

Project Summary

This is a Joint Research-Extension project to address control of the medically important vector ticks *Ixodes scapularis* (the blacklegged tick) and *Amblyomma americanum* (the lone star tick) at a high-use County-owned facility. After a detailed ecological assessment of tick populations and human risk, we will develop a flexible Integrated Pest Management (IPM) approach to the control of ticks that minimizes the use of area-wide chemical applications through the use of habitat management, host-targeted chemical applications, judicious use of acaricides in only high human risk areas, and education programs for facility employees. Efficacy of the approach will be assessed by monitoring abundance of questing ticks in treated and control areas, as well as the rate of human-tick encounters, over the three years of the study. We will also prepare training workshops and materials on the assessment and management of vector ticks for managers of public lands. Development of an IPM approach to tick control will include the creation of an Integrated Tick Management (ITM) Demonstration Project at the Monmouth County Reclamation Center (MCRC) in Tinton Falls, New Jersey. The proposed Demonstration Area will use multiple control techniques and will be able to accommodate the addition of new techniques for non-chemical or low-chemical tick control as they arise. Once the Demonstration Area is established it can be utilized as a training tool for the current technologies as well as a research area for inventing/integrating new techniques in the future. The proposed project addresses the Public Health Integrated Pest Management Priorities of the Northeastern Integrated Pest Management Center's Public Health IPM Working Group, which include evaluation of novel IPM methodologies for vector-borne diseases, such as Lyme disease, the most common vector-borne disease in the United States, and the dissemination of IPM guidelines and educational programs for control of ticks and management of vector-borne diseases. We are requesting \$50,000.00 of P.L. 89-106 funds to support the Research component and \$10,000.00 of Smith-Lever funds to support the Extension component of the 3-year project.

Project Narrative

Problem, Background and Justification

Problem: Lyme disease is the most common tick-borne illness in the United States, with over 181,000 confirmed cases reported since 1990.¹ During the same time, New Jersey ranked fourth with respect to Lyme disease reporting, with over 21,000 confirmed cases or about 11.6% of the national total. In 2005 alone, New Jersey reported 3,372 confirmed cases to the CDC, an increase of 674 cases or 25% over that reported in 2004. The principal vector of the Lyme disease spirochete, *Borrelia burgdorferi*, is the blacklegged tick (*Ixodes scapularis* Say), which is commonly found throughout rural and suburban areas of New Jersey.^{2,3} While the significant emphasis placed on Lyme disease prevention and control is clearly justified, a number of other tick-borne diseases have emerged, including human granulocytic anaplasmosis, human babesiosis, and human monocytic ehrlichiosis (HME). In addition, the lone star tick (*Amblyomma americanum* L.), has been expanding its range into the northeast and is common throughout the southern one-half of New Jersey. Because all life stages of the lone star tick aggressively attack people, the potential increases for transmission of pathogens including HME and southern tick-associated rash illness (STARI) are anticipated.⁴ However, integrated pest management practices for vector tick control have not kept pace with the changing risks of tick-borne disease transmission in the United States and few non-chemical or non-traditional strategies have been evaluated directly with and in addition to conventional chemical control. -

The Monmouth County Reclamation Center (MCRC) provides an example of how this problem is manifest at the local level. Approximately one-third of the 100 MCRC employees are engaged in activities that place them at risk for encountering ticks, including cutting grass, testing monitoring wells, and cleaning up debris. According to the MCRC, these high risk activities have led to frequent human-tick encounters, several of which have required medical intervention. Because of its juxtaposition to NWS Earle and habitat similarities, the MCRC is expected to be infested with *I. scapularis*, *A. americanum*, and to lesser extent, American dog ticks (*Dermacentor variabilis*). Based on research conducted at NWS Earle and elsewhere in Monmouth County, these ticks will be variously infected or co-infected with the pathogens that cause Lyme disease, human granulocytic anaplasmosis, human babesiosis, human monocytic ehrlichiosis, and southern tick-associated rash illness (S.P. Healy, unpublished data).⁵ The MCRC's prior response to the occupational exposure of its at-risk employees to infected ticks involves an annual application of acaricide to 300 acres of landfill area. In recognition of the limitations of this approach, the MCRC petitioned the Monmouth County Mosquito Extermination Commission (MCMEC), the lead agency for tick assessment and management in Monmouth County, for assistance.

Background: Shortly after Lyme disease was made reportable by the New Jersey Department of Health and Senior Services in 1980, a Lyme disease research initiative was begun in New Jersey. Although initial studies focused on epidemiology,⁶⁻⁹ later research emphasis has been on the ecology of Lyme disease, including geographical

distribution of tick vectors,^{2,3,10,11} seasonal distribution and host associations,¹²⁻¹⁶ tick infection rates,^{5,17-19} tick habitat associations,^{3,13,14,20,21} and factors affecting host-seeking behavior.²²⁻²³

The data generated by this research formed the basis for development of various components of an integrated tick management program. These included preparation and distribution of educational materials,²⁴⁻²⁸ development of information regarding risk assessment,^{24,27-31} habitat management,³² and application of acaricides.³³⁻⁴³ In addition, project personnel have been involved in research and development of several novel host-targeted tick control strategies. Recently, the United States Department of Agriculture (USDA) developed and tested a passive topical treatment device (4-Poster™) for the control of ticks parasitizing deer.^{44,45} The head, neck, and ears become treated as the deer rub against acaricide-impregnated paint rollers while feeding on corn. Deployment of the 4-Poster™ system resulted in 92-97% control of *A. americanum* on deer that regularly used the device. Preliminary trials in New Jersey showed peak levels of control of 77% and 94% for *I. scapularis* nymphs and adults, and 89% and 97% control of *A. americanum* nymphs and adults, respectively, within 5 years (Schulze et al., in press). A limited trial of the technology in Maryland resulted in 91-100% reduction of questing adult and subadult *I. scapularis* and 70-95% reduction of subadult *I. scapularis* on mice within 3 years of deployment.⁴⁶ Preliminary results of an integrated tick control study using 4-Posters™ in conjunction with Maxforce® TMS bait boxes and barrier applications of deltamethrin in a residential community demonstrated 98% and 92% reduction of *I. scapularis* nymphal and larval tick burdens on small mammals, and reductions of 94%, 91%, and 87% for host-seeking nymphs, larvae, and adults, respectively, after 2 years (T. L. Schulze, unpublished data). These studies document the effectiveness of host-target tick control technologies and suggest that their effectiveness can be enhanced when used in an integrated program.

In its 2003 needs-assessment evaluation, the Public Health Integrated Pest Management Working Group listed Lyme disease as one of two of the greatest disease threats and three other tick-borne diseases, ehrlichiosis, Rocky Mountain spotted fever, and babesiosis, as significantly impacting human health in the Northeast Region. The proposed study addresses a number of the priorities set forth in needs-assessment evaluation.

Justification: Although not unique to the region, the vast majority of Lyme disease, human granulocytic anaplasmosis, and human babesiosis cases, all transmitted by *I. scapularis*, are reported from the Northeast and as its range expands in the region, the number of cases of *A. americanum*-mediated diseases is likely to increase. Therefore, the ability to effectively reduce human-tick encounters will be of significant importance to the public, public health agencies, and the medical community in their effort to minimize disease transmission. By relying heavily on an educational and host-targeted strategy to control ticks in this proposed study, far less acaricide will be used, providing both environmental and economic benefits.

Chemical control has proven to be the most reliable means of suppressing populations of *Ixodes scapularis*,³³⁻⁴³ but use of conventional area-wide (habitat-targeted) acaricides is generally viewed by the public as having undesirable environmental impacts.³⁸ In a recent poll of nearly 1,200 households within a Lyme disease endemic area, less than 25% favored use of conventionally-applied acaricides. However, about 50% of households expressed support of government-sponsored tick control programs that employed host-targeted or other novel strategies (T.L. Schulze, unpublished data). Thus, there is a need to develop new integrated technologies for tick control that receive widespread community and government agency acceptance by minimizing environmental impacts,^{47,48} including host-targeted chemical control.

While host-targeted systems appear to be a viable approach to controlling *I. scapularis* and *A. americanum*, they require time to achieve results because of the tick's 2-year life cycle. By targeting primarily the adult stage of *I. scapularis*, the 4-Poster™ system requires a minimum of 1.5 years to provide any control of nymphs. A recent study demonstrated that, for new technologies to become widely accepted by the public, significant tick control must be achieved more rapidly.⁴⁹ In the interim, significant risk of exposure to *I. scapularis* nymphs, the stage epidemiologically linked to the majority of Lyme disease cases, continues to be of public health concern. The inherent delay in observed efficacy of host-targeted technologies can be mitigated through awareness training, habitat management techniques, and the judicious use of acaricides to high-risk areas.

The results of the proposed ITM study should be applicable in other regions. For example, Lyme disease also poses a significant public health threat in the upper Midwest. In this Region, the *I. scapularis*-small mammal-deer disease cycle is similar to that in the Northeast. Therefore, an ITM approach developed in the Northeast should be met with similar success in the upper Midwest. Further, since one component of the proposed ITM study targets deer as a means to reduce ticks, we envision benefits to emerging agricultural concerns, such as use of the technology to on game farms or at facilities where deer are raised commercially.

Objectives and Anticipated Impacts

Objectives:

The Research component of the proposed study will develop and test the efficacy of an integrated control strategy employing landscape management to reduce environmental suitability for ticks, host-targeted acaricides, and limited habitat-targeted acaricide applications against nymphs in the highest-risk areas to rapidly achieve and maintain reduced numbers of *I. scapularis* and *A. americanum* in a high-use landscapes. We will demonstrate reductions in the number of human-tick encounters among high-risk employees, a reduction in the amount of chemical acaricides used at the facility, and an overall reduction in cost of tick control.

The Extension component of the study will initially involve annual training of facility employees on the recognition of tick habitats and preventive measures to avoid exposure to ticks. As the study progress, we will make this integrated approach to tick control available for use at larger scales through creation of an ITM Demonstration Area at the MCRC facility, by offering tick management workshops and training materials to public land managers and others through cooperator websites and other means, and the development of a plan for widespread dissemination of information generated by this study.

Anticipated Impacts:

The proposed ITM study will address *Safeguarding human health and the environment* by changing the manner in which pesticides on public lands to control vector tick populations, including reducing the number and volume of chemical acaricide applications in favor of host-targeted control and habitat management. *Economic benefits* will accrue through reducing the cost of achieving tick control, loss in employee productivity, and direct cost of treating tick-borne illness, all while achieving more effective and long-term control of tick populations. The *Implementation of IPM* will be encouraged by documenting the successful concerted use of an array of tick control/risk reduction methods (host-targeted acaricides, non-chemical vegetation management, education) and making the results of the project available through the ITM Demonstration area, ITM Workshops, and stakeholder group educational venues. Anticipated impacts are summarized in the following table.

Type of Impact	Anticipated Potential Impacts from the Proposed ITM Study at the Monmouth County Reclamation Center
<i>Safeguarding human health and the environment</i>	<p><u>Research Component:</u></p> <p>a. The proposed study is expected to positively affect human health by reducing the frequency at which at-risk employees encounter or are actually bitten by ticks (thereby reducing the risk of disease transmission) by significantly reducing and maintaining vector tick populations at low levels.</p> <p>b. An added health benefit stems from the fact that the proposed study relies heavily on the use of habitat modification and a host-targeted tick control strategies, thereby reducing employee exposure to acaricide residues.</p> <p>c. Environmental benefits derived from the habitat modification and host-targeted approach to tick control, rather than an exclusively habitat-targeted acaricide spray program, include reduced impact on non-target organisms and reduction of runoff and/or drift of acaricide into adjacent sensitive wetland areas.</p>

	<p><u>Extension Component:</u></p> <p>a. From the human health perspective, Awareness Training of MCRC personnel and implementation of recommendations (e.g. use of dedicated repellent-treated coveralls when accessing tick habitat, frequent self-examinations for ticks, proper tick removal) will reduce tick bites and, thus, disease transmission. Similar benefits will be derived by a wider audience through the ITM Workshops.</p> <p>b. As word of the success of the ITM study spreads, it is expected that additional county agencies involved in tick control will adopt an ITM approach, thereby decreasing the amount of acaricides placed in the environment.</p>
<p><i>Economic benefits</i></p>	<p><u>Research Component:</u></p> <p>a. Current practice at the MCRC involves a single acaricide application to 300 acres of non-tick habitat (landfill area) at a cost of \$27,000/year. The proposed ITM study will document significantly greater tick control at a reduction in cost.</p> <p><u>Extension Component:</u></p> <p>Through the educational component, the proposed ITM study would redirect these assets to tick habitat and by reducing human-tick encounters, reduce medical expenditures and time loss. Although the 4-Poster™ is commercially available, sales are languishing, in large measure, due to the lack of published studies that document efficacy and because of the lag time in effectiveness. This study will help document the utility of an ITM program, popularize the more cost-effective and environmentally-sensitive approach, leading to more widespread use of the technology. As a result, we envision expanded use among stakeholder groups whose employees or clients are at risk for exposure to ticks, including the pest control industry and managers of public lands.</p>
<p><i>Implementation of IPM</i></p>	<p><u>Research Component:</u></p> <p>The proposed ITM study at the MCRC will document the efficacy of an integrated approach to tick control on public land by monitoring declines in tick populations on large test plots and by demonstrating reductions in human-tick encounters through periodic surveys of employees.</p> <p><u>Extension Component:</u></p> <p>The ITM project will provide a real-time Demonstration Area at the</p>

	<p>MCRC which will be available for inspection by other land managers, politicians and other decision makers, and the media in Monmouth County. In addition to training >30 at-risk MCRC personnel, the project will offer one or more 1-day ITM Workshop for other occupationally-exposed government employees. The PowerPoint presentations will be made available to Rutgers Cooperative Extension for use in instructing other stakeholders, such as those seeking certification or recertification as pesticide applicators, and appropriate educational materials will be available in printed form or electronically for posting on shareholder websites. As a result, the information generated by the proposed ITM project will receive widespread dissemination.</p>
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Approach and Procedures:

Site Description. The Monmouth County Reclamation Center (MCRC), Tinton Falls, New Jersey, will serve as the primary study site. Non-intervention control areas for the assessment of the efficacy of tick management methods will be established at Naval Weapons Station Earle NWS Earle. The MCRC facility, located in central Monmouth County, is bounded to the northeast by NWS Earle and a railroad right-of-way; to the southeast by Asbury Avenue and NWS Earle; to the southwest by Shafto Road, with mixed residential and commercial properties; and to the northwest by Shark River Station Road and a mix of agricultural, residential, and public lands. The site currently supports 400 acres of active landfill and recycling center surrounded by 1,000 acres of upland forest and wooded wetlands.

Research Component – Approaches to Managing Tick Populations

Ecological Site Assessment. The initial phase of the study will involve a comprehensive assessment of the MCRC site to identify primary tick habitats, areas at high risk for human-tick encounters, and specific tick management strategies to mitigate risk. The Assessment Index used in this study relies on documented habitat affinities of *I. scapularis* in the Northeast^{29,30}. Assessment of potential risk is based on an evaluation of plant communities associated with a particular site. Because potential risk is also dependent on human exposure, the Assessment Index also considers the degree to which suitable tick habitat is accessible to people potentially at risk. The assessment of actual risk of human-tick encounters at the MCRC will incorporate a systematic survey of suitable tick habitats for *I. scapularis* and *A. americanum* abundance. Use of this protocol will eliminate portions of the facility from concern, while targeting high-risk areas for specific interventions.

Habitat Modification. Habitat modification reduces potential exposure to ticks by altering environments to make them unattractive to hosts and unsuitable for tick survival.

Depending on the results of the ecological site assessment, habitat modification techniques employed at the MCRC may include physical destruction of vegetation by mowing and trimming back overhanging shrubs, along with the removal of leaf litter and plant debris in high-use areas of the facility. Removal of woodpiles, brush piles, fallen trees and stumps, and other harborage may be employed to keep rodent populations to a minimum.

Conventional Acaricide Applications. Areas judged to pose high risk for human-tick encounters will receive a single barrier application of acaricide performed during peak periods of nymphal abundance by licensed pesticide applicators under the direction of Principal Investigators.

4-Posters™ Deployment. Results of the ecological site assessment will be used to determine the appropriate number of 4-Poster and location to be deployed. The 4-posters will be deployed at a density of 1 unit/25 ha of tick habitat. The 4-posters will be treated, provisioned with re-cleaned whole kernel corn, and maintained weekly throughout the 9-month activity periods of all active stages of *A. americanum*. Unlike *I. scapularis*, which feeds primarily on deer only as adults, all active stages of *A. americanum* use deer as hosts. At a minimum, the 4-posters will receive a weekly application of Y-TeX® 4-Poster™ Tickicide (10% permethrin, EPA Reg. No. 89039-7, Y-TeX, Inc. Cody, WY) according to manufacturer's recommendations.

Research Component – Procedures to Document Efficacy

Tick Reduction. To document the suppression of tick populations over time, 20 100-m² plots each will be established in the treatment (MCRC) and control (NWS Earle) sites and sampled during peak activity of adult *I. scapularis* and *A. americanum* beginning in spring 2007. These plots will be surveyed 3 times during the activity period of each post-embryonic stage of *I. scapularis* and *A. americanum* over the 3-year study to evaluate the overall efficacy of the combined interventions. In addition, the efficacy of proposed habitat modification and barrier acaricide applications to high-risk areas will be determined by monitoring tick populations pre- and post-intervention at 10 100-m² plots for each intervention. Throughout the study, abundance of questing *I. scapularis* and *A. americanum* will be measured using a combination of walking and dragging sampling methods.^{31,50}

Statistical Analysis. Differences in questing *I. scapularis* and *A. americanum* abundance between treatment and control areas will be compared using repeated measures analysis of variance (ANOVA) or nonparametric equivalent, to determine the effects of sampling date and treatment on the numbers of questing ticks in the different areas.⁵¹ A modification of Henderson's method will be used to calculate percentage control of ticks on acaricide-treated areas: percent control = $100 - (T/U \times 100)$, where *T* and *U* are the mean after treatment/mean before treatment in treated plots and untreated plots, respectively.^{52,53}

Reduction in Human-Tick Encounters. During the initial Awareness Training (see Extension Component) and at periodic intervals thereafter to coincide with tick seasons, attendees will be surveyed to characterize their historic experiences with ticks at the MCRC facility and how these experiences changed over time following the interventions.

Reduction in Acaricide Use. The amount of habitat-targeted and host-targeted acaricides used will be monitored throughout the study. The amount of acaricide use recorded each year will then be compared to the amount of acaricide applied prior to initiation of the study to determine reduction.

Reduction in Cost of Tick Control. The annual cost of the ITM program will be monitored throughout the study. These data will then be compared to the historical costs for tick control at the facility prior to initiation of the study to determine reduction.

Extension Component

Awareness Training. Prior to the 2007 nymphal tick season, MCRC personnel judged to be at high occupational risk for encountering ticks will receive annual training on preventive measures to limit exposure to ticks. Subjects will include recognition of tick habitats, recognition of tick species and stages, personal protection measures (appropriate dress, use of personal and clothing repellents, frequency of self-examinations, proper tick removal, documentation of tick exposure, and signs and symptoms of common tick-borne diseases of New Jersey.

ITM Demonstration Area. Following the completion of the Ecological Site Assessment and after the initial round of interventions (habitat modification barrier acaricide applications, 4-Poster™ deployment, and tick collections, project personnel will provide tours of the MCRC to demonstrate the ITM project. These tours will be designed increase the awareness of government agency officials, politicians, and land managers to the options available for tick control, how an integrated approach can be more cost-effective, while reducing the amount of acaricide introduced into the environment.

ITM Workshop. As the study progresses, project personnel will develop an ITM Workshop for government employees responsible for pest control on public lands in Monmouth County. Appropriate municipal, county, and state government agencies (e.g. departments of transportation, health, parks and recreation, education) will be contacted and invited to send representative to the ITM Workshop, which will include a series of lectures and hands-on field training. PowerPoint presentations and hand-outs will be prepared as part of the ITM Workshop.

Plan for Widespread Dissemination of ITM Information. As part of the Extension Component, project personnel will develop a plan for widespread dissemination of the ITM information generated by this study. The plan would include ways to expand the

geographical area impacted, expand the program to include the private sector (e.g. pest management professionals), and methods to increase circulation of educational materials.

Approach and Procedures – Table

The MCMEC will manage the Research Component, while Rutgers Cooperative Extension (RCE) will take the leadership role in the Extension Component of this Joint Research-Extension application. The proposed multi-disciplinary and multi-organizational collaborative ITM study (limited to New Jersey, which precludes multi-state collaboration), will be coordinated through periodic meetings of key study personnel at the MCMEC, RCE, and MCRC. For each of the 3 years of the study, meetings will be scheduled at 2 to 3 month intervals to roughly correspond to the beginning of the 4 tick seasons to discuss projected Research and Extension activities to be completed during the period and discuss results from previous activity periods. Additional meetings may be convened as major events approach. Specific activities are summarized chronologically in the following timetable. Some tasks have finite completion times (e.g. Awareness Training and Workshops), while others are ongoing (e.g. maintenance of 4-posters).

Objective	Task	Complete By (Quarter)											
		2007				2008				2009			
ITM Study Design	Site Assessment	■	■										
Awareness Training	Design Training	■											
	Offer Training		■				■				■		
Control Ticks	Survey Staff		■	■			■	■	■		■	■	■
	Deploy 4-Posters			■	■		■	■	■		■	■	■
	Maintain 4-Posters			■	■		■	■	■		■	■	■
	Modify Habitats			■	■		■	■	■		■	■	■
Measure Efficacy	Barrier Treatments			■	■		■	■	■		■	■	■
	Survey Ticks			■	■		■	■	■		■	■	■
ITM Demo Area	Create Area			■	■								
	Offer Tours			■	■			■	■			■	■
ITM Workshop	Design Workshop			■	■								
	Offer Workshop						■				■		
Disseminate ITM	Identify Users								■	■			
	Offer Resources										■	■	■

Evaluation Plans

Research Component

Tick Reduction. The objective is to reduce the populations of *I. scapularis* and *A. americanum* by 50% after the second year and 75% after the third year of the study. However, at high risk areas where MCRC personnel are likely to encounter ticks, the objective is to reduce tick populations 95% during each year of the study. Differences in questing *I. scapularis* populations between treatment (MCRC) and control (NWS Earle) areas will be compared using repeated measures analysis of variance (ANOVA) or nonparametric equivalent, to determine the effects of sampling date and treatment on the numbers of questing ticks in the different areas.⁵¹ A modification of Henderson's method will be used to calculate percentage control of ticks on acaricide-treated areas: percent control = $100 - (T/U \times 100)$, where *T* and *U* are the mean after treatment/mean before treatment in treated plots and untreated plots, respectively.^{52,53}

Reduction in Human-Tick Encounters. As a result of the combined Research Component (habitat management, barrier acaricide applications, and deployment of 4-Posters™) and Extension Component (awareness training) interventions, the objective is to reduce the frequency of tick encounters by 75% and reduce actual tick attachment by 95% in each of the 3 years of the study. The ability to meet these goals will be determined through surveys of high-risk MCRC personnel. Historical information on the frequencies of human-tick encounters, tick attachments, and medical interventions will be gathered at the initial Awareness Training session and compared to subsequent surveys of the same personnel periodically throughout each year of the study to determine % reduction for each objective. [Project personnel have designed knowledge, attitude, and belief surveys and acaricide use surveys for CDC-funded Community Intervention Studies (TLS, unpublished data) and a survey of tick control services offered by the pest control industry.⁵⁴

Reduction in Acaricide Use. The objective is to not only reduce use by 50%, but to limit the application of acaricides only to tick habitats. Achievement of these goals will be determined by comparing the amounts of acaricides applied annually to the facility prior to the initiation of the ITM study to the amounts used during each year of the study and to characterize the areas treated historically and those treat as part of the ITM project.

Reduction in Cost of Tick Control. Although ITM programs, particularly those largely relying on host-targeted approaches are generally more expensive than conventional acaricide applications, the object is to reduce the cost of tick control by 50%. Success will be evaluated through a comparison of historical costs for tick control versus the annual cost of the ITM study.

Extension Component

Awareness Training. The objective is to increase the knowledge of ticks and preventive measures among high-risk MCRC staff incrementally by 25%, 50%, and 75% for the first, second, and third year of the study, respectively. At each annual Awareness

Training session, personnel will be tested prior to instruction and at the conclusion of the training. The success of the training will also be indirectly evaluated by any decrease in human-tick encounters, since training will emphasize prevention.

ITM Demonstration Area. The objective of this phase of the study is to educate land managers on the benefits of ITM projects by physically providing examples of an ongoing project. Evaluation criteria will include increase in the number of agency personnel that visit the Demonstration Area as the study progresses and the number of agencies that initiate similar ITM projects during the course of the study.

ITM Workshop. The goal of the ITM Workshop is to train a minimum of 50 public employees that have responsibility for some level of tick control. The objective of the ITM Workshop will be to increase tick-related knowledge by 50% among attendees as measured by pre- and post-training testing. Other evaluation criteria would include course evaluations and requests for additional ITM Workshops.

Plan for Dissemination of ITM Information. The objective of this phase of the Extension Component is to develop the popularity of ITM projects beyond the geographic area (Monmouth County) and target population (public employees) of this study. Evaluation criteria include requests for educational materials, either written or in electronic format for posting on agency websites; incorporation of ITM information in other training venues (e.g. Pesticide Applicator certification or recertification courses); and requests for additional ITM Workshops from other user groups (e.g. pest control industry) or groups outside of Monmouth County.

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Relevance Statement

George C. Hamilton, Rutgers University
 Sean P. Healy, Monmouth County Mosquito Commission and Rutgers University
 Terry L. Schulze, TLS Inc.

Integrated Pest Management to Control Vector Ticks on Public Lands Joint Research-Extension Project

Project Summary: This project addresses the control of the medically important vector ticks *Ixodes scapularis* (the blacklegged tick) and *Amblyomma americanum* (the lone star tick) at a high-use County-owned facility. After a detailed ecological assessment of tick populations and human risk, we will develop a flexible Integrated Pest Management (IPM) approach to the control of ticks that minimizes the use of area-wide chemical applications through the use of habitat management, host-targeted chemical applications, judicious use of acaricides in only high human risk areas, and education programs for facility employees. Efficacy of the approach will be assessed by monitoring abundance of questing ticks in treated and control areas, as well as the rate of human-tick encounters, over the three years of the study. We will also prepare training workshops and materials on the assessment and management of vector ticks for managers of public lands. Development of an IPM approach to tick control will include the creation of an Integrated Tick Management (ITM) Demonstration Project at the Monmouth County Reclamation Center (MCRC) in Tinton Falls, New Jersey. The proposed Demonstration Area will use multiple control techniques and will be able to accommodate the addition of new techniques for non-chemical or low-chemical tick control as they arise. Once the Demonstration Area is established it can be utilized as a training tool for the current technologies as well as a research area for inventing/integrating new techniques in the future.

Problem: Lyme disease is the most common tick-borne illness in the United States, with over 181,000 confirmed cases reported since 1990.¹ In 2005 alone, New Jersey reported 3,372 confirmed cases to the CDC, an increase of 674 cases or 25% over that reported in 2004. The principal vector of the Lyme disease spirochete, *Borrelia burgdorferi*, is the blacklegged tick (*Ixodes scapularis* Say), which is commonly found throughout rural and suburban areas of New Jersey.^{2,3} While the significant emphasis placed on Lyme disease prevention and control is clearly justified, a number of other tick-borne diseases have emerged, including human granulocytic anaplasmosis, human babesiosis, and human monocytic ehrlichiosis (HME). In addition, the lone star tick (*Amblyomma americanum* L.), has been expanding its range into the northeast and is common throughout the southern one-half of New Jersey. Because all life stages of the lone star tick aggressively attack people, the potential increases for transmission of pathogens including HME and southern tick-associated rash illness (STARI) are anticipated.⁴ However, IPM practices for vector tick control have not kept pace with the changing risks of tick-borne disease transmission in the United States and few non-chemical or non-traditional strategies have been evaluated directly with and in addition to conventional chemical control. -

The Monmouth County Reclamation Center (MCRC) provides an example of how this problem is manifest at the local level. Approximately one-third of the 100 MCRC employees are engaged in activities that place them at risk for encountering ticks, including cutting grass, testing/monitoring wells, and cleaning up debris. According to the MCRC, these high risk activities have led to frequent human-tick encounters, several of which have required medical intervention. The MCRC's prior response to the occupational exposure of its at-risk employees to infected ticks involves an annual application of acaricide to 300 acres of landfill area. In recognition of the limitations of this approach, the MCRC petitioned the Monmouth County Mosquito Extermination Commission (MCMEC), the lead agency for tick assessment and management in Monmouth County, for assistance.

Background: Project personnel have been involved in research and development of several novel host-targeted tick control strategies. Recently, the United States Department of Agriculture (USDA) developed and tested a passive topical treatment device (4-Poster™) for the control of ticks parasitizing deer.^{44,45} The head, neck, and ears become treated as the deer rub against acaricide-impregnated paint rollers while feeding on corn. Preliminary trials in New Jersey showed peak levels of control of 77% and 94% for *I. scapularis* nymphs and adults, and 89% and 97% control of *A. americanum* nymphs and adults, respectively, within 5 years (Schulze et al., in press). A limited trial of the technology in Maryland resulted in 91-100% reduction of questing adult and subadult *I. scapularis* and 70-95% reduction of subadult *I. scapularis* on mice within 3 years of deployment.⁴⁶ These studies document the effectiveness of host-targeted tick control technologies and suggest that their effectiveness can be enhanced when used in an integrated program.

In its 2003 needs-assessment evaluation, the Public Health IPM Working Group listed Lyme disease as one of two of the greatest disease threats and three other tick-borne diseases as significantly impacting human health in the Northeast Region. The proposed study addresses a number of the priorities set forth in the needs-assessment evaluation.

Justification: The ability to effectively reduce human-tick encounters is of significant importance to the public, public health agencies, and the medical community in their effort to minimize tick-borne disease transmission. By relying heavily on an educational and host-targeted strategy to control ticks in this proposed study, far less acaricide will be used, providing both environmental and economic benefits.

Chemical control has proven to be the most reliable means of suppressing populations of *Ixodes scapularis*,³³⁻⁴³ but use of conventional area-wide (habitat-targeted) acaricides is generally viewed by the public as having undesirable environmental impacts.³⁸ In a recent poll of nearly 1,200 households within a Lyme disease endemic area, less than 25% favored use of conventionally-applied acaricides. However, about 50% of households expressed support of government-sponsored tick control programs that employed host-targeted or other novel strategies (T.L. Schulze, unpublished data). Thus, there is a need to develop new integrated technologies for tick control that receive widespread community and government agency acceptance by minimizing environmental impacts,^{47,48} including host-targeted chemical control.

While host-targeted systems appear to be a viable approach to controlling *I. scapularis* and *A. americanum*, they require time to achieve results because of the tick's

2-year life cycle. By targeting primarily the adult stage of *I. scapularis*, the 4-Poster™ system requires a minimum of 1.5 years to provide any control of nymphs. A recent study demonstrated that, for new technologies to become widely accepted by the public, significant tick control must be achieved more rapidly.⁴⁹ In the interim, significant risk of exposure to *I. scapularis* nymphs, the stage epidemiologically linked to the majority of Lyme disease cases, continues to be of public health concern. The inherent delay in observed efficacy of host-targeted technologies can be mitigated through awareness training, habitat management techniques, and the judicious use of acaricides to high-risk areas.

The results of the proposed ITM study is applicable to other regions. For example, Lyme disease also poses a significant public health threat in the upper Midwest. In this Region, the *I. scapularis*-small mammal-deer disease cycle is similar to that in the Northeast. Therefore, an ITM approach developed in the Northeast should be met with similar success in the upper Midwest. Further, since one component of the proposed ITM study targets deer as a means to reduce ticks, we envision benefits to emerging agricultural concerns, such as use of the technology on game farms or at facilities where deer are raised commercially.

Objectives: The Research component of the proposed study will develop and test the efficacy of an integrated control strategy employing landscape management to reduce environmental suitability for ticks, host-targeted acaricides, and limited habitat-targeted acaricide applications against nymphs in the highest-risk areas to rapidly achieve and maintain reduced numbers of *I. scapularis* and *A. americanum* in a high-use landscape. We will demonstrate reductions in the number of human-tick encounters among high-risk employees, a reduction in the amount of chemical acaricides used at the facility, and an overall reduction in the cost of tick control.

The Extension component of the study will initially involve annual training of facility employees on the recognition of tick habitats and preventive measures to avoid exposure to ticks. As the study progress, we will make this integrated approach to tick control available for use at larger scales through creation of an ITM Demonstration Area at the MCRC facility, by offering tick management workshops and training materials to public land managers and others through cooperator websites and other means, and the development of a plan for widespread dissemination of information generated by this study.

Anticipated Impacts: The proposed ITM study will address *Safeguarding human health and the environment* by changing the manner in which pesticides are used on public lands to control vector tick populations, including reducing the number and volume of chemical acaricide applications in favor of host-targeted control and habitat management. *Economic benefits* will accrue through reducing the cost of achieving tick control, loss in employee productivity, and direct cost of treating tick-borne illness, all while achieving more effective and long-term control of tick populations. The *Implementation of IPM* will be encouraged by documenting the successful concerted use of an array of tick control/risk reduction methods (host-targeted acaricides, non-chemical vegetation management, education) and making the results of the project available through the ITM Demonstration area, ITM Workshops, and stakeholder group educational venues.