

## Metropolitan Mosquito Control District *IXODES SCAPULARIS* DISTRIBUTION STUDY 2012

### 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. From 2007-2010 and again in 2012 we collected *I. scapularis* from at least one site in all seven counties that comprise our service area. Overall, we tabulated a new record total of 71 positive sites (at least one *I. scapularis* collected), but will note that it is similar to our positive site total of 70 from 2010. From counties south of the Mississippi River, our 2012 positive site total of 27 (13 Dakota, 7 Hennepin, 4 Scott and 3 Carver) is also a new record, but is similar to our 2011 total of 26 and 24, from 2010. It was a high collection year for both mammals and ticks, with a total of 1460 *I. scapularis* removed from 1537 mammals for an overall season mean of .950 *I. scapularis* per mammal. In fact, 2012 was only the 2<sup>nd</sup> time *I. scapularis* comprised  $\geq 60\%$  of our overall collections (2012 65%, 2010 72%) and only 2005 had a higher season mean (1.180). Our Washington (46%) county sites accounted for the majority of our 2012 collections with an additional 29% obtained from Dakota County. Townships maintaining *I. scapularis* per mammal averages  $\geq 1.0$  included May, Afton, Lakeland, Hugo, Cottage Grove, and Denmark of Washington County (range 1.309 - 3.494), Burnsville, Hastings, and Vermillion of Dakota County (range 1.462 - 8.323), Ham Lake, Coon Rapids, Saint Francis, Ramsey, and East Bethel of Anoka County (range 1.0 - 3.455), Eden Prairie (2.778) and Brooklyn Park (2.0) of Hennepin County, and Credit River (2.233) of Scott County. Oak Grove, Andover, Linwood, (Anoka), Stillwater, New Scandia, Lake Elmo, (Washington), Inver Grove Heights, Ravenna (Dakota), Louisville, and Saint Lawrence (Scott) townships all averaged  $\geq .500$  *I. scapularis* per mammal. Anoka County maintained the highest 1990-2012 overall season mean (.954), followed by Washington County (.868). Our compiled 1990-2012 township averages (all  $> 1.0$ ) north of the Mississippi River include May, Hugo, New Scandia, and Grant of Washington County, and Coon Rapids, Blaine, Saint Francis, Ham Lake, and East Bethel of Anoka County. South of the river, the highest 1991-2012 averages ( $> .500$  *I. scapularis* per mammal) occurred in Inver Grove Heights, Burnsville, Vermillion and Ravenna townships of Dakota County (range .524 - 1.014). Both small mammal and immature tick species diversity in 2012 appeared comparable to past years. As in past years, *Peromyscus leucopus* was the predominant mammal species collected and for *I. scapularis*, since 2002 and including 2012, *I. scapularis* has comprised  $\geq 50\%$  of our overall collections seven times. Tabulating our data differently than we typically do showed that while the average number of *I. scapularis* per infested mammal (any with at least one *I. scapularis*) was higher for years other than 2012, the 27% we calculated for 2012 is our highest infestation percentage ever. As of April 29, 2013 provisional statewide tallies for 2012 as tabulated by the MN Dept Health (MDH) were Lyme (917) and human anaplasmosis (488), both lower than 2011. 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 *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:

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**

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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, 2012 and ended on October 25, 2012 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**

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### **➤ 2012 Study (Repeat Sites):**

From 2007-2010 and again in 2012 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 71 of our 100 sampling sites, with 44 of these positive sites located north of the Mississippi River in Anoka (21 sites positive/28 sites sampled), Washington (22 sites positive/25 sites sampled), and Ramsey 1 site positive/3 sites sampled) counties. Twenty-seven additional positive sites were detected south of the river in Dakota (13), Hennepin (7), Scott (4) and Carver (3) counties (Figure 5A).

Overall, 1537 mammals (Figure 1 and 2012 results in Table 2) were inspected: 641 from north of the Mississippi River and 896 from south of the river and a total of 1460 *I. scapularis* (Figure 2 and 2012 results in Table 3) were collected from them. The Washington County sites accounted for 46% of the total *I. scapularis* collections (626L; 44N) with the highest numbers collected in May (287L; 17N) Township. Dakota County accounted for another 29% of our total *I. scapularis* collections (396L; 23N), with the highest numbers collected in Burnsville (254L; 4N) Township. An additional 13% of the total (139L; 55N) were collected from our Anoka County sites, with the highest collections occurring in Ham Lake (18L; 20N) and Andover (28L; 3N) townships.

The overall season mean number of *I. scapularis* collected per mammal in 2012 was .950 (larvae: .859, nymphs: .090). The mean increases to 1.301 (larvae: 1.177, nymphs: .124) when all sites negative for *I. scapularis* are excluded (see 2012 results in Figure 6). The highest average number of *I. scapularis* per mammal was calculated for Washington County (1.909), followed by Dakota (1.132), Anoka (.785) and Scott (.539) counties (see 2012 results in Figure 3). North of the Mississippi River, townships in Washington County averaging  $\geq 1.0$  *I. scapularis* per mammal in 2012 were May (3.494), Lakeland (2.5), Hugo (2.333), Cottage Grove (2.324), and Denmark (1.309) and in Anoka, Ham Lake (3.455), Coon Rapids (1.4), Saint Francis (1.333) and East Bethel (1.0). Averaging  $\geq .500$  *I. scapularis* per mammal were Stillwater (.833), New Scandia (.737), Lake Elmo (.535) of Washington County and Andover (.738), Oak Grove (.783), and Linwood (.600) townships of Anoka County (Figure 4). South of the Mississippi River (no figure), townships maintaining averages  $\geq .500$  *I. scapularis* per mammal were Burnsville (8.323), Hastings (1.724), Vermillion (1.462), Inver Grove Heights (.860) and Ravenna (.571) of Dakota County, Credit River (2.233), Louisville (.786), and Saint Lawrence (.750) of Scott County, and Eden Prairie (2.778) and Brooklyn Park (2.0) of Hennepin County.

### ➤ **Compiled Results (Repeat Sites) from 1990 - 2012 or 1991 - 2012:**

The 1990-2012 mean number of *I. scapularis* collected per mammal is .351, with the highest averages continuing to occur north of the Mississippi River. For individual years, 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 and 2011 (Figure 3). Anoka's compiled 1990-2012 overall season mean is .954 and is followed closely by Washington County (.868). The 1990-2012 township averages (all  $> 1.0$ ), north of the Mississippi River include May, Hugo, New Scandia, and Grant of Washington County and Coon Rapids, Blaine, Saint Francis, Ham Lake, and East Bethel of Anoka County, while the averages for Linwood of Anoka County and Afton, Lakeland, and Lake Elmo 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 (1991 – 2012), Inver Grove Heights (1.014), Burnsville (.964), Vermillion (.740), and Ravenna (.524) townships of Dakota County maintained 1991-2012 averages  $> .500$  *I. scapularis* per mammal<sup>2</sup> (no figure).

*I. scapularis* status at the 100 repeat sampling locations is shown on Figure 5. The status has changed at 91 of the sites since 1990 or 1991 (see 2012 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. The second Shoreview Township site was positive for *I. scapularis* again in 2005, 2006, 2008 and 2010. 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 *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.

<sup>1</sup> 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  $\geq .500$ .

<sup>2</sup> 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.

In 1998 we first detected *I. scapularis* in Hennepin and Scott counties<sup>3</sup> and in 2000 we began to tabulate more sites south of the river. Our tabulation of 27 positive sites south of the river in 2012 is a new record total, surpassing the previous high of 26 that had been set in 2011 (Table 1A).

Comparing our 2012 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 and for *I. scapularis*, since 2002 and including 2012, *I. scapularis* has comprised  $\geq 50\%$  of our overall collections seven times. Comparatively, in any other year *Dermacentor variabilis* had comprised the majority of our collections (Table 3). As Figures 3 and 6 show, our 2012 overall season mean of .950 *I. scapularis* per mammal is our 2<sup>nd</sup> highest on record but it remains comparable to the averages we have come to expect in recent years (2000 – 2002, 2004, 2005, 2007, 2009 and 2010 were all  $\geq .806$ ); higher than the averages we had compiled from 1990-1999 (range .089 - .406). There was roughly a five-fold increase in our 2012 larval collections compared to 2011 and while our nymphal collections decreased by half compared to 2011, the total of 139 is the sixth-highest total we have collected to date (Table 3). *P. leucopus* consistently has been the predominant mammal species collected each year with some variability in the total percentages collected<sup>4</sup> (Figure 1 and Table 2). The 2012 average number of mammals collected per site (15.37) represents a higher than typical yearly small mammal collection level (Table 2). Our compiled average small mammal collection success level per site for 1990 through 2012 is 12.78 (1991-2012 average of 12.11 for 100 repeat sites only), with results ranging from the low of 7.02 mammals collected per site in 2008 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 some 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<sup>5</sup>. However, as we have begun to document more positive sites south of the Mississippi River in recent years, including 2012, we believe that tick-borne disease risk via greater *I. scapularis* exposure opportunities is occurring now in areas south of the Mississippi River as well. In fact, our Dakota County sites accounted for the 2<sup>nd</sup> highest percentage of our total *I. scapularis* collections for the 3<sup>rd</sup> consecutive year and it is now becoming common for us to find at least one *I. scapularis* in all seven of the counties that comprise our service area each year.

It was a high collection year for both mammals (Table 2) and larval *I. scapularis* ticks (Table 3). In fact, 2012 was only the 2<sup>nd</sup> time *I. scapularis* comprised  $\geq 60\%$  of our overall collections (2012 65%, 2010 72%). Yet based on only that data, it was not the remarkable, record-setting year that we had suspected it would be during the season. For that reason we compiled our data differently and have presented it in Table 4. Table 4 shows that although we did set a new record of 71 positive sites in

<sup>3</sup> *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.

<sup>4</sup> 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

<sup>5</sup> 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).

2012, we had tabulated a similar high total of 70 positive sites in 2010. The average number of *I. scapularis* per infested mammal (any with at least one *I. scapularis*) was higher for years other than 2012. However, 2012 did have the highest ever percentage of infested mammals, so maybe it had been a remarkable year, just not in the way we had expected. Although March 2012 was the warmest ever in Minnesota<sup>6</sup> and adult *I. scapularis* and *Dermacentor variabilis* emerged in very early March (personal observation), we do not think we missed many collections of larval *I. scapularis* as any eggs laid by an adult female do not hatch for a month. We do acknowledge a possible impact on our larval *D. variabilis* collections and our tabulation of the 2012 proportion of *I. scapularis* to *D. variabilis* collected, as *D. variabilis* larvae overwinter unfed and could have emerged much earlier than in a typical year as well.

Examining human data, as of April 29, 2013 statewide tallies for 2012 as tabulated by the MDH were not yet available. They reported provisional 2012 data as Lyme (917) and human anaplasmosis (488). Their 2011 Lyme total was 1201, with 782 human anaplasmosis cases (the current record high for HA). Their 2010 Lyme (1293) and human anaplasmosis (720) totals had both been new record highs when tabulated and the 2010 Lyme total remains the record high for that disease. The 2009 totals for Lyme (roughly 1065) and HA (317) were similar to the case totals of 2007 (Lyme 1239; HA 322 (record setting at the time)) and were also close to the 2008 totals (Lyme 1050; HA 278). The Lyme case total for 2004 was 1023, with the Lyme case totals of 2005 (918), 2006 (914), and 2002 (867) also at very high levels compared to other years. For reference, compared with roughly 250 cases per year through 1999, their statewide Lyme case total in 2000 was 463 cases, with the Lyme case totals of 2001 (465 cases), and 2003 (473 cases) being similar. As we have already shown, statewide human anaplasmosis case totals have increased in recent years, too. Through 1999 the MDH had only been compiling an average of roughly 15 HA cases per year but case totals ranged from 78 to 152 from 2000 – 2004. 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. Although slightly lower than the 2007 record total of 322, the HA case totals for 2008 and 2009 were similar in count and very high in comparison to prior years.

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 – 1999 and 40 to 69 from 2000 – 2006. Although HA had been detected in metro-collected small mammals beginning in 1995<sup>7</sup> in MMCD collaborative research, locally acquired human HA cases were not documented by MDH until 2000. From 2000 – 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 period when the MDH separated metro residents from people who reside elsewhere in the state, they had consistently documented that metro residents comprised roughly half of the Lyme cases they tallied<sup>8</sup>.

We believe that the risk of tick encounters in the metro 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.

<sup>6</sup>MN Climatology Working Group. State Climatology Office – DNR Division of Ecological and Water Resources. University of Minnesota. [http://climate.umn.edu/doc/twin\\_cities/march\\_msp\\_rank.htm](http://climate.umn.edu/doc/twin_cities/march_msp_rank.htm)

<sup>7</sup>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](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.

<sup>8</sup>Slide 37 [www.health.state.mn.us/divs/idepc/diseases/lyme/lymeslide.ppt](http://www.health.state.mn.us/divs/idepc/diseases/lyme/lymeslide.ppt)

## ADDITIONAL UPDATES/RESEARCH:

### STUDIES/PROJECTS FOR 2013.

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

- **Additional projects:**

As we have since 2009, MMCD will provide samples to Dr. Roger Moon (UM – St Paul), to further the knowledge of the rodent bot fly (Genus *Cuterebra*). In 2012 we are collecting pupae and rearing them out (hopefully) to the adult stage by waiting for emergence from their vials containing sawdust.

### INCORPORATING TECHNICAL ADVISORY BOARD (TAB) SUGGESTIONS-POSTING AT DOG PARKS.

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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. Since 2010 signs have been posted in at least 21 parks with additional signs posted in active dog walking areas, including at Stubbs Bay Park, Luce Line Trail Entrance. We have also worked on expanding our sign placements into additional metro locations. In 2012 we posted a total of 52 signs at 28 locations throughout the metro.

### DISTRIBUTING MATERIALS TO TARGETED AREAS

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In 2012 brochures, tick cards, and/or posters were dropped at roughly 247 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.

### AMBLYOMMA AMERICANUM

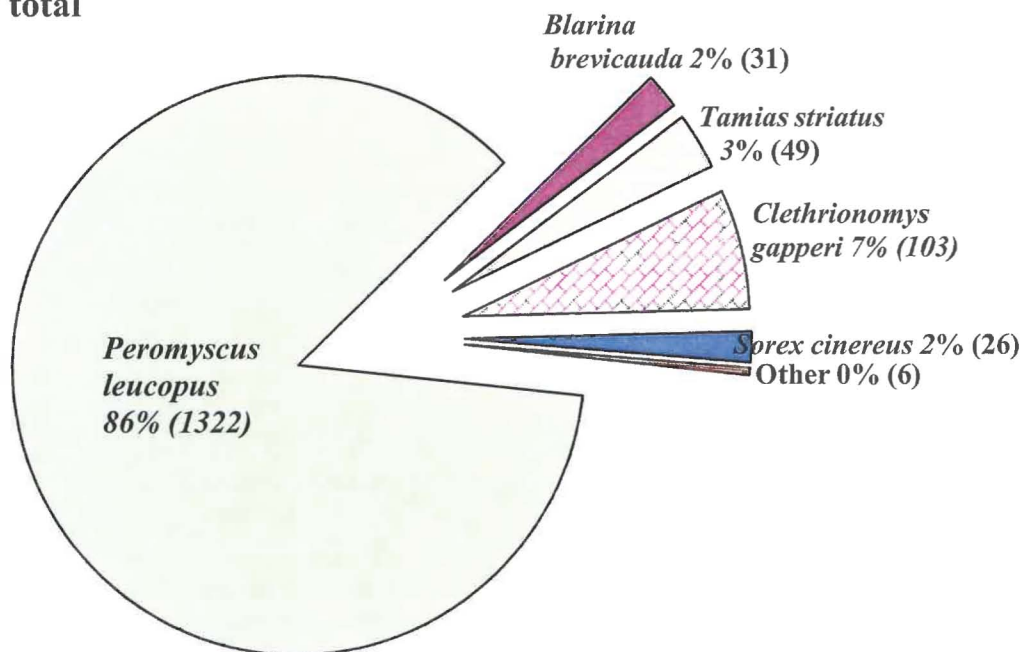
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*Amblyomma americanum* (lone star tick) records are significant because these ticks vector human monocytic ehrlichiosis, they are an aggressive human biter, and their range is known to be moving northward. Though found here since 1990 on a rare, sporadic 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.

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**Small Mammals Collected  
2012: 1537 total**

**Figure 1**



**Ticks, by Species and Stage,  
Removed from Small Mammals  
2012: 2223 total**

**Figure 2**

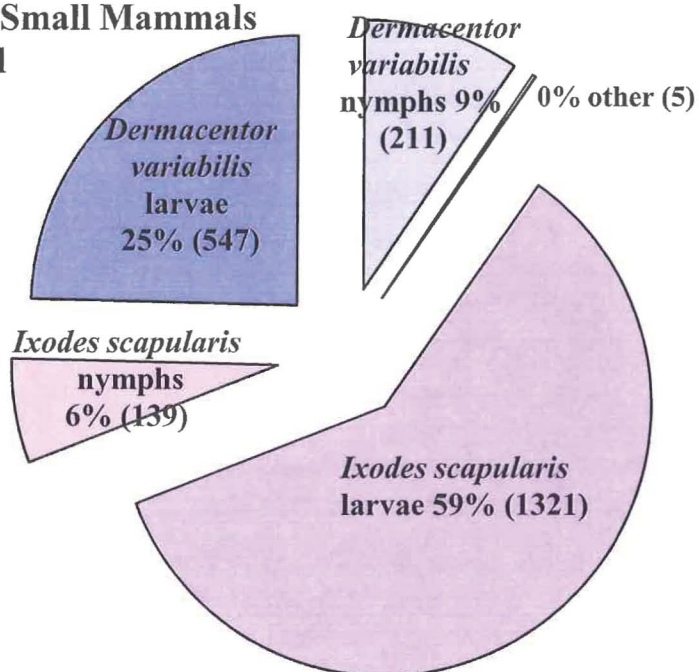


Figure 3

Average number of *I. scapularis* collected per mammal at 100 sampling locations in Anoka, Washington, and Ramsey counties: 1990 - 2012  
(white box shows the total number of sites where at least one *I. scapularis* was found: by year)

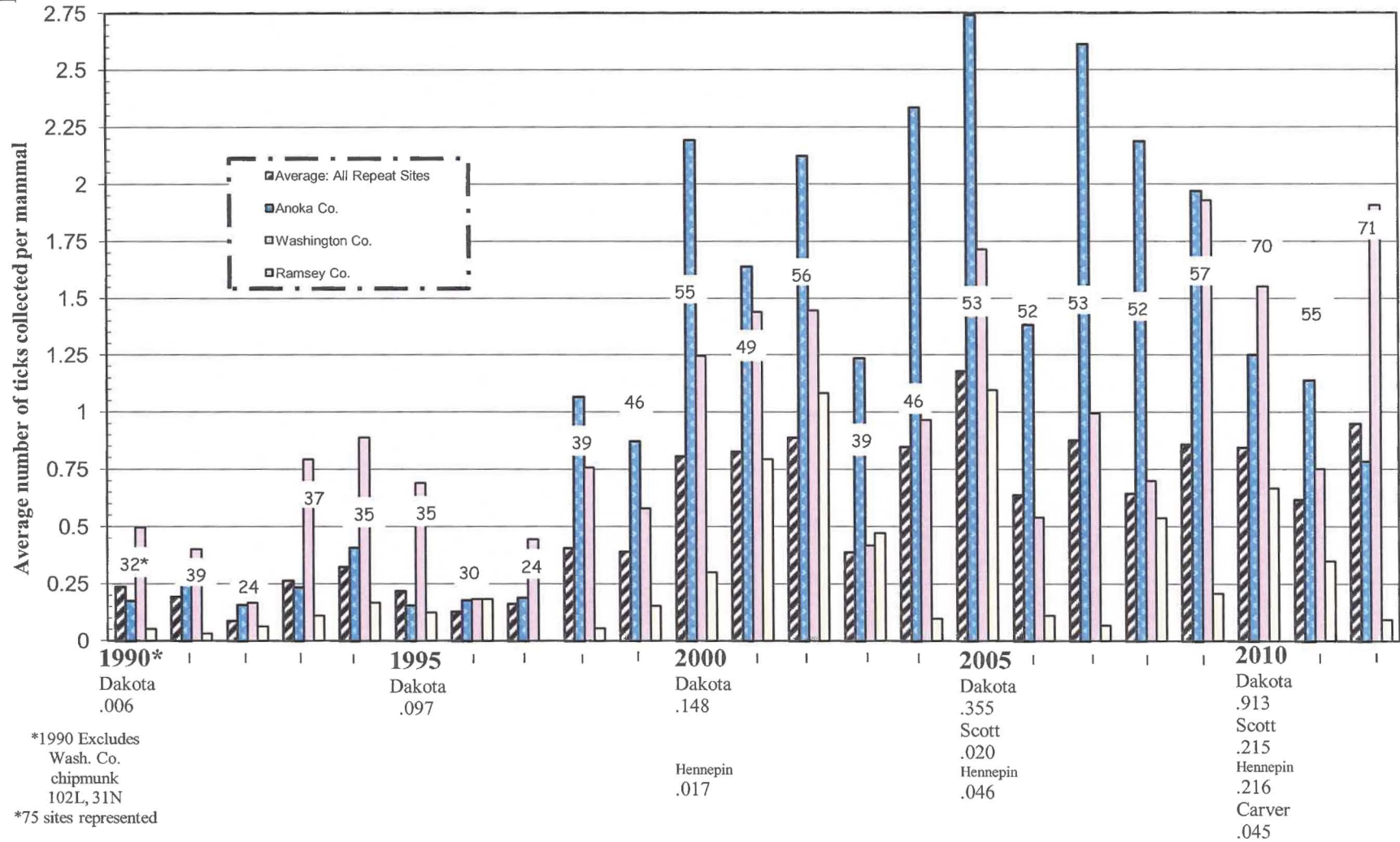
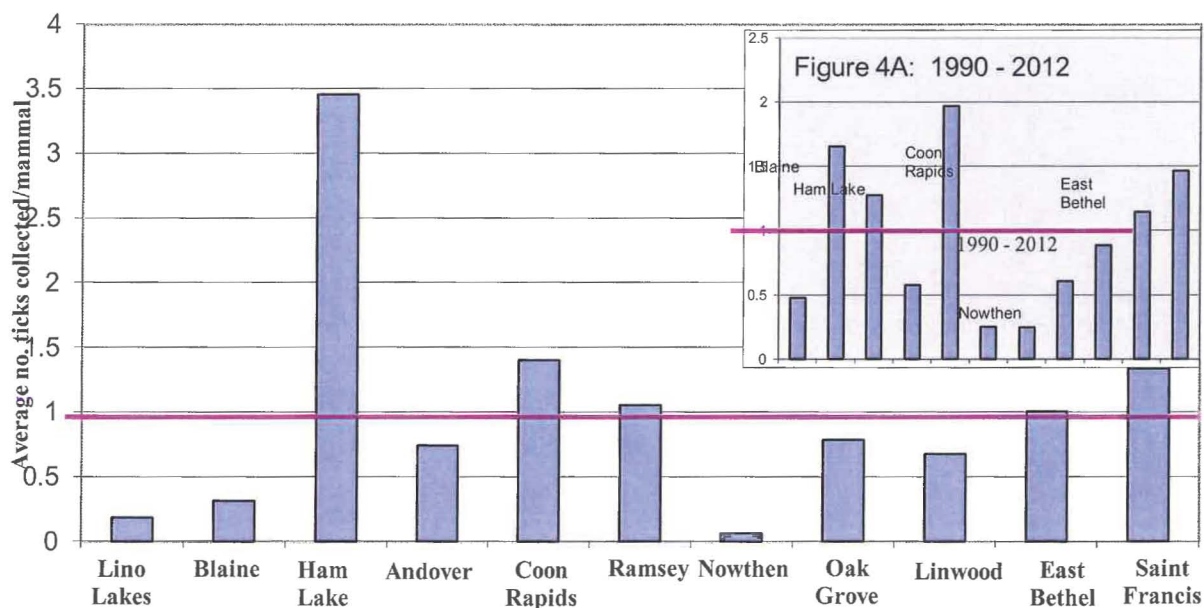


Figure 4

Average number of *I. scapularis* collected per mammal in  
Anoka county (by township): 2012 results



Average number of *I. scapularis* collected per mammal in  
Washington county (by township): 2011 results

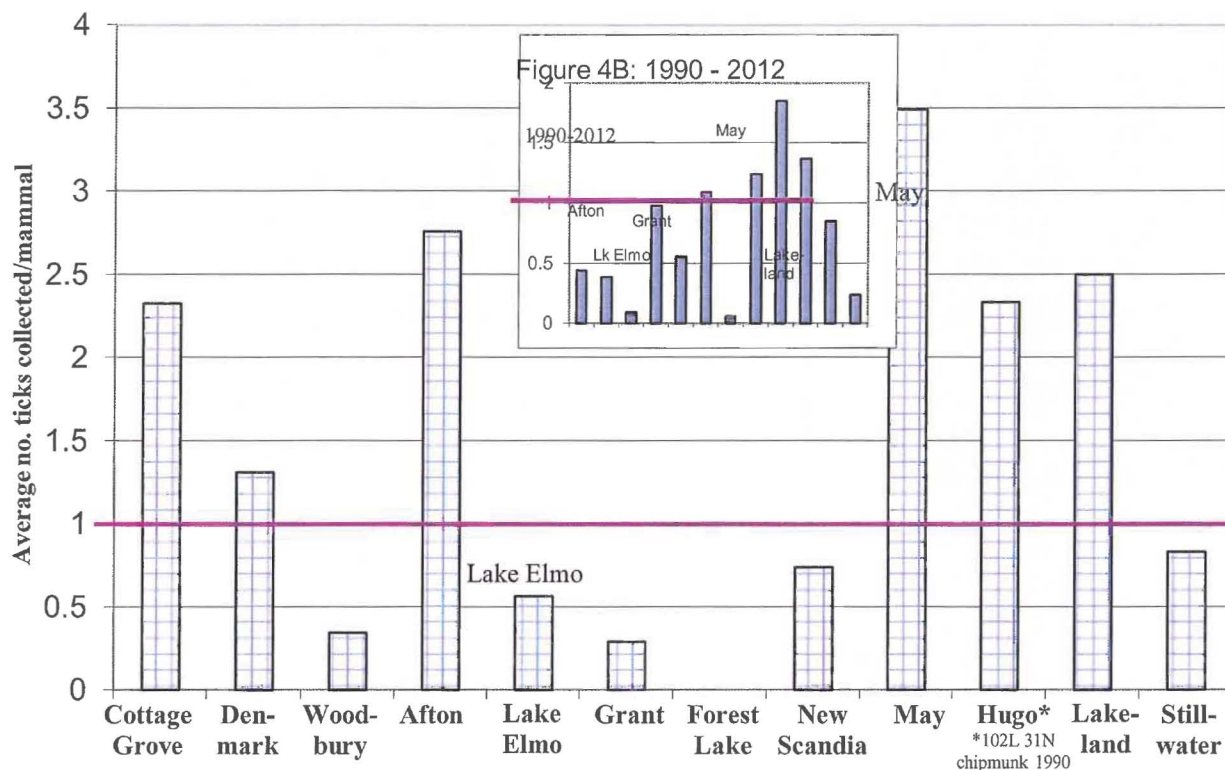
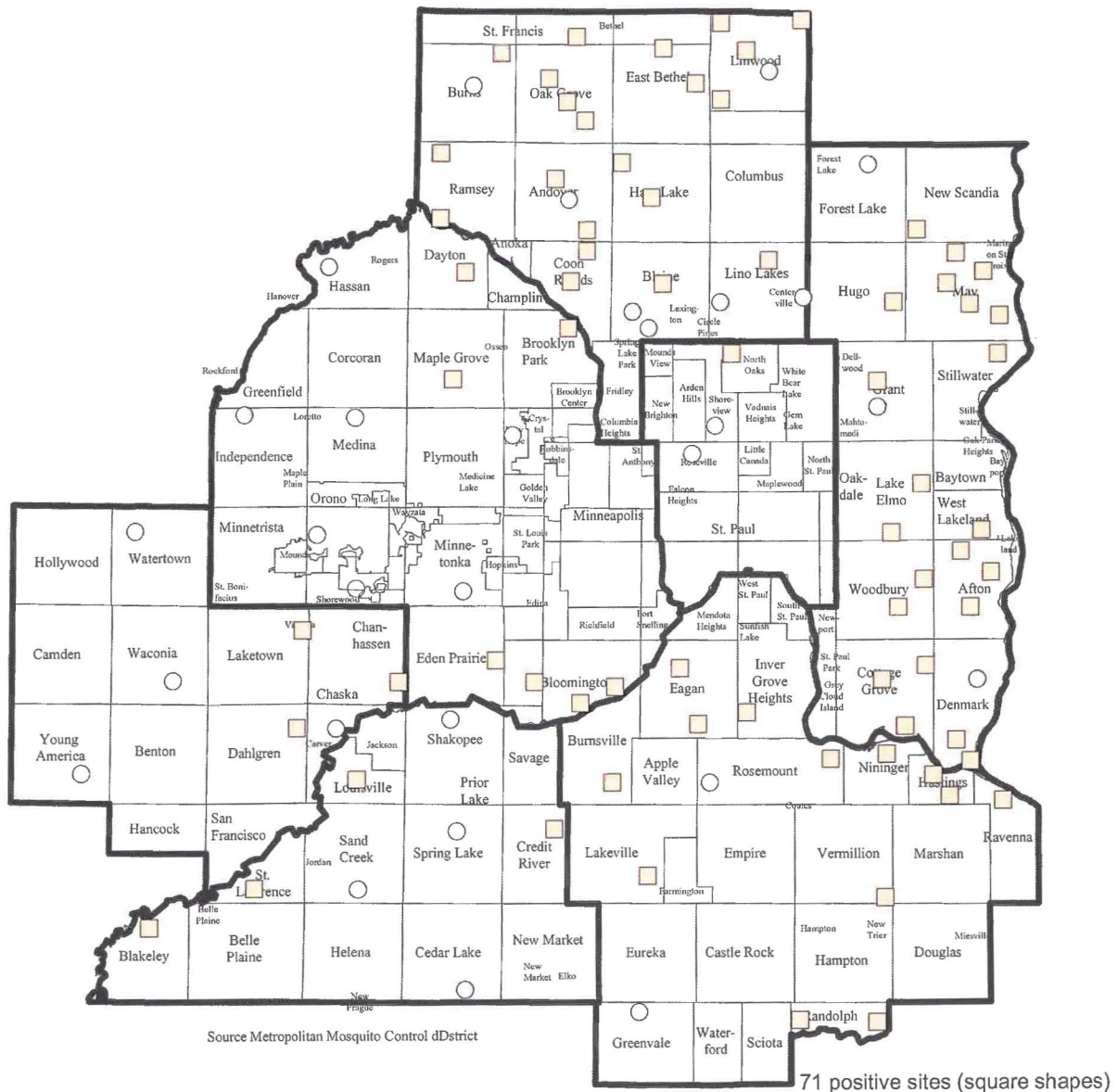


Figure 5A

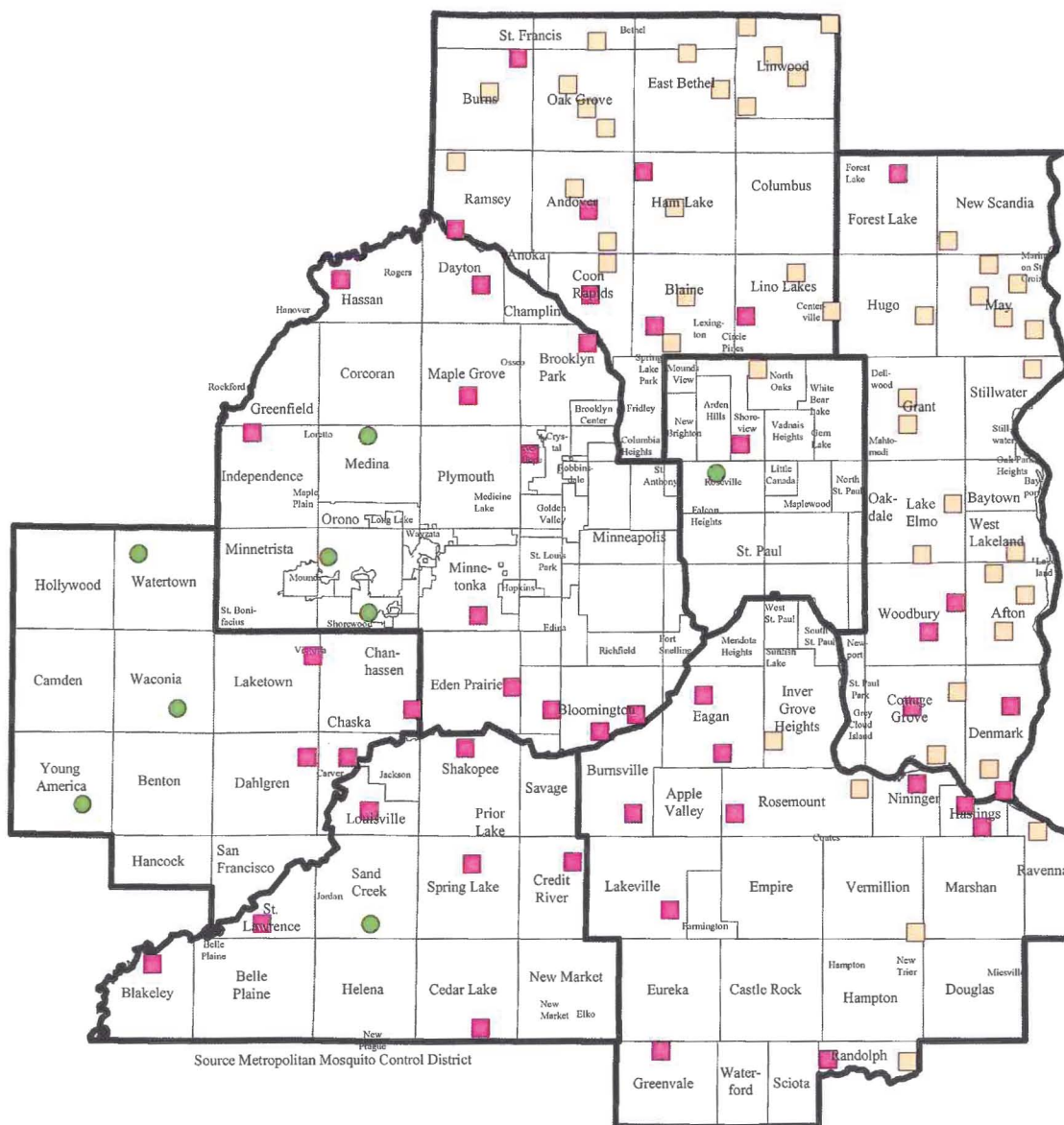
*Ixodes scapularis* Presence / Absence status: 2012  
(present if at least one *I. scapularis* is collected)



| Status 2012           |      |
|-----------------------|------|
| ■ present             | (71) |
| ○ absent this year    | (21) |
| ○ not found 1990-2012 | (8)  |

Figure 5

*Ixodes scapularis* Presence/Absence status: 1990 - 2012  
(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               | (46) |
| (not found)                     | (8)  |

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Figure 6

Average number of *I. scapularis* collected per mammal at 100 repeat sampling locations 1990-2012 overall vs. sites where at least one *I. scapularis* was collected (positive sites)

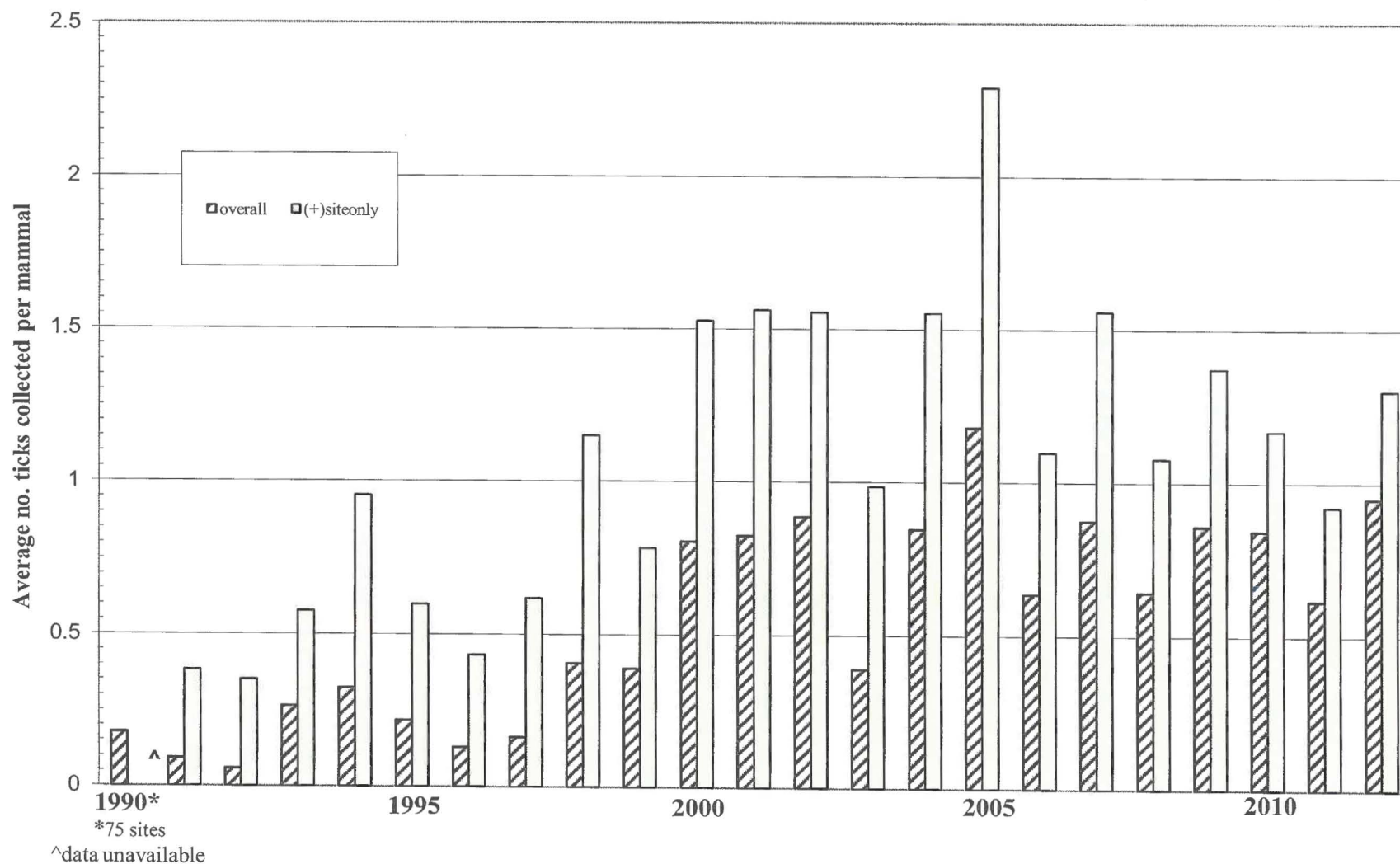


Table 1: Comparison of *I. scapularis* Presence/Absence Status  
at 100 Repeat Sampling Locations

| No. sites<br>changing status | 1992 | 1994 | 1996 | 1998 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
|                              | 26   | 38   | 47   | 58   | 61   | 66   | 69   | 72   | 75   | 76   | 78   | 80   | 81   | 83   | 88   | 90   | 91   |
| Ticks found:                 |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| all years                    | 21   | 17   | 11   | 5    | 5    | 5    | 4    | 3    | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 1    |
| most years                   | 5    | 15   | 19   | 27   | 31   | 34   | 35   | 37   | 38   | 41   | 41   | 45   | 42   | 44   | 44   | 44   | 45   |
| least                        | 21   | 23   | 28   | 31   | 30   | 32   | 34   | 35   | 37   | 35   | 37   | 35   | 39   | 39   | 44   | 46   | 46   |
| (not found)                  | 53   | 45   | 42   | 37   | 34   | 29   | 27   | 25   | 24   | 23   | 21   | 19   | 18   | 16   | 11   | 9    | 8    |

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 | 2008 | 2009 | 2010 | 2011 | 2012 |
|----------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Total sites south of river | *1   | 2    | 4    | 4    | 7    | 10   | 12   | 6    | 9    | 10   | 12   | 16   | 19   | 19   | 24   | 26   | 27   |
| By county:                 |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Dakota                     | *1   | 2    | 4    | 2    | 6    | 7    | 8    | 6    | 8    | 7    | 9    | 10   | 12   | 11   | 10   | 11   | 13   |
| Hennepin                   | *0   | 0    | 0    | 1    | 1    | 2    | 3    | 0    | 0    | 1    | 2    | 3    | 3    | 3    | 6    | 9    | 7    |
| Scott                      | *0   | 0    | 0    | 1    | 0    | 1    | 1    | 0    | 1    | 2    | 1    | 2    | 2    | 3    | 6    | 6    | 4    |
| Carver                     | *0   | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 1    | 2    | 2    | 2    | 0    | 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>Clethrionomys gapperi</i> percent (n) | <i>Blarina brevicauda</i> percent (n) | Other* percent (n) |
|-------------------|-----------|-------------------------|--|--|------------------------------------|--|---------------------------------------|--------------------|
| <sup>a</sup> 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)            |

\*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 <sup>b</sup><br>percent (n) | <i>Dermacentor variabilis</i> N <sup>c</sup><br>percent (n) | <i>Ixodes scapularis</i> L <sup>b</sup><br>percent (n) | <i>Ixodes scapularis</i> N <sup>c</sup><br>percent (n) | Other species <sup>d</sup><br>percent (n) |
|-------------------|-----------|-----------------------|---|---|--|--|---|
| <sup>a</sup> 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)                                    |

<sup>a</sup> 1990 data excludes one *Tamias striatus* with 102 larval & 31 nymphal *I. scapularis*

<sup>b</sup> L = larvae

<sup>c</sup> N = nymphs

<sup>d</sup> Other species mostly *Ixodes muris* 1999-2nd adult *I. muris* collected 2007-collected 7 *I. marxi* nymphs

**Table 4. Percentage of Infested to Total Mammals; also shown, Number of Positive Sites, By Year 1990-2012**

(mammals or sites with at least 1 *I. scapularis*)

| Year | infestation % | no. infested | total mammals | average <i>Is</i> per<br>infested mammal | no. positive<br>sites |
|------|---------------|--------------|---------------|--|-----------------------|
| 1990 | 8.14%         | 106          | 1302          | 2.906                                    | 32                    |
| 1991 | 6.16%         | 145          | 2354          | 2.834                                    | 39                    |
| 1992 | 4.57%         | 58           | 1268          | 0.914                                    | 24                    |
| 1993 | 9.14%         | 141          | 1543          | 2.901                                    | 37                    |
| 1994 | 9.50%         | 159          | 1672          | 3.415                                    | 35                    |
| 1995 | 8.82%         | 124          | 1406          | 2.467                                    | 35                    |
| 1996 | 7.71%         | 61           | 791           | 1.672                                    | 30                    |
| 1997 | 7.14%         | 52           | 728           | 2.269                                    | 24                    |
| 1998 | 10.27%        | 128          | 1246          | 3.953                                    | 39                    |
| 1999 | 13.58%        | 221          | 1627          | 2.869                                    | 46                    |
| 2000 | 19.78%        | 232          | 1173          | 4.073                                    | 55                    |
| 2001 | 20.96%        | 188          | 897           | 3.941                                    | 49                    |
| 2002 | 18.04%        | 223          | 1236          | 4.928                                    | 56                    |
| 2003 | 11.77%        | 144          | 1226          | 3.313                                    | 39                    |
| 2004 | 17.36%        | 200          | 1152          | 4.88                                     | 46                    |
| 2005 | 21.35%        | 206          | 965           | 5.427                                    | 53                    |
| 2006 | 19.42%        | 241          | 1241          | 3.282                                    | 52                    |
| 2007 | 21.32%        | 181          | 849           | 4.11                                     | 53                    |
| 2008 | 18.95%        | 133          | 702           | 3.398                                    | 52                    |
| 2009 | 21.04%        | 198          | 941           | 4.08                                     | 57                    |
| 2010 | 20.53%        | 271          | 1320          | 4.118                                    | 70                    |
| 2011 | 20.90%        | 158          | 756           | 2.949                                    | 55                    |
| 2012 | 27.46%        | 422          | 1537          | 3.46                                     | 71                    |