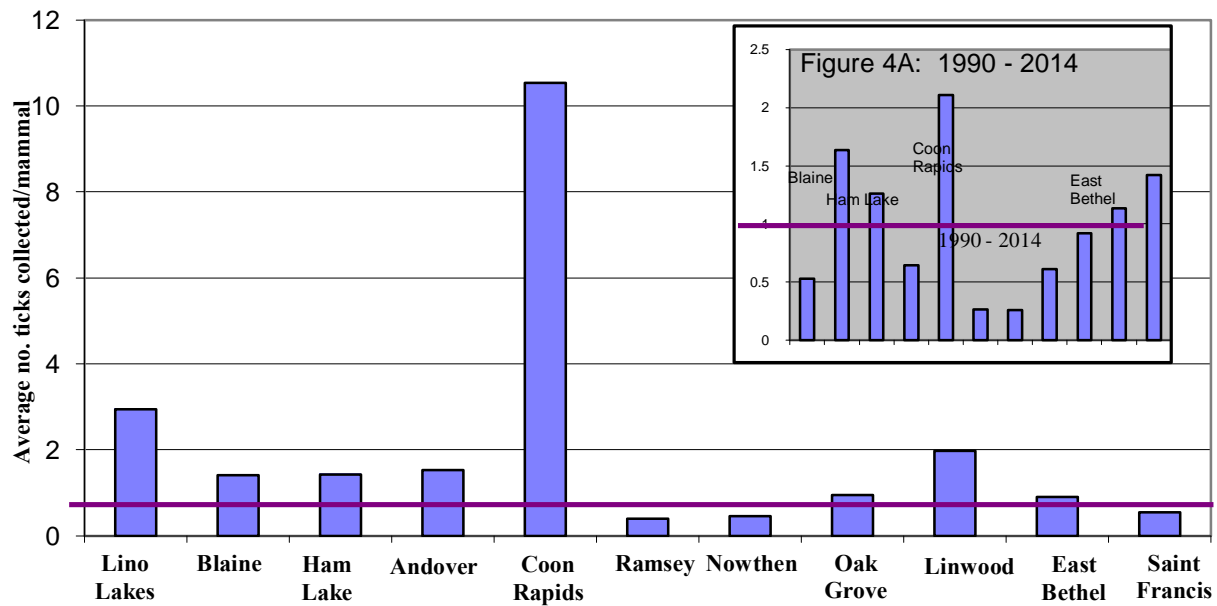
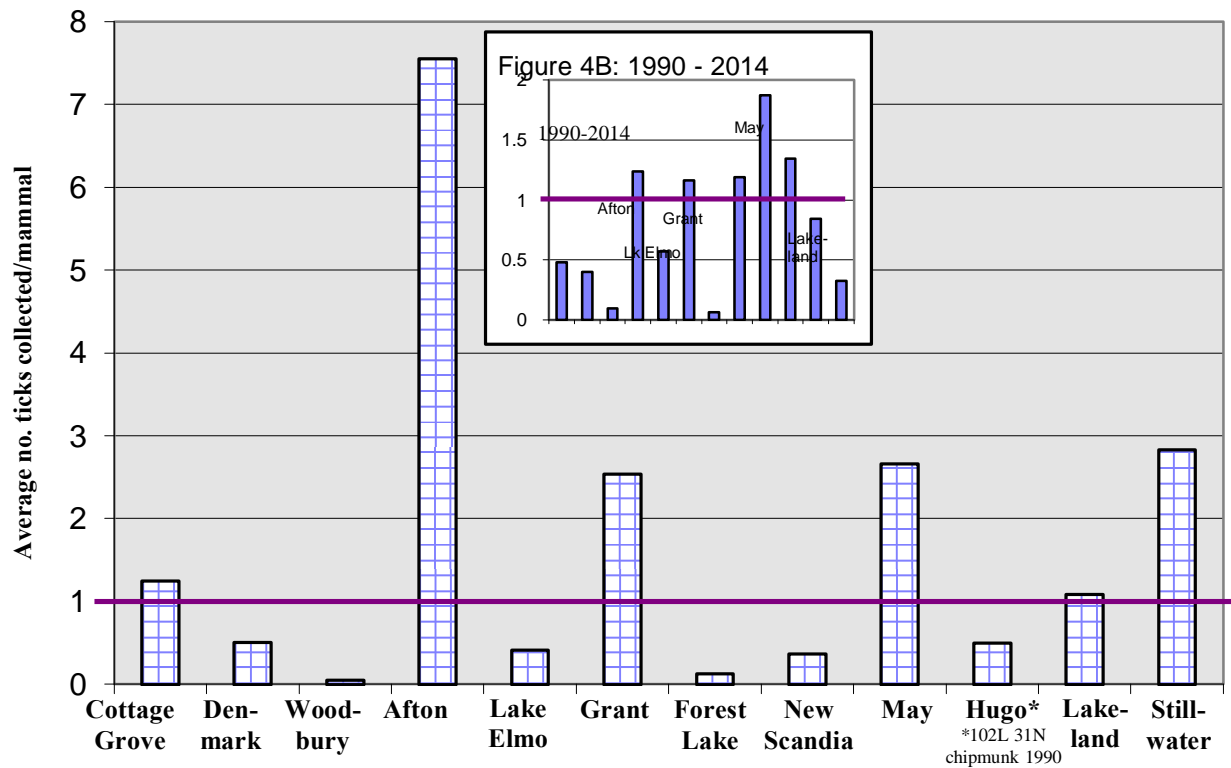


Figure 4

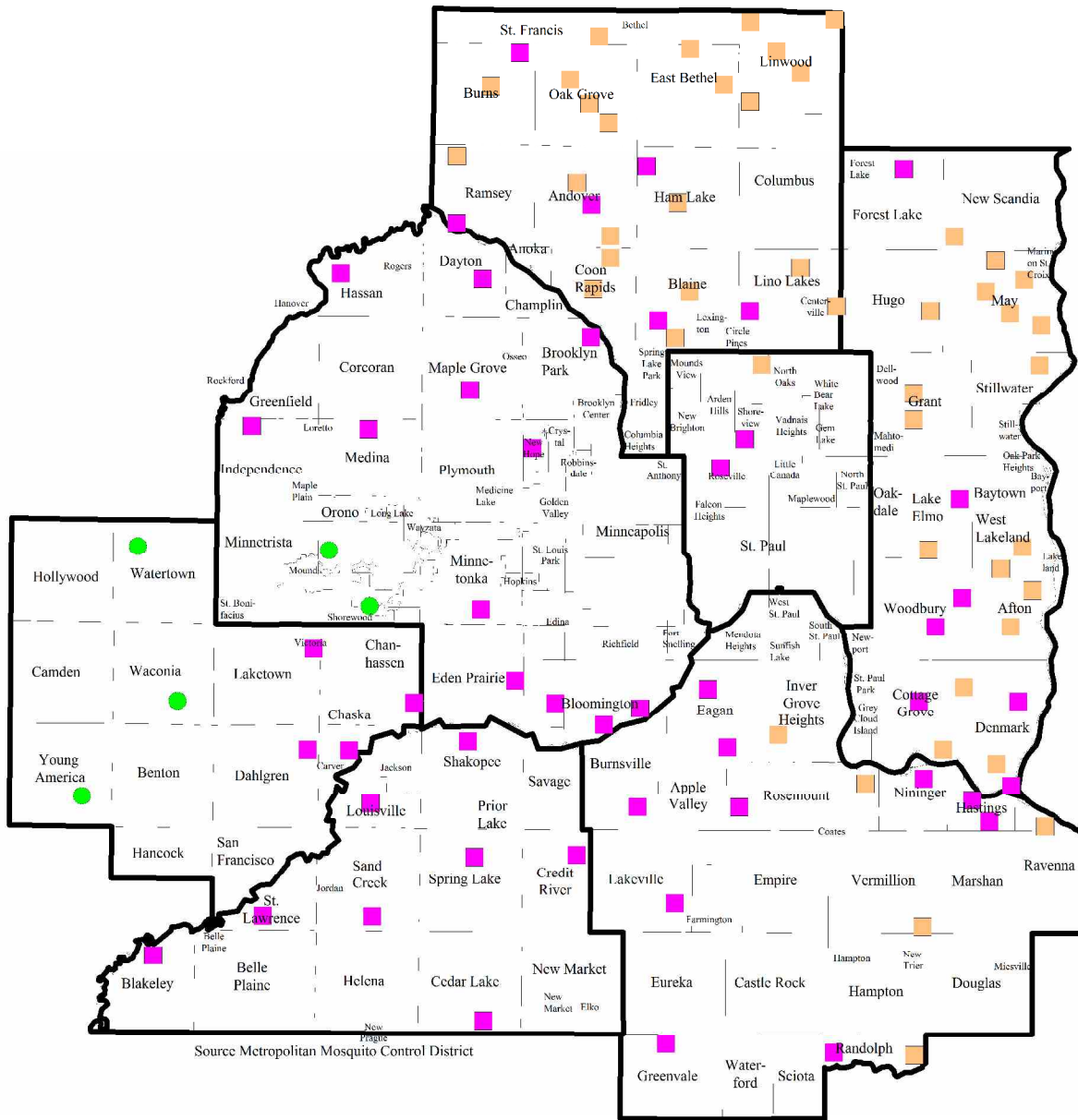
Average number of *I. scapularis* collected per mammal in Anoka county (by township): 2014 results



Average number of *I. scapularis* collected per mammal in Washington county (by township): 2014 results



Ixodes scapularis Presence/Absence status: 1990 - 2014
 (present if at least one *I. scapularis* is collected during a year)

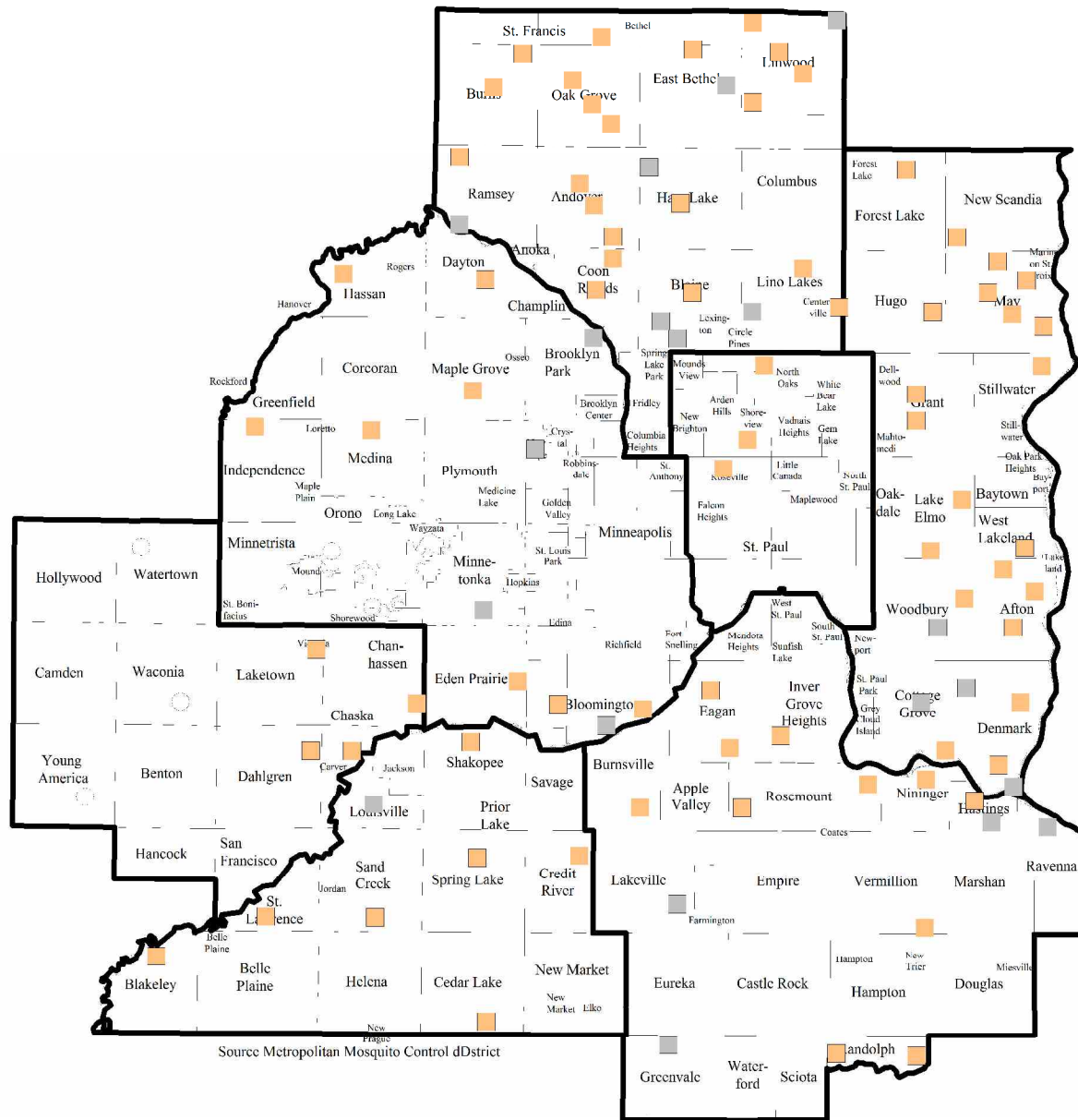


At least one tick found during:

- all/most years (46)
- at least one year (49)
- (not found) (5)

Figure 5A

Ixodes scapularis Presence / Absence status: 2014
 (present if at least one *I. scapularis* is collected)



Status 2014	
■ present	(75)
■ absent this year	(20)
○ not found 1990-2014	(5)

Figure 6

Average number of *I. scapularis* collected per mammal at 100 repeat sampling locations 1990-2014 overall vs. sites where at least one *I. scapularis* was collected (positive sites)

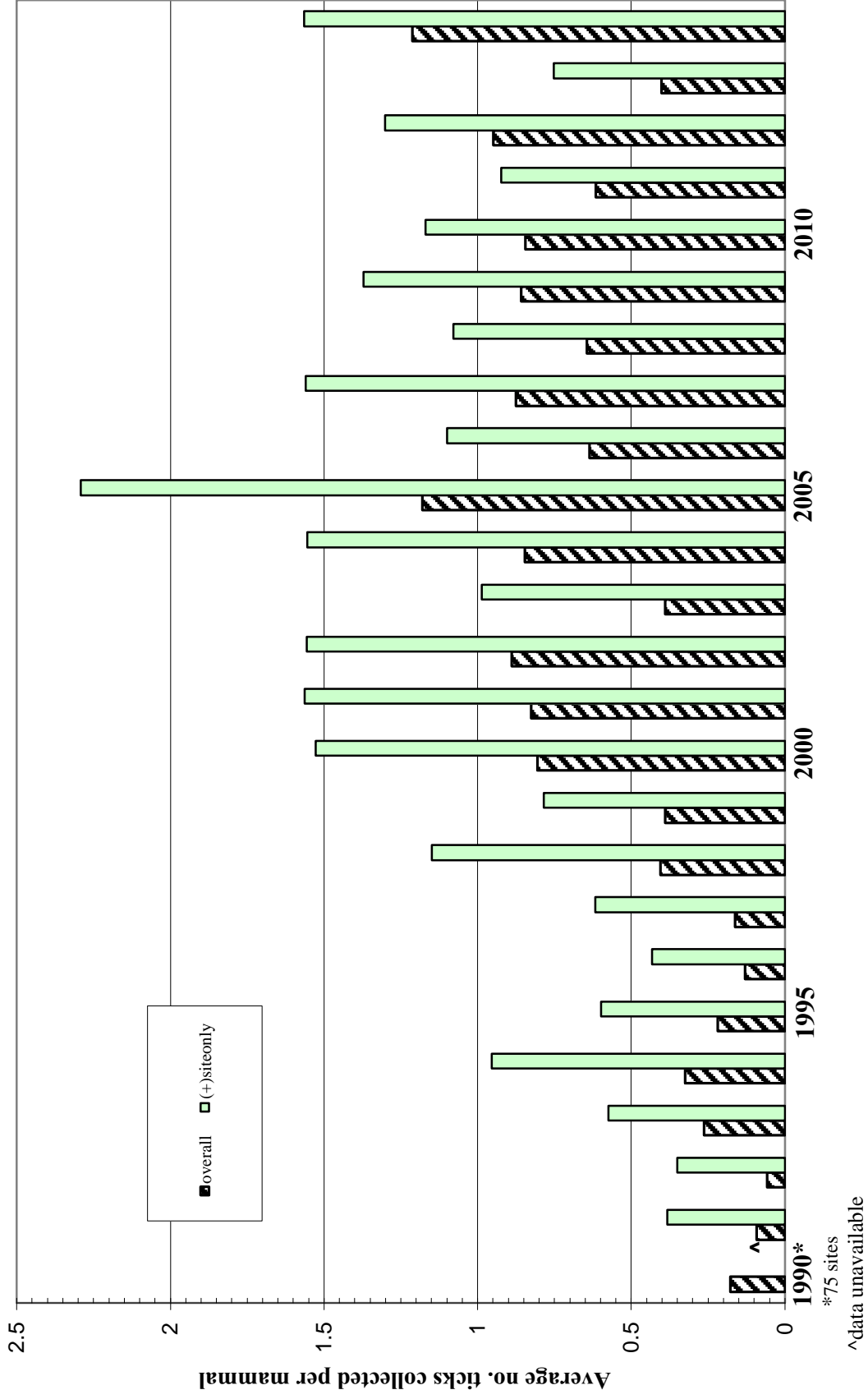


Table 1: Comparison of *I. scapularis* Presence/Absence Status at 100 Repeat Sampling Locations

No. sites changing status	1992	1994	1996	1998	2000	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	
Ticks found:	26	38	47	58	61	69	72	75	76	78	80	81	83	88	90	91	92	94	
all years	21	17	11	5	5	4	3	1	1	1	1	1	1	1	1	1	1	1	1
most years	5	15	19	27	31	35	37	38	41	41	45	42	44	44	44	45	45	45	45
least	21	23	28	31	30	34	35	37	35	37	35	39	39	44	46	46	47	47	49
(not found)	53	45	42	37	34	27	25	24	23	21	19	18	16	11	9	8	7	7	5

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

Total sites south of river	1992	1994	1996	1998	2000	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
By county:	*1	2	4	4	7	12	6	9	10	12	16	19	19	24	26	27	15	30
Dakota	*1	2	4	2	6	8	6	8	7	9	10	12	11	10	11	13	9	11
Hennepin	*0	0	0	1	1	3	0	0	1	2	3	3	3	6	9	7	4	8
Scott	*0	0	0	1	0	1	0	1	2	1	2	2	3	6	6	4	1	7
Carver	*0	0	0	0	0	0	0	0	0	0	1	2	2	2	0	3	1	4

*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]	Peromyscus leucopus		Tamias striatus		Clethrionomys gapperi		Blarina brevicauda		Other**	
				percent (n)	percent (n)	percent (n)	percent (n)	percent (n)	percent (n)	percent (n)	percent (n)		
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% (1115)	11% (156)	4% (55)	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% (561)	8% (53)	6% (43)	4% (29)	2% (16)					
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)					

*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)

^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