Metropolitan Mosquito Control District

IXODES SCAPULARIS DISTRIBUTION STUDY

2007

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. For the first time in a single sampling season we collected *I. scapularis* from at least one site in all seven counties comprising our service area. Overall, we tabulated 53 positive sites (at least one *I. scapularis* collected), a total in the 50's for the 3rd consecutive year and for only the 5th time (all since 2000). We also continued to tabulate higher than typical number of positive sites from counties south of the Mississippi River and our 2007 total of 16 (10 Dakota, 3 Hennepin, 2 Scott, and 1 Carver) is a new record, surpassing our previous high of 12 (2002, 2006). A total of 744 *I. scapularis* were removed from 849 mammals for an overall season mean of .876 *I. scapularis* per mammal; a rebound from 2006 (.637) and comparable to 2000 – 2002, 2004 and 2005 (all ≥ .806). We detected a drop in larval *I. scapularis* but a large increase in nymphs (178 - a nymph count in the 100's for only the 4th time (all since 2000)). The Anoka County sites accounted for 40% of the total 2007 *I. scapularis* collections (179L; 116N) with the highest numbers collected in Ham Lake (68L; 38N) and Linwood (35L; 54N) townships. Our Washington County sites accounted for an additional 30% (201L; 20N) of our *I. scapularis* collections with another 26% collected in Dakota. The highest county average number of *I. scapularis* per mammal (2.611) was calculated for Anoka and was followed by Washington (.995) and Dakota (.799) counties. Townships maintaining *I. scapularis* per mammal averages ≥ 1.0 included Ham Lake, Linwood, East Bethel, Saint Francis, Coon Rapids, and Oak Grove of Anoka (range 1.636 – 7.571), Lake Elmo, May, Hugo, and Afton of Washington (range 1.222 – 3.773), Ravenna, Inver Grove Heights, Vermillion, and Hastings of Dakota (range 1.077 – 2.944), and Dayton (1.800) of Hennepin. Averaging ≥ .500 *I. scapularis* per mammal were Andover, Lino Lakes, Blaine (Anoka), Stillwater (Washington), Eden Prairie, Hassan (Hennepin), Laketown (Carver), and Saint Lawrence (Scott) townships. Anoka County maintained the highest 1990-2007 overall season mean (.895), followed by Washington County (.743). Our compiled 1990-2007 township averages (all > 1.0) include May, New Scandia, Hugo, and Grant of Washington County, and Blaine, Coon Rapids, Saint Francis, Ham Lake, and East Bethel of Anoka County. South of the Mississippi River, the highest 1991-2007 averages (> .500 *I. scapularis* per mammal) occurred in Inver Grove Heights and Vermillion townships of Dakota County. Both small mammal and immature tick species diversity in 2007 appeared comparable to past years although the tabulation of "only" 44% *I. scapularis* overall is atypical; *I. scapularis* has comprised ≥ 50% of our overall collections four times between 2002 and 2006. As in past years, *Peromyscus leucopus* was the predominant mammal species collected and the 2007 average number of mammals collected per site (8.49) appears to represent a lower than typical yearly small mammal collection level. Examining human data, in 2007 the Minnesota Department of Health compiled new all-time high tick-borne disease case totals for Lyme (1239) and human granulocytic anaplasmosis (322) [previous: Lyme 1023 (2004); HGA 186 (2005)]. The 2007 Twin Cities metro-exposed case totals were also at all-time highs (Lyme 80; HGA 9). Despite the drop in 2007 larval *I. scapularis* collections, our overall results seem to indicate that the metro *I. scapularis* population remains elevated, as we believe it has been since 2000. Of note was the collection of *I. marxi* for the first time in a number of years as well as the collection of *I. scapularis* at two Ramsey County parks-extra sites last sampled in 1990 and where *I. scapularis* had been previously undetected. At some future point we may have to consider that the metro *I. scapularis* population has stabilized to a new norm, rather than being considered elevated. Even now, however, our 2007 results seem to provide evidence that a Twin Cities resident's risk of encountering *I. scapularis* locally is greater than it once was.

Introduction

In 1990 the Metropolitan Mosquito Control District initiated a Lyme Disease Tick Surveillance Program to determine the distribution and prevalence of *Ixodes 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 and may intensify our sampling effort in areas that have shown potential *I. scapularis* range expansion.

Periodically, additional sites have been sampled:
Two additional sites were sampled from 1995-1997; 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.

Although we are still sampling a limited number of parks today, in 1990 a larger number of our sampling sites had been selected inside metropolitan parks to provide a primitive assessment of park user risk to potential encounters with *I. scapularis*. Included were Joy Park in North Saint Paul (62-08-01) and a location near Pigs Eye Lake in St Paul (62-13-02) and *I. scapularis* was not collected at either park in three rounds of sampling. These two Ramsey County parks were re-sampled in 2007 as extra sites. The 2007 Joy Park site was in the same (square mile) section, but east of our 1990 location. The 2007 Pigs Eye site was moved over one section, to section 3. Unlike 1990, only two rounds of sampling were performed at these two sites in 2007.

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 23, 2007 and ended on October 25, 2007 with small mammal trapping 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

- **2007 Study (Repeat Sites):**

For the first time in a single sampling season we collected *I. scapularis* from at least one site in all seven counties comprising our service area. We found at least one *I. scapularis* at 53 of 100 sampling sites, with 37 of these positive sites located north of the Mississippi River in Anoka (19 sites positive/28 sites sampled), Washington (17 sites positive/25 sites sampled), and Ramsey (1 site positive/3 sites sampled) counties. Sixteen additional positive sites were detected south of the river in Dakota (10), Hennepin (3), Scott (2), and Carver (1) counties (Figure 5A).

Overall, 849 mammals (Figure 1 and 2007 results in Table 2) were inspected: 350 from north of the Mississippi River and 499 from south of the river and a total of 744 *I. scapularis* (Figure 2 and 2007 results in Table 3) were collected from them. The Anoka County sites accounted for 40% of the total

I. scapularis collections (179L; 116N), with the highest numbers collected in Ham Lake (68L; 38N) and Linwood (35L; 54N) townships. An additional 30% of the total (201L; 20N) were collected from our Washington County sites, with the highest collections occurring in Lake Elmo (81L; 2N) and May (52L; 7N) townships. We collected a total of 227 *I. scapularis* (186L; 41N) from our sites located south of the Mississippi River, with the majority (171L; 24N) collected from within Dakota County.

The overall season mean number of *I. scapularis* collected per mammal in 2007 was .876 (larvae: .667, nymphs: .210). The mean increases to 1.560 (larvae: 1.187, nymphs: .373) when all sites negative for *I. scapularis* are excluded (see 2007 results in Figure 6). The highest average number of *I. scapularis* per mammal was calculated for Anoka County, which had a season mean of 2.611 compared with Washington (.995) and Dakota (.799) county's season means (see 2007 results in Figure 3). Townships in Anoka County averaging $\geq$ 1.0 *I. scapularis* per mammal in 2007 included Ham Lake (7.571), Linwood (5.563), East Bethel (4.333), Saint Francis (3.800), Coon Rapids (3.167), and Oak Grove (1.636), with Andover (.800), Lino Lakes (.688) and Blaine (.600) townships averaging $\geq$ .500 *I. scapularis* per mammal. Lake Elmo (3.773), May (1.903), Hugo (1.889), Afton (1.222), and Stillwater (.875) townships of Washington County maintained averages $\geq$ .500 *I. scapularis* per mammal (Figure 4), as did Ravenna (2.944), Inver Grove Heights (2.923), Vermillion (2.278), and Hastings (1.077) of Dakota County, Dayton (1.800), Eden Prairie (.750), and Hassan (.500) of Hennepin County, Laketown (.545) of Carver County, and Saint Lawrence (.588) of Scott County south[1] of the Mississippi River (no figure).

I. marxi collected.

Of general interest was the removal of seven *Ixodes marxi* nymphs from a male chipmunk (*Tamias striatus*) collected in Scott County on June 1. This chipmunk was also infested with eight *I. scapularis* nymphs and one larval and one nymphal *D. variabilis*. Although *I. marxi* has not been associated with Lyme disease transmission, we felt it to be a noteworthy observation as we had not collected *I. marxi* from our metro sampling sites since the mid-1990's.

I. scapularis newly detected at several Ramsey County parks.

Joy Park in North St Paul (near Silver Lake) and a location near Pigs Eye Lake in St Paul had been sampled in 1990 and *I. scapularis* was not collected at either park in three rounds of sampling. These same general areas were re-sampled as extra sites in 2007 and we removed a total of ten *I. scapularis* larvae from two mammals in Joy Park as well as one nymph from one mammal at Pigs Eye in two rounds of sampling. It is possible that additional *I. scapularis* could have been collected in 2007 but neither park was sampled in our final, third round.

- **Compiled Results (Repeat Sites) from 1990 - 2007 or 1991 - 2007:**

The 1990-2007 mean number of *I. scapularis* collected per mammal is .457, with the highest averages continuing to occur north of the Mississippi River. Washington County maintained the highest yearly county season means from 1990-1997 and Anoka County has maintained the highest yearly county season means since 1998 (Figure 3). The highest compiled 1990-2007 overall season mean was tabulated for Anoka County (.895), followed closely by Washington County (.743). The 1990-2007 township averages (all > 1.0) include May, New Scandia, Hugo, and Grant of Washington County and Blaine, Coon Rapids, Saint Francis, Ham Lake, and East Bethel of Anoka County, while the averages for Linwood and Andover of Anoka County and Afton and Lakeland townships of Washington County are > .500 *I. scapularis* per mammal (Figures 4A and B—inserts on Figure 4). In compiled results from south of the Mississippi River, both Inver Grove Heights (.895) and Vermillion (.711) townships of Dakota County maintained 1991-2007 averages > .500 *I. scapularis* per mammal[2] (no figure).

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[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.

I. scapularis status at the 100 repeat sampling locations is shown on Figure 5. The status has changed at 80 of the sites since 1990 or 1991 (see 2007 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).

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

	1992	1994	1996	1998	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
No. sites changing status	26	38	47	58	61	66	69	72	75	76	78	80
Ticks found:												
all years	21	17	11	5	5	5	4	3	1	1	1	1
most years	5	15	19	27	31	34	35	37	38	41	41	45
least	21	23	28	31	30	32	34	35	37	35	37	35
(not found)	53	45	42	37	34	29	27	25	24	23	21	19

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). In 2003 we tabulated two positive Ramsey County sites (both of our Shoreview Township sites) for the first time. The second Shoreview Township site was positive for *I. scapularis* again in 2005 and 2006. South of the river from 1990 – 1999 it was typical to tabulate a maximum total of 3-4 positive sites each season. Except for 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 counties[3] and in 2000 we began to tabulate more sites south of the river. Our tabulation of 16 positive sites south of the river in 2007 is yet another new record total (Table 1A).

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

	1992	1994	1996	1998	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Total sites south of river	*1	2	4	4	7	10	12	6	9	10	12	16
By county:												
Dakota	*1	2	4	2	6	7	8	6	8	7	9	10
Hennepin	*0	0	0	1	1	2	3	0	0	1	2	3
Scott	*0	0	0	1	0	1	1	0	1	2	1	2
Carver	*0	0	0	0	0	0	0	0	0	0	0	1

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

Comparing our 2007 small mammal and immature *I. scapularis* collection results with past study efforts, both small mammal (Table 2) and immature tick (Table 3) species diversity appears comparable to past years, although the tabulation of "only" 44% *I. scapularis* overall is atypical for recent years; *I. scapularis* has comprised ≥ 50% of our overall collections four times in the five year period between 2002 - 2006 (Table 3). Our 2007 overall season mean of .876 *I. scapularis* per mammal appears to indicate a rebound from 2006 (.637) and is comparable to 2000 – 2002, 2004 and 2005's elevated averages (all ≥ .806 and illustrated in Figures 3 and 6). In 2007 we collected the fewest number of larval *I. scapularis* since 2003 and in numbers more similar to 1999's larval total, but we collected 178 *I. scapularis* nymphs – technically our 2nd highest nymphal total (3rd highest in percentages) but comparable to 2002 (177) and a nymphal total in the hundreds for only the 4th time (all since 2000) since the inception of this study. *P. leucopus* consistently has been the predominant mammal species collected each year with some variability in the total percentages collected[4] (Figure 1

[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 reports.

and Table 2). The 2007 average number of mammals collected per site (8.49) appears to represent a lower than typical yearly small mammal collection level (Table 2). Our compiled average small mammal collection success level per site for 1990 through 2007 is 13.29 (1991-2007 average of 12.57 for 100 repeat sites only), with results ranging from the low of 7.28 mammals collected per site in 1997 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 northeastern Anoka and northern Washington counties while remaining localized or nonexistent in areas 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. Given the consistency of our results, where greater numbers of *I. scapularis* continue to be collected in the northeastern metropolitan area each season, we believe that the greatest Lyme disease risk continues to occur in the northeastern metropolitan area[5].

Our 2007 results appear to indicate that we again detected signs of an elevated metro *I. scapularis* population; a trend we feel has been ongoing since 2000. To summarize what is expressed throughout this paper and within the attached tables and graphs, our season means of 2000 – 2002, 2004, 2005 and 2007 have all been elevated (all $\geq$ .806), and even our 2006 average of .673 is higher than the averages compiled for any other year (Figures 3 and 6). Although in 2003 both our overall season mean (.389) and our overall positive site total (39) had been more comparable to those from 1990 – 1998 rather than more recent results, we had still felt in 2003 that signs such as more positive sites south of the Mississippi River (2003 results in Table 1A) and a high *I. scapularis* nymph count (2003 results in Table 3) were important to the overall picture. Like 2003, in 2007 we detected an overall decrease in our larval *I. scapularis* collections but at the same time collected a higher than typical number of nymphs, and also, *I. scapularis* comprised < 50% of our overall tick collections (Table 3). However, unlike 2003, in 2007 our overall results were more typical of recent years (Figure 3) and we continued to set new records. As expressed in Table 1A, 16 of our 53 overall positive sites were located south of the Mississippi River, exceeding our previous high of 12, and we have now tabulated a double digit positive site total from these southern sites five times, all since 2001. Finally, although over time we did eventually collect *I. scapularis* from all seven counties that comprise MMCD's service area, in 2007 we collected *I. scapularis* from all seven counties in one single sampling season (Figure 5A) for the first time. Although an argument could be made that our low small mammal collections of 2007 (Table 2) could have artificially inflated our 2007 *I. scapularis* average, we feel our ongoing compilations of high averages and positive site totals along with additional indicator signs like new single season records and the detection of *I. scapularis* in an expanding geographic area seem to justify our ongoing elevated *I. scapularis* population conclusion.

Further support to our elevated *I. scapularis* conclusion seems to be provided by our sampling of two extra Ramsey County park sites; *I. scapularis* was found in these areas in 2007 whereas they had not been detected in 1990. While we acknowledge that *I. scapularis* could have simply remained undetected in our 1990 sampling at these same general locations, especially as we had sampled for only one season, and while we acknowledge that both Figure 5A and Figure 5 document positive *I. scapularis* sites near both parks, we feel it is just as likely that *I. scapularis* populations have increased or small numbers magnified enough so that our surveillance could detect them in 2007.

While not a smooth fit with the rest of this discussion, we would be remiss not to note the collection of *I. marxi* in 2007. It is the author's recollection that researchers in the early 1990's had hypothesized that as *I. scapularis* built up in an area they would displace, and eventually replace, other *Ixodes*

[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).

species such as *I. marxi*. Over more than the last decade, our own MMCD tick surveillance results seemed to be providing support to this theory. While collection of *I. marxi* had always been uncommon, it had been typical in the early years to collect at least a few *I. marxi* from time to time. As the years went by and fewer and then no *I. marxi* were being collected, we had thought perhaps there was some basis to the theory, even though from 1990 - 2007 we have continued to collect the occasional *I. muris*, albeit in smaller numbers than the early years. We were happy to find that *I. marxi* continue to exist (or have been re-introduced), if only for their own sake. As we have already noted in the results section, *I. marxi* have not been associated with Lyme disease transmission.

Examining human data, the MN Dept Health compiled new all-time high statewide tick-borne disease case totals in 2007 for both Lyme (1239) and human granulocytic anaplasmosis (322). Their prior all-time high statewide Lyme disease tabulation had occurred in 2004 (1023 cases) with the Lyme case totals of 2005 (918), 2006 (914), and 2002 (867) also at very high levels compared to other years. As has been noted in this and previous reports, 2000 was the year that MMCD began to detect obvious increases in our *I. scapularis* collections. It was also in 2000 that the MDH began compiling larger human tick-borne disease totals. Compared with roughly 250 cases per year for prior years, their statewide Lyme case total in 2000 was 463 cases, with the Lyme case totals of 2001 (465 cases), and 2003 (473 cases) being comparable. Statewide human granulocytic anaplasmosis (HGA) case totals have increased in recent years, too. Through 1999 the MDH had only been compiling an average of roughly 15 HGA cases per year but case totals ranged from 78 to 152 from 2000 – 2004. Their previous all-time high HGA case total (186) had been set in 2005 and they recorded 177 HGA cases for 2006, making the new record of 322 HGA cases for 2007 that much more impressive.

The Twin Cities metro tick-borne disease case totals have also risen over time, but not as dramatically as the statewide totals. Like the 2007 statewide data, however, the 2007 metro-exposed case totals were at all-time highs (80 Lyme, 9 HGA). Comparatively, the range for metro-exposed Lyme cases for all seven counties combined was 15 to 43 from 1991 – 1999 and 40 to 69 from 2000 – 2006. Although HGA had been detected in metro-collected small mammals beginning in 1995[6] in MMCD collaborative research, locally acquired human HGA cases were not documented by MDH until 2000. From 2000 - 2006 MDH typically tabulated a few metro-exposed HGA cases each year (range 0-7) and this trend obviously continued in 2007 with their tabulation of 9 metro-exposed HGA cases.

As has been written in the discussion sections in many past reports, we attempt to understand variances in our collection results by developing hypotheses and examining additional data sets, including what we consider to be relevant environmental factors, which for 2007 we considered to be the lower than average monthly precipitation levels for April, June, and July[7]. While we noted a dip in our larval *I. scapularis* collections compared to 2006 and that our nymphal collections were high compared to most other years, when we examined Table 3 we saw no obvious connection or year to year correlation this time between collection totals when following a co-hort. In other words, even after allowing some room for mortality factors as from desiccation or overwintering, a large nymphal *I. scapularis* collection does not automatically follow a large larval collection from the previous year, or, in the case of nymphs molting into adult *I. scapularis*, the expectation that a large larval collection should occur in a later year, even assuming both a two or a three year *I. scapularis* life cycle. We acknowledge that our study is designed and better suited to examine broad overall trends like geographic spread and expansion or contraction of the metro *I. scapularis* population as a whole rather than these more specific population dynamic questions that we attempt to understand. However, as an initial evaluation,

[6]Several 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.

[7]MMCD 80 gauge precipitation network average vs MNDNR State Climatology Office 1891-2005 cumulative average was April -.50 inches, June -2.56 inches, July -1.82 inches

we did compile the average number of *Dermacentor variabilis* and *I. scapularis* collected by Round[8] from 1993 – 2007. As shown in Tables 6 and 7 (below) we did not detect a major, unexpected shift to our collections in any sampling round, although we did tabulate a higher 2007 Round C average for both *D. variabilis* and *I. scapularis* compared to any other year, and also, the 2007 Round C *I. scapularis* average would have been significantly higher than other years if we had not, as broadly noted under Table 7, excluded the *I. scapularis* tick load from one *Tamias striatus* as we considered it to be an anomaly.

Table 6: Average *D. variabilis* per Mammal by Round, 1993 – 2007

	Round A	Round B	Round C
1993	4.210	.511	.007
1994	1.900	.288	.002
1995	2.023	.456	.013
1996	3.133	.641	.013
1997	4.008	.181	0
1998	2.671	.116	.012
1999	2.276	.233	.015
2000	2.948	.409	.005
2001	4.646	1.176	.082
2002	3.339	.388	.013
2003	2.638	.327	.014
2004	2.270	.396	.006
2005	3.258	.657	.021
2006	1.484	.324	.055
2007	3.478	.312	.159

Table 7: Average *I. scapularis* per Mammal, by Round, 1993 - 2007

	Round A	Round B	Round C
1993	.591	.144	.239
1994	.710	.302	.086
1995	.327	.212	.153
1996	.308	.152	.032
1997	.500	.060	.114
1998	1.257	.223	.037
1999	.296	.727	.143
2000	1.204	.879	.345
2001	2.128	.759	.322
2002	1.681	1.170	.243
2003	.703	.463	.161
2004	2.146	.691	.216
2005	1.254	2.006	.473
2006	.895	.910	.302
2007	1.500	.534	*.575

*excludes Wash Co. chipmunk 54L, 1N. If included, number increases to .743

All in all we feel our data continues to support our conclusion of an elevated *I. scapularis* population. If our surveillance continues to show similar overall results in the future, at some point we will have to consider that the metro *I. scapularis* population has stabilized from an elevated level to a new norm. Even our 2007 results appear to offer some evidence that our Twin Cities residents' risk of encountering *I. scapularis* locally is likely not only greater than in the past due to higher volumes of ticks in general, but also due to a greater spread geographically than we had once detected.

[8] The completion of one entire cycle of our 100 sampling site network.

ADDITIONAL UPDATES/RESEARCH:

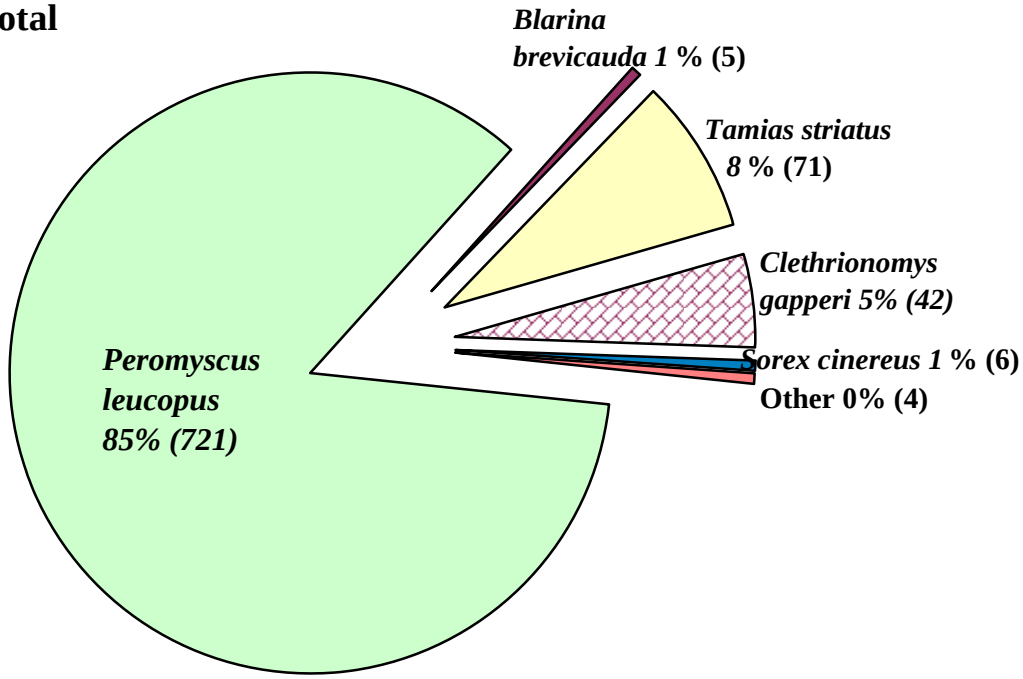
CONTINUING STUDIES FOR 2008.

- ***Ixodes scapularis* distribution study** (sites unchanged from 1993).

Our tick loads have not yet been determined but through August 2008 our small mammal collection numbers have been considerably smaller than expected.

Small Mammals Collected
2007: 849 total

Figure 1



Ticks, by Species and Stage, Removed from Small Mammals
2007: 1700 total

Figure 2

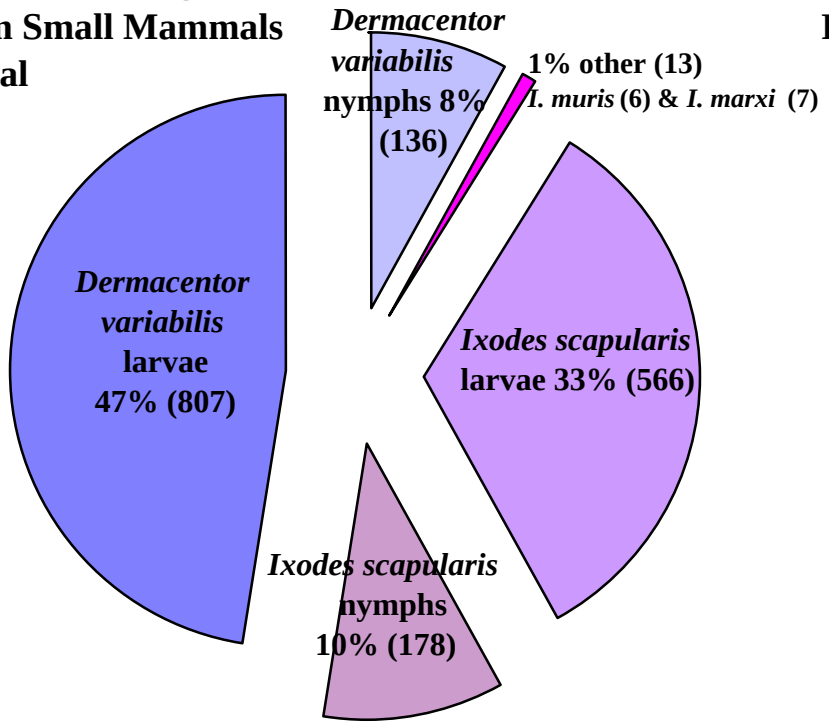


Figure 3

Average number of *I. scapularis* collected per mammal at 100 sampling locations in Anoka, Washington, and Ramsey counties: 1990 - 2007
(white box shows the total number of sites where at least one *I. scapularis* was found: by year)

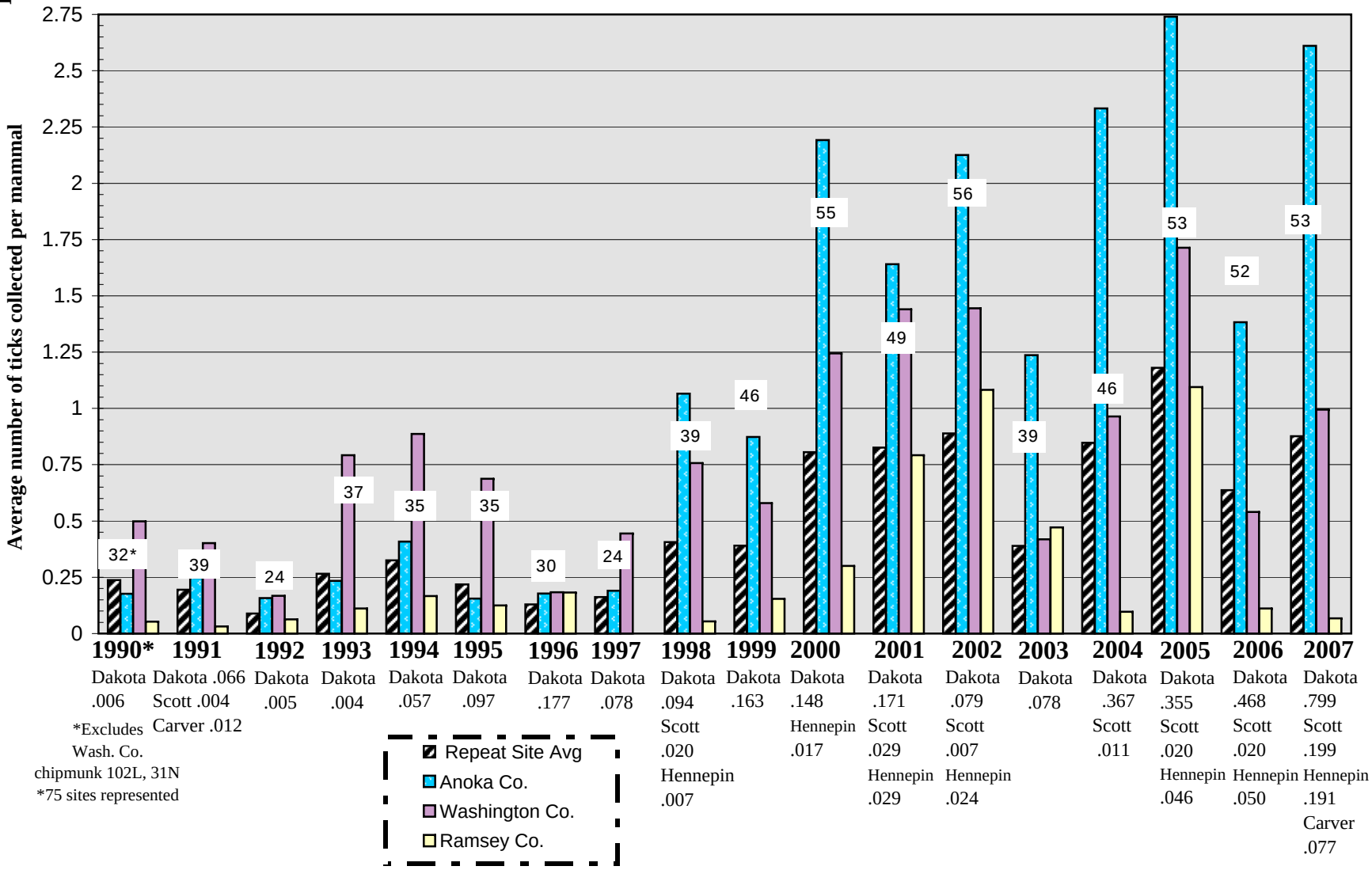
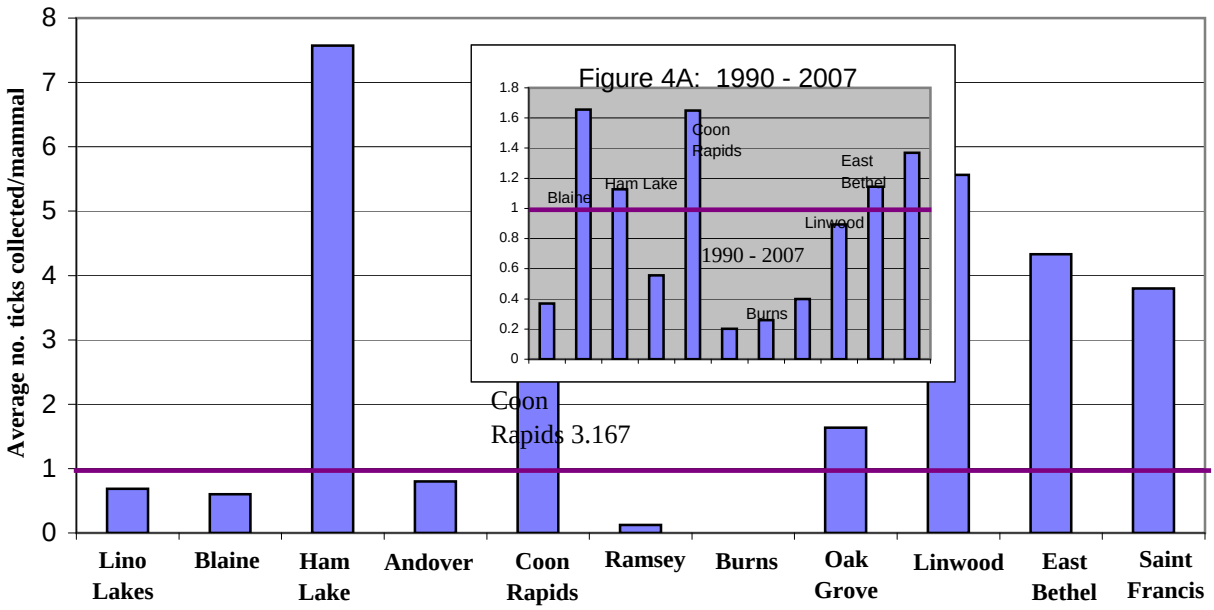


Figure 4

Average number of *I. scapularis* collected per mammal in Anoka county (by township): 2007 results



Average number of *I. scapularis* collected per mammal in Washington county (by township): 2007 results

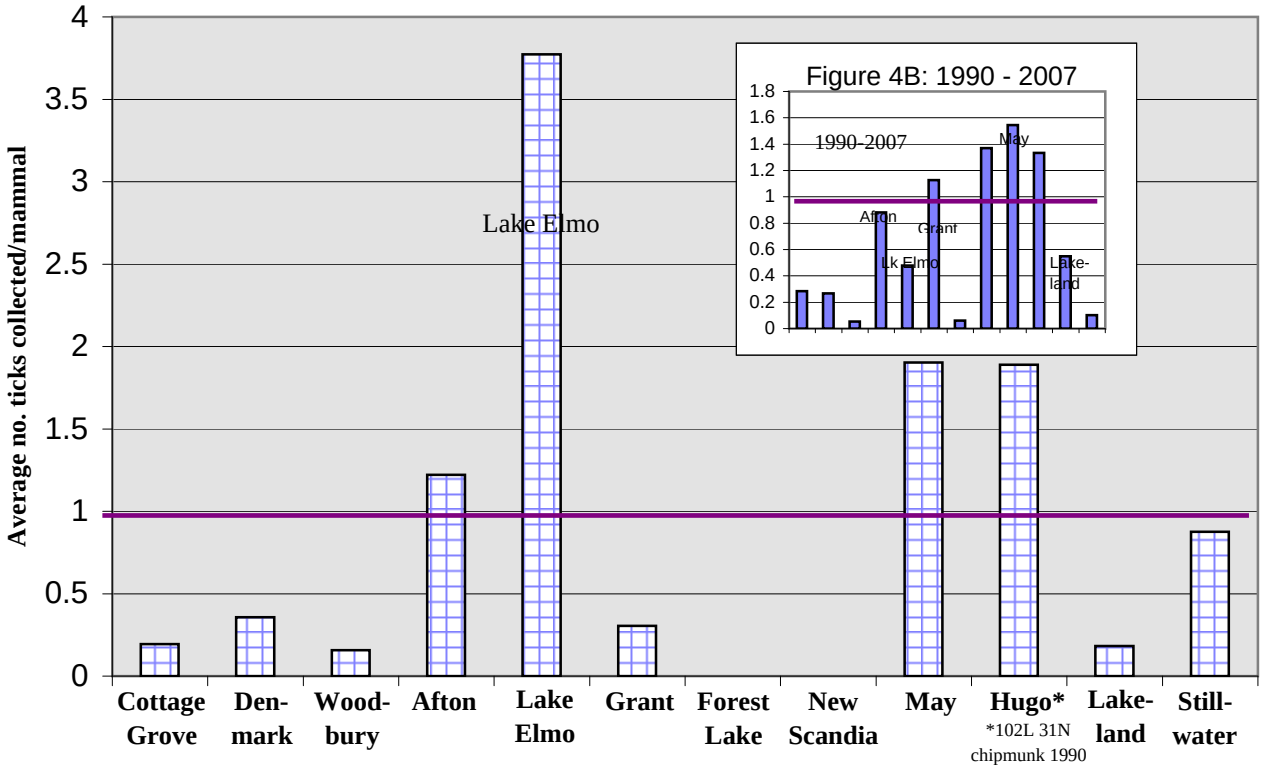
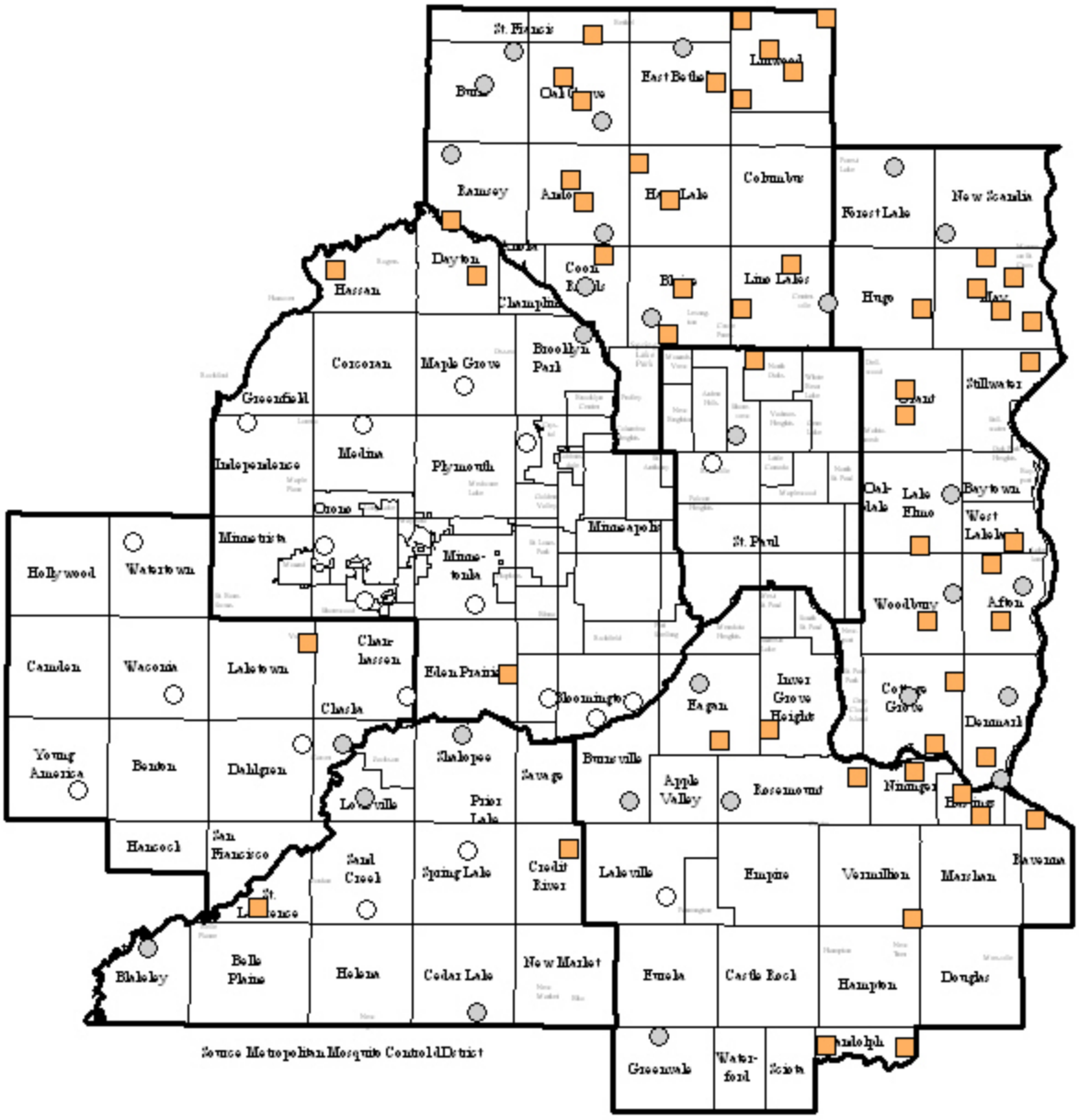


Figure 5A

Ixodes scapularis Presence / Absence status: 2007

(present if at least one I. scapularis is collected)



Status 2007

present	(53)
absent this year	(28)
not found 1990 -2007	(19)

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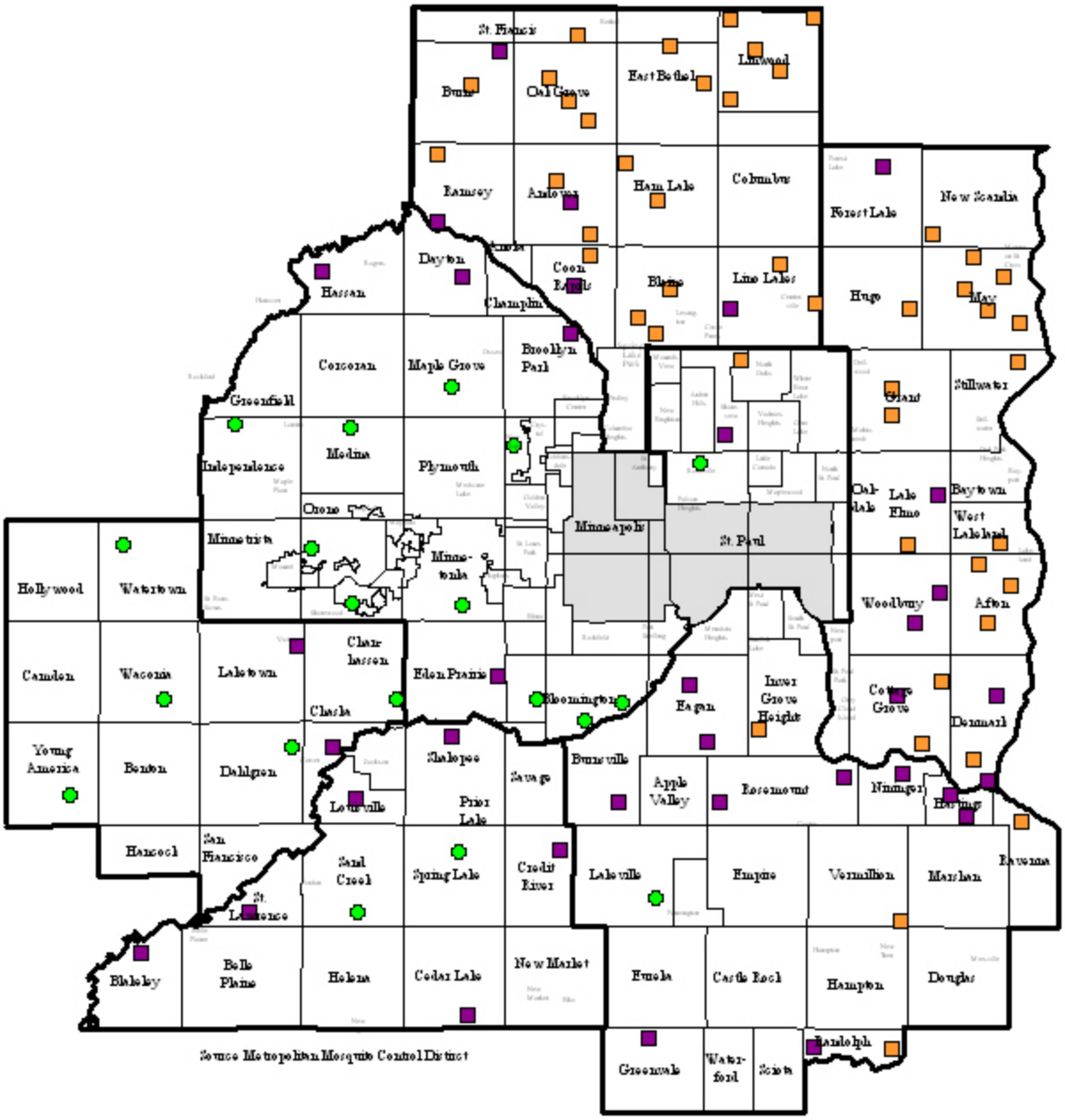
Figure 5

Ixodes scapularis Presence/Absence status: 1990 - 2007

(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 (35)
- (not found) (19)

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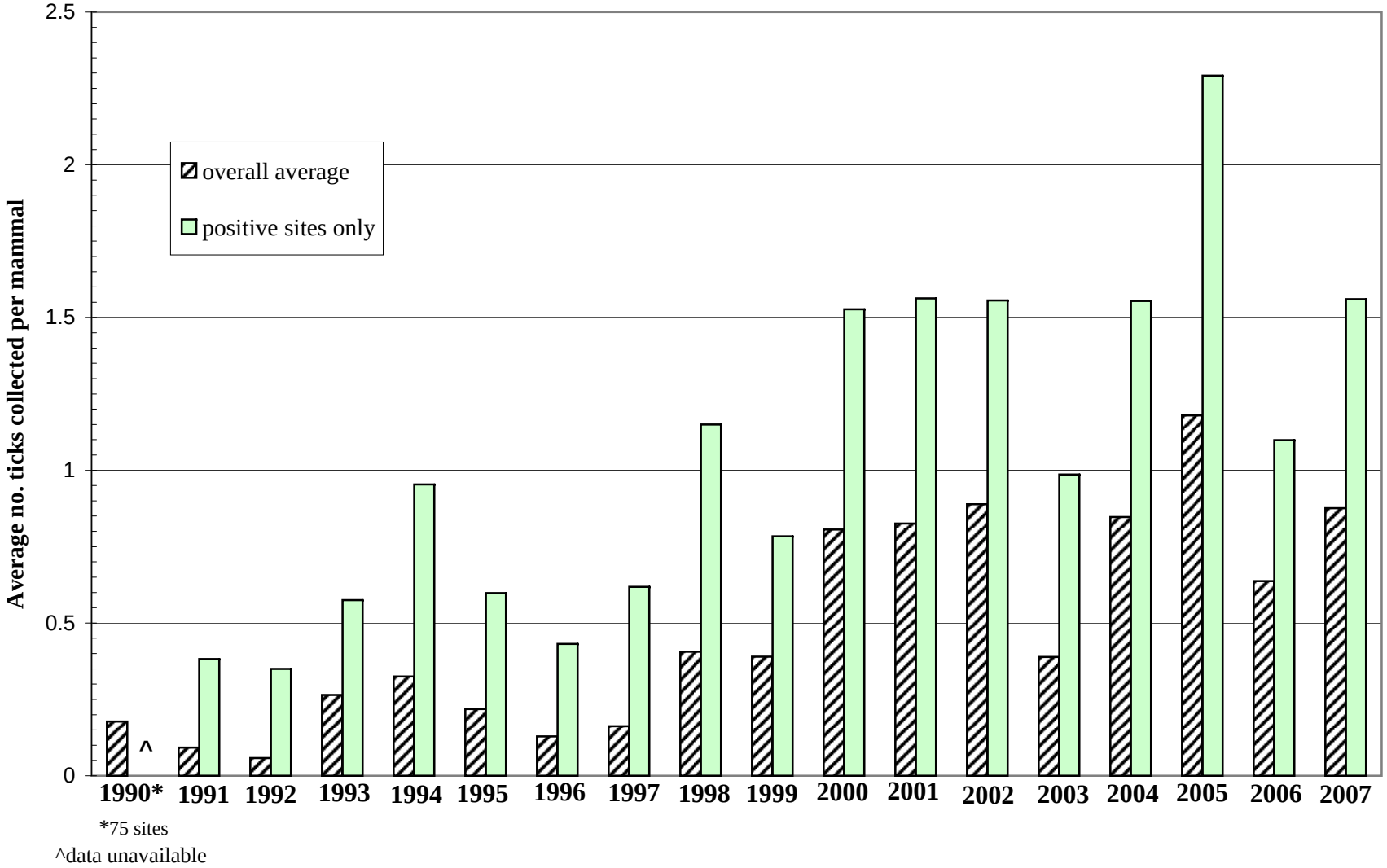
Figure 6

Average number of *I. scapularis* collected per mammal at 100 repeat sampling locations 1990-2007: overall vs. sites where at least one *I. scapularis* was collected (positive sites)



*75 sites

^data unavailable

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* percent (n)	*Tamias striatus* percent (n)	*Clethrionomys gapperi* percent (n)	*Blarina brevicauda* 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% (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)	1% (9)
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% (19)
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)

*Other includes *Microtus pennsylvanicus, Spermophilus tridecemlineatus, Zapus hudsonius, Mustela erminea, Tamiasciurus hudsonicus, Glaucomys volans, Sorex articus, Sorex cinereus* , 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	*Dermacentor variabilis* L[b] percent (n)	*Dermacentor variabilis* N[c] percent (n)	*Ixodes scapularis* L[b] percent (n)	*Ixodes scapularis* 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)

[a] 1990 data exludes 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