The Role of Publicly Owned Properties in the Transmission of Lyme Disease in Central New Jersey

Terry L. Schulze, PhD and Robert A. Jordan, PhD

ABSTRACT

Using an ecological index to generate a relative ranking of sites regarding potential and actual Lyme disease transmission risk, 610 public parks, recreation areas, and public school properties were surveyed during the summer of 1993. The majority of surveyed sites (56.4%) were judged to pose low potential risk; only 60 sites (9.8%) were identified as posing a high potential risk, requiring additional assessment to estimate actual population densities of infected ticks.

High-risk sites typically were large, multiple-use parks and recreation areas located in areas of lower human population density. Parks and recreation areas in populated coastal areas generally were smaller and more developed. Publicly owned land may be surveyed effectively for Lyme disease transmission risk using an existing ecological index and tick survey techniques, allowing surveillance and intervention efforts to be targeted toward areas posing significant risk of transmission.

Key words: public parks, recreation areas, Lyme disease

INTRODUCTION

Despite general acceptance that the majority of Lyme disease cases are the result of exposure to infected black-legged ticks at or near the patient's place of residence,[1-3] other studies have suggested substantial transmission risk among visitors, workers, and nearby residents of some parks and recreation areas.[4-6] None of these studies adequately characterized habitats and use within the areas studied and, owing to the labor intensity inherent in surveying large areas for ticks, the number of study sites was limited. As a result, the majority of parks and recreational areas are never assessed, leaving the public unaware of potential risk. No studies of transmission risk associated with school properties have been published.

From the Division of Communicable Diseases, New Jersey Department of Health and Senior Services (Dr Schulze), Trenton; and Freehold Area Health Department (Dr Jordan), New Jersey.

The current work was supported by a Cooperative Agreement (U50/CCU206567-05) between the New Jersey Department of Health and Senior Services and the Centers for Disease Control and Prevention.

Address correspondence to Terry L. Schulze, PhD, Division of Communicable Diseases, NJ Department of Health and Senior Services, NJ Department of Health, CN 360, Trenton, NJ 08625.

Recognizing the limitations resulting from the level of effort required to perform tick surveys, an ecological assessment index (Index) was designed to predict potential Lyme disease transmission risk based on the presence, amount, and accessibility of vegetation associations capable of supporting *Ixodes scapularis* Say and its hosts.[7] The results of that pilot study suggested that the Index provides a rapid, accurate method to identify areas at risk for the transmission of Lyme disease.

Through a broad-scale assessment program, the study attempted to test and refine the efficacy of the Index throughout a county where Lyme disease is endemic. Such research is the first step toward the creation of cost-effective management procedures to reduce the incidence of Lyme disease in people using public properties by reducing exposure to infected *I. scapularis*. We report here the results of a survey of all public land in Monmouth County, NJ, for Lyme disease transmission risk.

METHODS

Site selection

Publicly owned land in Monmouth County, NJ, served as study areas for this project. Since Lyme disease became reportable in New Jersey in 1980, Monmouth County has accounted for approximately 22% of all reported cases statewide through 1989. The overall goal of the project was to assess the risk of transmission on all publicly owned lands in Monmouth County as a first step in a county-wide program of Lyme disease prevention and control. Included in the survey were all municipal- and county-administered parks and recreation areas, local- and county-owned open space, state-administered wildlife management areas (WMA) and parks, and federally owned lands. In addition, athletic fields and other open spaces associated with all public schools were included in the surveys.

Habitat of *Ixodes scapularis* in Monmouth County, NJ

I. scapularis tends to be most prevalent in wooded areas and associated ecotones and in old fields in secondary woody succession.[7-11] In the coastal plain of New Jersey, where the majority of Lyme disease cases have been reported, habitats that support high densities of ticks are comprised of mixed hardwood (*Quercus alba, Quercus prinus,* and *Quercus rubra*); mixed hardwood/pine (*Pinus rigida*); and pine forests with a dense shrub layer dominated by highbush blueberry (*Vaccinium corymbosum*), lowbush blueberry (*Vaccinium angustifolium*), and huckleberries (*Gaylussacia* spp.). Minor species generally include sheep laurel (*Kalmia angustifolia*), northern bayberry (*Myrica pensylvanica*), and often dense tangles of common greenbriar (*Smilax rotundifolia*).[12]

Brush/scrub habitats (late old fields) also may serve as adequate habitat, as do certain ornamental landscapings.[11] Suburban residential foci for Lyme disease in the Northeast frequently are associated with adjacent or nearby woodlands.[2,4,13] The presence of dense shrub layers, leaf litter, and other plant debris seems to play an important role in the survival of subadult ticks by maintaining conditions of high humidity.[14,15] Thus, habitats generally unfavorable for ticks include open sunny areas such as turfgrass (lawns, athletic fields, and other recreational areas), agricultural land, and wetlands.

Ecological assessment Index

The assessment Index used in this study relies on documented habitat affinities of *I. scapularis*, the black-legged tick (formerly *I. dammini*), the primary vector for the Lyme disease spirochete *Borrelia burgdorferi* in the Northeast. Assessment of potential risk relies on evaluation of plant communities associated with a particular site. Because potential risk also is dependent on human exposure, the Index also considers the degree to which suitable tick habitat is accessible to people potentially at risk. The assessment of actual risk of transmission incorporates *I. scapularis* abundance and rate of infection by *B. burgdorferi*.

Assessment of potential risk

Potential risk was evaluated based on the characterization of sites with respect to three parameters that describe the suitability of vegetation as tick habitat, the extent of that habitat, and its accessibility to people using the site[7]:

1. The habitat suitability parameter addresses the relative suitability of available plant cover types for the support of *I. scapularis* populations. A numeric value is assigned, ranging from 1 (agricultural fields and lawns) to 5 (mature forest with substantial shrub layer).
2. Amount of tick habitat on a given property is represented as a percentage of the total area of the property. Point values for habitat availability range from 1 (<20% of the property is tick habitat) to 5 (80% to 100% of the property is tick habitat).
3. Accessibility of tick habitat recognizes that although tick habitat may be present on a particular site, its presence poses no risk if people do not or cannot access it and thus become exposed to infected ticks. Relative accessibility is ranked on a scale from 1 (no access or no suitable tick habitat present) to 5 (suitable tick habitat easily accessible or access is encouraged).

Availability of habitat for ticks may be assessed throughout the year, whereas the seasonality of tick activity restricts use of the simple presence or absence of a given stage of *I. scapularis* to a particular time of year. Owing to the relative ease in collection and high infection rates in adults compared with immature *I. scapularis*,[10,16] assessment of tick abundance is logistically limited to the early spring and fall in New Jersey.[17] Thus, the Index permits characterization of potential risk apart from the presence of ticks and can be performed at any time to determine whether additional action is necessary.

Point values, ranging from a minimum of 1 to a maximum of 5, are assigned to each of the three parameters and totaled. The resulting score is used to determine the appropriate response action for each site and the need to proceed to the second phase of the survey to assess actual risk (Table 1). Sites ranked as having either a moderate or high potential risk of Lyme disease infection are surveyed for actual risk according to a predetermined numeric priority.

Assessment of actual risk

Actual risk is evaluated using data on the presence and size of the tick population and its rate of infection with *B. burgdorferi*. Sites were surveyed for questing adult *I. scapularis* during periods of peak adult activity in October and November 1993.[17] Adult ticks were chosen for use in the Index because of their demonstrated high rate of infec-

Table 1
Scoring and Response Actions: Potential Risk of Transmission

Scoring range	Description of risk	Response action
11 to 15	High	Place under routine tick surveillance and establish rates of infection.
6 to 10	Moderate	Consider periodic tick surveillance and establishment of infection rates.
<6	Low	No action necessary at this time or any time in the future.

Table 2
Scoring and Response Action: Actual Risk of Transmission

Scoring range	Description of risk	Response action
21 to 25	Definite risk	Take immediate action (post area, devise control strategy).
16 to 20	Potential risk	Consider action as above, place under routine tick surveillance.
11 to 15	Limited risk	Perform periodic tick surveillance.
6 to 10	No present risk	Consider periodic tick surveillance; no action necessary.
<6	No risk likely	No action necessary at this time or at any time in the future.

tion.[18] Suitable habitats at all sites were evaluated systematically using walking surveys.[10] All surveys were performed by the same personnel (to avoid sampling biases) on clear days between 10 AM and 2 PM when peak activity was expected. Areas were surveyed for a 60-minute period. At smaller sites, the survey time was reduced as appropriate and the number of ticks collected was extrapolated to the 60-minute standard for ease of comparison.

This survey technique provides a fairly accurate representation of the expected number of adult ticks encountered by humans.[10] The methodology, however, may be modified to permit collection of subadults.[5] The relative abundance of questing ticks was ranked using numeric values ranging from 1 (0 ticks/survey) to 5 (>30 ticks/survey).

Ticks collected during surveys were retained and evaluated for the presence of *B. burgdorferi*.[19] Ticks were dissected and midguts were triturated in phosphate-buffered saline solution on microscope slides. A maximum of 50 fields were examined at ×400 magnification to calculate minimum field infection rates. Field infection rates of collected ticks were ranked using numeric values ranging from 1 (0% to 9% of ticks infected) to 5 (>40% of ticks infected). Point values for potential risk (tick habitat suitability, amount, and accessibility) are added to the point values for tick abundance and infection rate to obtain the actual risk scores used to establish priorities for surveillance and intervention strategies (Table 2).

RESULTS

Potential risk of transmission

Within Monmouth County's 52 municipalities, 610 sites were surveyed for potential risk of transmission, including 415 municipal parks and recreation areas, 27 county parks, seven state parks and WMAs, three federal properties, and 158 school properties (Table 3). Sites ranged in size from less than 1 acre to the 16-mile^2 Naval Weapons Station Earle (NWS Earle). Excluding NWS Earle and Fort Monmouth, a total of 26,923 acres of publicly held parks and recreation areas was surveyed. Acreage of school properties was not available.

A total of 58 (12.8%) parks and recreation areas demonstrated high potential risk of transmission; 136 (30.1%) parks were assigned moderate risk; and the remaining 258 (57.1%) parks and recreational areas received a low rating for potential risk. Of the public school properties, only two (1.3%) demonstrated high potential risk of transmission; 70 (44.3%) were assigned moderate risk; and the remaining 86 (54.4%) received a low risk rating.

Actual risk of transmission

Under normal circumstances, the Index requires survey of both high and moderate potential risk sites. Owing to the magnitude of the study and resource constraints, however, only high potential risk sites were surveyed to determine actual risk. A total of 60 sites (9.8% of all sites) in Monmouth County received numeric scores that suggested high potential risk for Lyme disease transmission. Of the 60 sites in the high potential risk category, 34 were either undeveloped or no longer being used, and therefore were not considered for additional assessment. The remaining 26 sites subsequently were surveyed to assess the level of actual risk to design future surveillance activities and intervention strategies.

Ticks were collected from 11 of 24 parks and recreation areas surveyed for actual risk of transmission. In 60-minute surveys, the sites yielded between 3 and 53 ticks (mean=20.2 ticks/60-minute survey). Minimum field infection rates ranged between 0 and 50% (mean=32.9%). As a result of tick abundance and infection rate data, three of the parks and recreation areas (12.5%) were classified as definite risk, 11 (45.8%) as potential risk, and 10 (41.7%) as limited risk. Tick collections were made at only two of the 158 schools (1.3%) surveyed. No ticks were collected from either site during 60-minute surveys and both were classified as posing limited risk for Lyme disease transmission. A summary of tick abundance and infection rates recorded at surveyed areas is provided in Table 4.

DISCUSSION

The majority of sites (344, or 56.4% of all sites) ranked low in potential transmission risk and required no further survey efforts. Although human resource constraints prevented further assessment of moderate potential risk sites, these public properties likely will require additional attention as the goals of local authorities and responsible agencies warrant. Surveillance of tick populations is a labor-intensive and time-consuming enterprise.[5] Therefore, depending on available human resources and local understanding of the relative degree that different public areas tend to be used, assessment personnel must prioritize sites using relative potential risk. For example, sites that score a potential risk value of 9 or 10 should be addressed with greater urgency than sites scoring 6 or 7 when allocating resources for subsequent assessments for actual risk of transmission. Local officials can best assess whether habitat suitability, accessibility of existing tick habitat, or another of the measured parameters actually contributes most to transmission risk at a particular site. Local knowledge of public land can be quite useful in developing intervention or management strategies.

Some areas yielded no ticks during surveys, yet were classified as demonstrating high potential risk. This apparently anomalous result is explained by the fact that the Index relies both on the actual presence and infection rates of ticks and on the suitability of available habitats to support tick populations. For example, a particular park that scored high with regard to potential risk may be assigned limited actual risk if surveys fail to produce many infected ticks. The high score resulting from the assessment of the habitat parameters, however, suggests that the potential for ticks to be present in subsequent years is significant and underscores the need for periodic surveillance. Even relatively low tick density can generate high transmission risk.[20]

In other instances, sites yielding higher numbers of ticks were ranked lower in actual risk of transmission than sites with fewer ticks. For example, NWS Earle yielded 46 ticks/60-minute survey and was classified as having potential risk, although Turkey Swamp Park yielded only 21 ticks/60-minute survey and was classified as a definite risk site. Turkey Swamp Park ranked higher in potential risk of transmission because of a high accessibility score compared with NWS Earle, which is a secured facility with severe access restrictions.

During the course of this project, it became apparent that although the Index provided a flexible survey instrument allowing the rapid assessment of potential and actual risk of Lyme disease transmission over large geographic areas, some operational modification of the methodology would be required. The utility of the Index generally was limited to large tracts; primarily because as tract size increases, habitat diversity increases, and larger tracts tend to feature multiple-use facilities. The risk of exposure at larger parks, then, generally is use dependent. For example, park visitors accessing hiking trails that run through forested areas suitable as tick habitat will experience significantly greater risk of exposure to *I. scapularis* than those who limit their activity to athletic fields and paved courts.

Similarly, certain areas tend to be of limited use or used by a limited public constituency. For example, state WMAs are relatively undeveloped and generally are used by hunters and anglers rather than the public at large. Exposure to *I. scapularis* is, therefore, user group related. Consequently, any future assessment of risk transmission performed as part of an integrated management program should address the specific constituency at risk. For larger sites with more than one type of suitable tick habitat or use, and where some type of intervention is anticipated, the assessment of potential risk should address each habitat and use separately.

Data on the geographic distribution of public properties at risk for Lyme disease transmission suggest certain trends. In general, high-risk sites were limited in number and confined to the western portion of the county. Coastal towns consistently had the greatest number of low-risk municipal parks, recreation areas, and schools. Of the

Table 3
Summary Statistics for Parks, Recreational Areas, Open Space, and Public School Grounds Surveyed for Potential Risk of Lyme Disease Transmission in Monmouth County, NJ, June to November 1993

		Number of sites		
Site type	Acreage*	High†	Moderate	Low
Municipal parks	4278	44 (10.6%)	115 (27.7%)	256 (61.7%)
School grounds	-	2 (1.3%)	70 (44.3%)	86 (54.4%)
County parks	8374	10 (37.0%)	16 (59.3%)	1 (3.7%)
State lands	12 671	3 (42.9%)	4 (57.1%)	-
Federal lands‡	1600	1	1	1
Total	26 923	60 (9.8%)	206 (33.8%)	344 (56.4%)

**Acreage of municipal lands is approximate; acreage for school grounds unavailable.*
†High potential risk indicates need for additional survey work to ascertain actual risk; moderate potential risk=additional survey work should be considered; low potential risk=no additional action necessary.[7]
‡Excludes NWS Earle and Fort Monmouth.

Table 4
Summary of **Ixodes scapularis** *Abundance and Infection Rates (IR) From Recreational Areas and School Properties Yielding Ticks in Monmouth County, NJ, and Resultant Actual Risk of Lyme Disease Transmission*

Municipality	Location	Number of ticks*	IR (%)	Relative risk†
Colts Neck Township	NWS Earle	46	38.9	Potential risk
Eatontown Township	Wall Street Park	4	0	Potential risk
	Woodmere School	0	-	Limited risk
Freehold Borough	Lake Topanemus	9	33.3	Potential risk
Freehold Township	Turkey Swamp Park	21	41.7	Definite risk
	Whittier Oaks Park	24	33.3	Definite risk
	Woodgate Farms	0	-	Potential risk
	Freehold High School	0	-	Limited risk
Holmdel Township	Holmdel County Park	3	0	Limited risk
Howell Township	Allaire State Park	53	37.8	Definite risk
	Oak Glen Park	4	0	Limited risk
Manalapan	Deerway Mobile Park	0	-	Potential risk
	Gordons Corner Park	0	-	Limited risk
	Pinewood Drive Park	0	-	Potential risk
Middletown	Hartshorne County Park	0	-	Potential risk
	Huber Woods County Park	0	-	Limited risk
	Poricy Park	4	50.0	Potential risk
	Tatum Park	0	-	Limited risk
	Thompson Park	0	-	Limited risk
Millstone Township	Assunpink WMA	33	30.0	Potential risk
Neptune	Shark River County Park	21	14.3	Potential risk
Sea Girt	Crescent Park	0	-	Limited risk
Tinton Falls	Pinebrook Recreation	0	-	Limited risk
Wall Township	Marigold Park	0	-	Limited risk
West Long Branch	Wall Street Park	0	-	Limited risk

**Adult ticks/60-min survey.*
†Response actions recommended[7]:
definite risk—take immediate action (post area, devise control strategy);
potential risk—consider action as stated above but with lower priority, place under routine tick surveillance;
limited risk—perform periodic tick surveillance.

one third (n=17) of municipal parks and recreation areas with the lowest mean scores, 15 (88.2%) were in coastal towns. Parks and recreation areas in these communities—primarily urban areas with high development intensity—tend to be of low suitability for the support of tick populations. Developed parks tend to be maintained lawns or beach areas; areas supporting woody vegetation tend to be maritime forest with poorly developed understory structure, which offers poor habitat for ticks. Demographic data show that the majority of the population in Monmouth County is concentrated in the shore communities; consequently, limited resources available for prevention and control activities can be more appropriately targeted to specific areas that demonstrate the highest risk of transmission.

Although most (54.4%) school properties demonstrated low risk, a significant number (n=70) were assigned moderate potential risk. A total of 61 of the 70 schools, however, received a score of "6," indicating that suitable tick habitat was located on private property adjacent to the school grounds. As such, prevention and control options may be limited.

Park managers had mixed reactions to the results of this study. Some felt that as only a small number of public properties posed any real risk of Lyme disease transmission, public concerns regarding the relative safety of parks, recreation areas, and schools should be allayed. Some managers of parks identified as having high risk, however, voiced concerns that a decrease in park use and loss of revenue would follow public disclosure of the study. Clearly, public health officials and park administrators should work in concert to develop ways to inform park visitors about habitats and behaviors that may reduce risk of exposure to infected ticks. Ideally, information obtained from these educational efforts will carry forward and have an impact on reducing peridomestic exposure.

Where intervention is deemed a next step at high-risk sites—which generally are large, multiple-use parks and recreation areas—tick management through the use of acaricides may be impractical and may not receive public support. Rather, the goal of prevention and control activities should be "exposure management," where an integrated approach (education, posting, vegetation control, etc) is used to reduce transmission risk. Targeting areas most at risk for transmission of Lyme disease also will assist in directing educational efforts at human populations at risk. Awareness signs and other efforts may be most productively used in parks and recreational areas where the risk is highest and the user groups are more clearly defined.

Where the use of acaricides is deemed appropriate, control efforts directed against vector ticks should be limited to areas that provide suitable habitat for ticks, thus eliminating unnecessary applications and reducing the amount of acaricide placed into the environment. This is particularly important around schoolyards and other areas where children spend significant periods of time. Because acaricide use is minimized, the costs of intervention are reduced significantly.

Results of this project may be used to identify managed areas at risk for Lyme disease prospectively. Previously, areas at risk could be identified only retrospectively, either by randomly conducted tick surveys or by plotting locations of case reports. Use of the Index allowed the majority of public areas to be systematically eliminated from public health concern after initial assessment efforts indicated low potential risk for Lyme disease transmission because existing vegetative cover did not provide adequate habitat for *I. scapularis*.

REFERENCES

1. Hanrahan JP, Benach JL, Coleman JL, et al. Incidence and cumulative frequency of endemic Lyme disease in a community. *J Infect Dis.* 1984:150:489-496.
2. Falco RC, Fish D. Prevalence of *Ixodes dammini* near homes of Lyme disease patients in Westchester County, New York. *Am J Epidemiol.* 1988:127:826-830.
3. Falco RC, Fish D. Ticks parasitizing humans in a Lyme disease endemic area of southern New York State. *Am J Epidemiol.* 1988:128:1146-1152.
4. Lastavica CC, Wilson ML, Berardi VP, Spielman A, Deblinger RD. Rapid emergence of a focal epidemic of Lyme disease in coastal Massachusetts. *N Engl J Med.* 1989:320:133-137.
5. Falco RC, Fish D. Potential for exposure to tick bites in recreational parks in a Lyme disease endemic area. *Am J Public Health.* 1989:79:12-15.
6. Schwartz BS, Goldstein MD, Childs JE. Antibodies to *Borrelia burgdorferi* and tick salivary gland proteins in New Jersey outdoor workers. *Am J Public Health.* 1993:83:1746-1748.
7. Schulze TL, Taylor RC, Taylor GC, Bosler EM. Lyme disease: a proposed ecological index to assess areas of risk in the northeastern United States. *Am J Public Health.* 1991:81:714-718.
8. Cary AB, Krinsky WL, Main AJ. *Ixodes dammini* (Acari: Ixodidae) and associated ixodid ticks from south-central Connecticut, USA. *J Med Entomol.* 1980:17:89-99.
9. Anderson JF, Magnarelli LA. Vertebrate host relationships and distribution of ixodid ticks (Acari: Ixodidae) in Connecticut, USA. *J Med Entomol.* 1980:17:314-323.
10. Ginsberg HS, Ewing CP. Comparison of flagging, walking, trapping, and collecting ticks from hosts as sampling methods for northern deer ticks, *Ixodes dammini*, and lone-star ticks, *Amblyomma americanum* (Acari: Ixodidae). *Exp Appl Acarol.* 1989:7:313-322.
11. Maupin GO, Fish D, Zultowsky J, Campos KG, Piesman J. Landscape ecology of Lyme disease in a residential area in Westchester County, New York. *Am J Epidemiol.* 1991:133:1105-1113.
12. Robichaud B, Buell MF. *Vegetation of New Jersey*. New Brunswick, NJ: Rutgers University Press: 1973:340.
13. Schulze TL, Vasvary LM, Jordan RA. *Lyme Disease: Assessment and Management of Vector Tick Populations in New Jersey*. Cook College/NJAES: 1994:17.
14. Schulze TL, Jordan RA. Potential influence of leaf litter depth on the effectiveness of granular carbaryl against subadult *Ixodes scapularis* (Acari: Ixodidae). *J Med Entomol.* 1995:32:205-208.
15. Schulze TL, Jordan RA, Hung RW. Suppression of subadult *Ixodes scapularis* (Acari: Ixodidae) following removal of leaf litter. *J Med Entomol.* 1995:32:730-733.
16. Schulze TL, Jordan RA, Vasvary LM, et al. Suppression of *Ixodes scapularis* (Acari: Ixodidae) nymphs in a large residential community. *J Med Entomol.* 1994:31:206-211.
17. Schulze TL, Bowen GS, Lakat MF, Parkin WE, Shisler JK. Seasonal abundance and host utilization of *Ixodes dammini* (Acari: Ixodidae) and other ixodid ticks from an endemic Lyme disease focus in New Jersey, USA. *J Med Entomol.* 1986:23:105-109.
18. Schulze TL, Lakat MF, Parkin WE, Shisler JK, Charette DJ, Bosler EM. Comparison of rates of infection by the Lyme disease spirochete in selected populations of *Ixodes dammini* and *Amblyomma americanum* (Acari: Ixodidae). *Zentralblatt fur Bakteriologie, Mikrobiologie und Hygiene.* 1986:263:72-78.
19. Bosler EM, Coleman JL, Benach JL, et al. Natural distribution of the *Ixodes dammini* spirochete. *Science.* 1983:220:321-322.
20. Gineberg HS. Transmission risk of Lyme disease and implications for tick management. *Am J Epidemiol.* 1993:138:65-73.

An author of "The Jarisch-Herxheimer Reaction in Patients with Erythema Migrans," which appeared in the June 1996 issue, would like to add the following note to go along with Table 1: Single EM lesions were noted in 43 of 50 patients (86%) with Jarisch-Herxheimer reactions (JHR) and in 243 of 305 patients (80%) without JHR.