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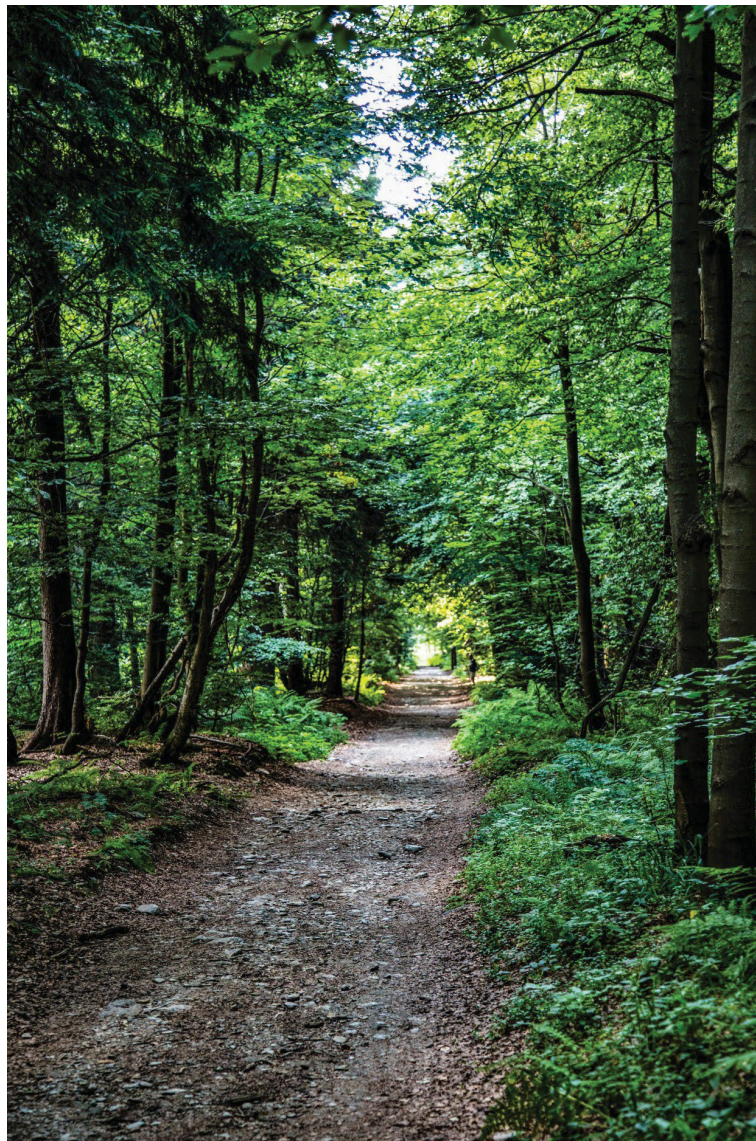
# TICK KNOWLEDGE, SURVEILLANCE, CONTROL, and COMMUNICATION EFFORTS AMONG MIDWESTERN and NORTHEASTERN LAND TRUSTS

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## EXECUTIVE SUMMARY

Land trusts are important organizations that not only crucially conserve natural spaces and ecosystems but are also frequently accessible to the public for recreation. In the past fifty years, their number has grown exponentially (Gerber, 2012). Nearly fifty million acres of land in the United States (U.S.) are owned, managed, or under easement by these non-profit, non-governmental organizations, and an estimated 6.25 million visitors use these spaces annually (Land Trust Alliance, 2015). Concomitantly, publicly accessible private lands have been shown to be predictive of reported human-tick encounters (Anderson et al., 2021). Exposure to ticks is noteworthy, as ticks represent a substantial human health threat, representing more than 75% of human vector-borne disease diagnoses across the country (Rosenberg et al., 2018). This study sought to inventory land trust managers' tick knowledge and perceptions as well as land trust tick surveillance, control, and communication efforts, which to our knowledge have not yet been systematically explored.

This project gathered both quantitative and qualitative data from an online survey. A list of U.S. land trusts was collected through LandTrustAlliance.org for Midwest and Northeast defined regions. These two regions were chosen for exploration due to the distribution and abundance of multiple tick species in these areas. In total, 465 organizations were identified for survey recruitment, and ultimately 198 responses (43%) were included. Responses were gathered from land trusts operating in eighteen U.S. states, representing 724,600 protected acres. 142 (72%) respondents represented Northeastern land trusts and 56 (28%) represented Midwestern land trusts.



Results indicated that nearly all land trust managers are highly knowledgeable about ticks and tick-borne diseases. Almost half of respondents reported that they “almost always” or “frequently” see ticks on their land trust’s properties that are accessible to the public, and approximately half of respondents also reported that they have observed an increase in tick populations during their tenure at their land trust. Both measures were higher among land trusts in the Northeast. With respect to surveillance, nearly 30% of respondents indicated that their land trust conducted at least one form of active or passive tick surveillance; most indicated that their land trust did not desire to practice tick surveillance. Trusts in the Northeast reported higher rates of tick surveillance (33%) than their counterparts in the Midwest (16%).

Most land trusts do not practice any sort of tick control, although more than one-third of respondents reported practicing vegetation modification to reduce the likelihood of a human-tick encounter; host species reduction was also reported by more than one-fifth of respondents. More than half of respondents identified funding constraints or the lack of trained personnel as barriers to tick surveillance and control; however, more than half of respondents indicated that their land trust engages in communication efforts with visitors, recommending protective behaviors such as walking on established trails, using insect repellent, and conducting a tick check.

Open-ended feedback generally supported quantitative data results. Several comments identified barriers to tick surveillance (e.g., staffing, expertise). Additionally, many

respondents shared that with limited budgets, resources were tight; however, their land trusts may be interested in collaborating with academic or health institutions to better understand and prevent human-tick encounters. Still, some other comments reiterated the primary mission of land trusts—open space and ecosystem preservation—and shared that some tick-bite prevention efforts, like insecticide spraying, are not aligned with their organizational goals.

Land trusts are important institutions, protecting natural landscapes and providing many ecosystem services, including recreational opportunities. Identifying tick knowledge, surveillance, control, and communication efforts among these organizations, as well as understanding barriers to efforts that might prevent human-tick encounters on their lands, is important not only for the hundreds of land trusts doing this important work, but also for research, health, or other institutions that work to prevent tick-borne disease transmission nationwide.

## INTRODUCTION

Across the United States, ticks are a growing public health threat, representing more than 75% of vector-borne disease diagnoses (Rosenberg et al., 2018). In response, several recent research efforts have sought to understand current and future predictors of human-tick encounters (Anderson et al., 2021; Hook et al., 2021; MacDonald et al., 2020; Martin et al., 2022) as well as systematically evaluate the practice of tick surveillance and control efforts (Mader et al., 2020). Endeavors to understand tick presence and individuals' affective and behavioral responses to ticks have generally represented studies conducted near residential areas (Connally et al., 2009; Omodior & Anderson, 2020) or state/sub-state government levels (Mader et al., 2020). Additionally, most systematic tick surveillance occurs on public lands (Mitcham et al., 2018; Sempertegui-Sosa et al., 2020). However, nearly 50 million acres of land in the United States (U.S.) are owned, managed, or under easement by nonprofit, non-governmental land trusts. Lands under management of a land trust are frequently open to the public and can represent large swaths of undeveloped, natural areas. In one recent study, publicly accessible private lands such as those under management of a land trust were found to be significantly predictive of a reported human-tick encounter (Anderson et al., 2021).



As such, understanding the role of land trust-managed spaces as sites of tick exposure, surveillance, and control may be critical to efforts seeking to understand and reduce human-tick encounters. Generally, land trusts seek to conserve natural resources, protect water quality, and preserve open spaces and working landscapes (Alexander & Hess, 2012; Land Trust Alliance, 2015). Across the U.S., an estimated 6.25 million visitors use and recreate in these spaces annually (Land Trust Alliance, 2015). Research has indicated that land trusts can further land management goals to address environmental problems, such as through

improving water quality (Grant & Langpap, 2019) or protecting spaces of known native species richness (Fishburn, Boyer, Kareiva, Gaston, & Armsworth, 2013). However, (a) tick knowledge and perceptions among these land stewardship managers and (b) the degree to which tick surveillance and control efforts are undertaken on land managed by these entities have gone unexplored.

Existing literature illustrates that higher tick or tick-borne disease risk perceptions among individuals are often associated with tick activity in an area (Omodior & Anderson, 2020). Evidence has also indicated that when outdoor employees of a state park system have high tick-borne disease (TBD) perception, they are also more likely to engage in personal protective behaviors against ticks (Donohoe et al., 2018). With respect to public agencies' institutional responses to ticks, Mader et al. (2020)'s work surveyed 140 individuals working in tick surveillance or control at local, county, and state public health and vector control institutions nationwide, reporting key metrics such as the agency's tick surveillance objectives, pathogen testing efforts, and whether the jurisdiction funds tick control methods. Their work found that while less than half of respondents reported that their institution practiced active tick surveillance (46%), 66% engaged in passive tick surveillance. By region, 64% of Upper and Central Midwest programs and 71% of Northeastern programs conducted tick pathogen testing; however—overall—only 12% indicated that their institution engages in tick control efforts, such as host-targeted treatments or vegetation modification.

To our knowledge, no such inventory of tick knowledge, perceptions, or surveillance and control practices has been assessed among land trusts, despite their role as administrators of large swaths of publicly accessible outdoor recreation spaces, and despite emerging evidence suggesting that recreating on privately-owned, publicly accessible lands is significantly associated with human-tick encounters (Anderson et al., 2021). This project pursued two over-arching objectives. First, we sought to evaluate knowledge and perceptions regarding ticks among land trust stewardship staff. Then, with respect to publicly accessible, land trust-managed land, we sought to describe the extent of tick surveillance and control methods employed. Therefore, a survey of this kind not only has the potential to illuminate important findings on tick knowledge and perceptions among our target population (land trust managers) but may identify disparities in tick surveillance and control efforts at privately managed land trusts, in comparison to publicly managed lands. Such results may warrant future outreach, guidance, or financial/resource support for land trusts with respect to understanding and responding to tick populations on their managed lands.

## METHODS AND MATERIALS

### Design and Development

This project featured an explanatory sequential design, a mixed method approach in which quantitative data is followed up with qualitative data and analysis. Our application of this method emphasized quantitative representation and analysis of survey data, but utilized joint display to illustrate new insights from example quotes to an open-ended prompt (Guetterman, Fetters, & Creswell, 2015). The online survey consisted of 35 multiple choice, multiple selection, Likert scale, and open-ended free response questions using the online survey software Qualtrics (Qualtrics, Provo, UT). Questions regarding tick-borne disease transmission and tick identification derived from the work of Omodior et al. (2021); those reflecting tick surveillance and tick control methods derived from Mader et al. (2020)'s survey, with some minor edits to improve relevance for the target population. After survey design and initial beta testing, the survey was tested with representatives of three land trusts. Given their feedback and survey responses, minor edits and adjustments to survey flow were made.

### Participants & Survey Dissemination

The Institutional Review Board of the primary investigator's institution approved the study design protocol (IRB #10828). A list of land trusts operating across the U.S. Midwest and Northeastern regions were identified through online directories at the public website LandTrustAlliance.org. Reflecting U.S. Census designations of these U.S. regions (U.S. Census Bureau, 2020), Midwestern states included Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin; Eastern states included Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont. These two U.S. regions were prioritized given the distribution and abundance of multiple tick species across these two regions (Eisen, Kugeler, Eisen, Beard, & Paddock, 2017; Rosenberg et al., 2018), particularly the blacklegged (deer) tick, *Ixodes scapularis*, which is a primary vector of several tick-borne diseases including Lyme disease.

Using LandTrustAlliance online statewide directories for each state, a list of local and statewide land trusts for sampling was determined. For purposes of our work, we defined a land trust as "a nonprofit legal entity that owns (acquires) and/or manages (stewards) land, for the purpose of land conservation." The term "land trust" need not be in the organization's name. This resulted in 536 unique land trusts. However, land trusts with no owned land according to their LandTrustAlliance profile, which was interpreted to mean that they primarily conserve land through conservation easements with private landowners, were excluded from participation (n = 71), resulting in a final list of 465 land trusts to be recruited for participation.

For each land trust, an attempt was made to identify the highest-ranking staff member with land stewardship duties. This process was facilitated via links to each individual land trust's website, and a search for staff member directories on that website, which sometimes included staff titles (e.g., Stewardship Manager, Director of Stewardship) and individual e-mail addresses. Additionally, the generic e-mail address for each land trust was recorded as a backup contact; this e-mail address served as the primary contact for land trusts without publicly available staff directories. Inclusion criteria reflected (a) acknowledgment of affiliation with a land trust according to the outlined definition and (b) that their land trust has owned/monitored properties that are both 1) open to the public for recreation and 2) for



which the respondent had a general understanding of the land stewardship / monitoring activities taking place on those properties.

### **Variables & Analysis**

The survey targeted five variables related to tick perception: “tick frequency-12 months,” “tick frequency-3 months,” “general likelihood of tick encounter among public,” “highest likelihood of tick encounter among public,” and “perceived change in tick population.” A complete list outlining the item phrasing is available in the Appendix. Similarly, there were five variables related to tick surveillance: “current conducted form of tick surveillance,” “desired form of tick surveillance,” “objectives of tick surveillance,” “partners in tick surveillance,” and “barriers to tick surveillance,” and an additional variable related to tick control, “current conducted form of tick control.”

For clarity, the definitions for tick surveillance and tick control were defined in the survey for respondents and reflect those set out by Mader et al. (2020). Active surveillance is defined as “focused collection of tick samples from the field for identification, testing, or analysis,” while passive surveillance is “accepting tick samples submitted by the public, veterinarians, physicians, etc., for identification, testing, or analysis.” A third option was provided for “Other, informal tick monitoring (please describe).”

An additional two variables explored land trust communication with property users around tick risk; these were “inform users of the risk of a tick encounter,” which had options of yes / no / I’m not sure, and “personal protective measures,” which included nine tick-related safety measures and sought to identify which, if any, a land trust encouraged users to engage in. Full text of prompt and options is available in the Appendix.

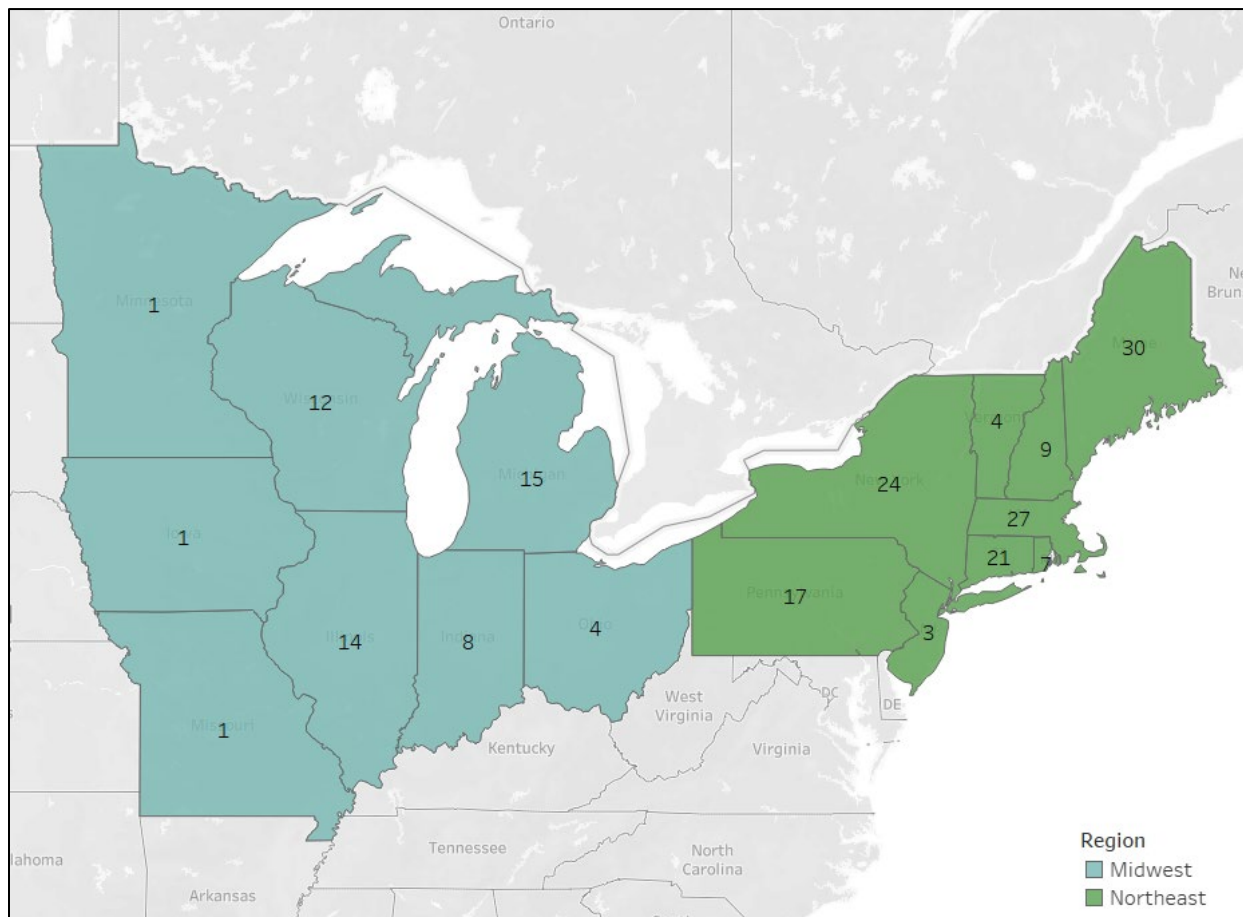
Respondents were split into groups based on (a) land trust size by number of employees (small, medium, large) and region (Midwest, Northeast). For the purposes of this report, analysis primarily consisted of descriptive statistics.

## RESULTS

The survey received 204 responses, and 198 individuals representing land trusts meeting the inclusion criteria ultimately were included in subsequent analysis, resulting in a response rate of 43%. Respondents represented land trusts operating in 18 states, with those land trusts owning and/or with oversight of 724,600 acres. By acreage, respondents representing land trusts in the Midwest owned/had oversight of 112,300 acres; those in the Northeast represents 612,300 acres—however nearly half of the Northeastern region acreage is represented by one land trust operating out of Maine. By average acreage per land trust, the average responding land trust in the Midwest was 2,005 acres in size (median = 821 acres), and the average land trust in the Northeast was 4,312 acres (median = 574 acres). Overall, by region, 142 (72%) of respondents represented Northeastern land trusts and 56 (28.3%) represented Midwestern land trusts.

Figure 1

Region Distribution of Respondents and Count of Respondents by State.



By land trust staffing size, 45 (22.7%) respondents represented entirely volunteer-run land trusts (no reported paid staff), 84 reflected limited staffing (42.4%), i.e., 1-5 full or part-time paid staff, and 69 (34.9%) represented larger land trusts with more robust staffing (greater than 5 full-time staff). By role, 29 (14.7%) identified as the Executive Director of their land trust, 85 (42.9%) identified as the Director, Manager, or otherwise lead of land stewardship,

ecology, or restoration work, 19 (9.6%) were in a land stewardship or ecologist/restoration technician role, 41 (20.7%) were a member of the board, and 24 (12.1%) identified as some other role.

### Tick Knowledge

Respondents indicated high levels of *Tick Knowledge*. When posed with several insect images, all 198 (100%) correctly identified a tick (“Tick Identification”). Nearly all (192, 97.0%) indicated the correct period of highest tick exposure (May – October), while 5 (2.5%) indicated November-April and 1 (0.5%) was unsure. Additionally, all 198 (100%) indicated that ticks can spread disease to humans; and 195 (98.5%) indicated that this disease transmission occurs via a tick bite whereas the remaining 2 (1.1%) were either unsure or believed transmission occurred via close contact with an animal with a tick-borne disease.

### Tick Surveillance

Among respondents, 28% (n = 55) indicated that their land trust conducted one form of active or passive tick surveillance. By region, 16% (n = 9) of Midwestern land trusts conducted active or passive tick surveillance; passive surveillance was most frequently reported (14%, n = 8). Reported tick surveillance was higher among Northeastern land trusts. Of this group, 33% (n = 46) reported conducting at least one form of active or passive tick surveillance, and while passive surveillance was also most frequently reported (25%, n = 35), ad hoc active surveillance was more frequently reported among this group (16%, n = 22) when compared to their Midwest land trust peers (Table 1). Notably, differences between the current and desired forms of tick surveillance generally spanned 5-20%. For example, whereas 2% of Midwestern land trusts currently practice ad hoc active tick surveillance, 20% of those respondents desired to. Overall, where 1% of land trusts currently practice regular active tick surveillance, 7% desire to practice this level of tick surveillance.

**Table 1**

#### *Tick Surveillance*

	Total		Midwest		Northeast	
	n	%	n	%	n	%
<b>Current form of tick surveillance<sup>1</sup></b>	<b>(n = 196)</b>		<b>(n = 56)</b>		<b>(n = 140)</b>	
Regular active	2	1%	1	2%	1	1%
Ad hoc active	23	12%	1	2%	22	16%
Passive	43	22%	8	14%	35	25%
None or other/informal	141	72%	47	84%	94	67%
<b>Desired form of tick surveillance<sup>2</sup></b>	<b>(n = 187)</b>		<b>(n = 55)</b>		<b>(n = 132)</b>	
Regular active	14	7%	3	5%	11	8%
Ad hoc active	28	15%	11	20%	17	13%
Passive	24	13%	5	9%	19	14%
None or other/informal	121	65%	36	65%	85	64%

<sup>1</sup>Categories reflect multiple selection item; sum of percentages greater than 100

<sup>2</sup>Responses reflect multiple choice item

A subset of respondents identified further details regarding the objectives of such tick surveillance programs (n = 184). Among those with current surveillance programs, the most frequently indicated objective was detection of ticks by species (10%, n = 19), followed by monitoring the distribution of tick species (7%, n = 12), monitoring the abundance of ticks of public health concern (5.4%, n = 10), and monitoring the emergence of new tick species (5%, n = 9). When asked their desired objectives for a tick surveillance program, the most frequently indicated objective among all land trust representatives was evaluating tick abundance by species (20%, n = 36) and monitoring the abundance of ticks that are of public health concern (20%, n = 36), followed by evaluating the prevalence of tick-borne pathogens in ticks (17%, n = 32), evaluating or calculating the risk of tick-borne illness to humans (17%, n = 32), and detecting the presence of tick-borne pathogens in ticks (17%, n = 31). Still, between 72% (n = 132) and 80% (n = 129) of land trust respondents indicated that the available options were neither current nor desired program objectives. A complete reporting of this data is provided in Table 2.



Table 2

*Tick Surveillance Objectives*

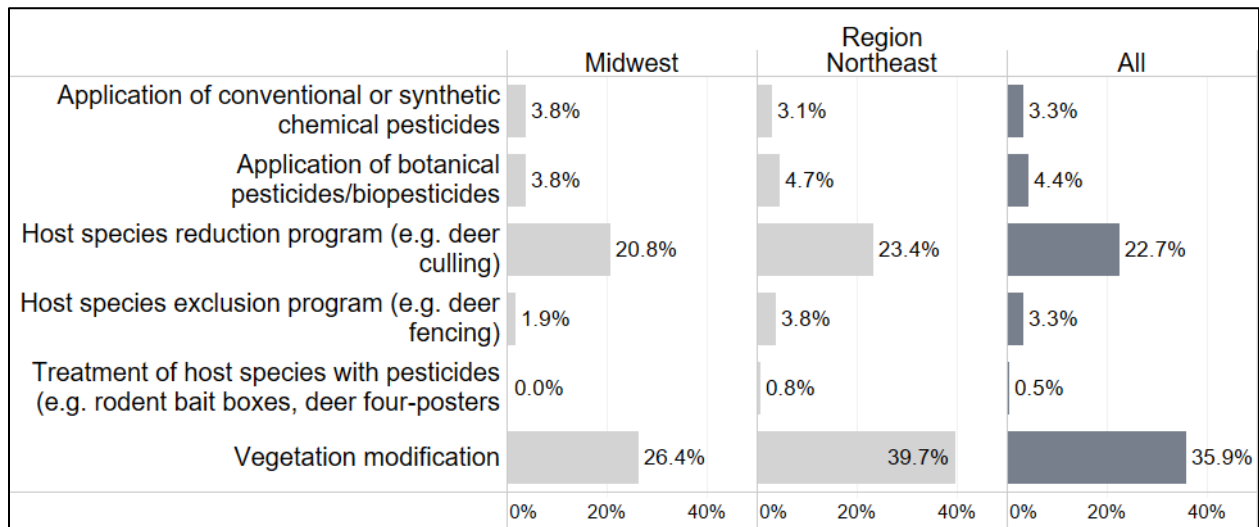
	Current			Desired			Not a program objective		
	Midwest (n = 53)	Northeast (n = 131)	Total (n = <b>184</b> )	Midwest (n = 53)	Northeast (n = 131)	Total (n = <b>184</b> )	Midwest (n = 53)	Northeast (n = 131)	Total (n = <b>184</b> )
<b>Surveillance Objectives</b>									
Detect the presence of ticks by species	6 11%	13 10%	<b>19</b> <b>10%</b>	8 15%	20 15%	<b>28</b> <b>15%</b>	38 72%	94 72%	<b>132</b> <b>72%</b>
Evaluate tick abundance by species	0 0%	8 6%	<b>8</b> <b>4%</b>	10 19%	26 20%	<b>36</b> <b>20%</b>	41 77%	92 70%	<b>133</b> <b>72%</b>
Monitor the current distribution of tick species	3 6%	9 7%	<b>12</b> <b>7%</b>	7 13%	21 16%	<b>28</b> <b>15%</b>	40 75%	95 73%	<b>135</b> <b>73%</b>
Monitor the geographic spread of tick species	1 2%	7 5%	<b>8</b> <b>4%</b>	5 9%	16 12%	<b>21</b> <b>11%</b>	44 83%	103 79%	<b>174</b> <b>80%</b>
Monitor the emergence of new tick species	1 2%	8 6%	<b>9</b> <b>5%</b>	9 17%	18 14%	<b>27</b> <b>15%</b>	40 75%	101 77%	<b>141</b> <b>77%</b>
Detect the presence of tick-borne pathogens in ticks	0 0%	6 5%	<b>6</b> <b>3%</b>	10 19%	21 16%	<b>31</b> <b>17%</b>	40 75%	98 75%	<b>138</b> <b>75%</b>
Evaluate the prevalence of tick-borne pathogens in ticks	0 0%	6 5%	<b>6</b> <b>3%</b>	10 19%	22 17%	<b>32</b> <b>17%</b>	41 77%	97 74%	<b>138</b> <b>75%</b>
Evaluate the prevalence of tick-borne pathogens in reservoir hosts	0 0%	3 2%	<b>3</b> <b>2%</b>	5 9%	18 14%	<b>23</b> <b>13%</b>	44 83%	104 79%	<b>148</b> <b>80%</b>
Monitor the abundance of ticks that are of public health concern	0 0%	10 8%	<b>10</b> <b>5%</b>	11 21%	25 19%	<b>36</b> <b>20%</b>	39 74%	90 69%	<b>129</b> <b>70%</b>
Assess infection rates of ticks that are of public health concern	0 0%	3 2%	<b>3</b> <b>2%</b>	7 13%	22 17%	<b>29</b> <b>16%</b>	43 81%	100 76%	<b>143</b> <b>78%</b>
Evaluate or calculate risk of tick-borne illness to humans	0 0%	4 3%	<b>4</b> <b>2%</b>	9 17%	23 18%	<b>32</b> <b>17%</b>	42 79%	98 75%	<b>140</b> <b>76%</b>

## Tick Control

Of the tick control options, approximately one-third of respondents (36%, n = 66) indicated that their land trust practices vegetation modification in an effort to control ticks. This differed by region; whereas 40% (n = 52) of Northeast land trusts reported vegetation modification, 2% (n = 14) of Midwest land trusts reported this practice. Also, 23% (n = 41) indicated that their land trust has conducted host species reduction; this varied slightly by Midwest (21%, n = 11) and Northeast (23%, n = 30) land trusts. All other forms of tick control had fewer than 5% of respondents reporting use of that method (Figure 2).

Figure 2

*Tick Control*



## Barriers to Surveillance & Control

Land trust representatives were also asked a series of questions regarding barriers to tick surveillance and tick control programs at their institution (Table 3). The most frequently indicated barrier to tick surveillance (57%, n = 180) and tick control (45%, n = 4) was that of funding constraints. Following this, the lack of trained personnel was selected as a barrier to tick surveillance (55%, n = 96) and tick control (38%, n = 67). Additional barriers to tick surveillance identified by at least one-third of respondents included limitations in facilities/equipment (43%, n = 76) and lack of access to testing labs or resources (36%, n = 64).

Table 3

### *Barriers to Tick Surveillance and Control*

	Total (n = 176)		Midwest (n = 52)		Northeast (n = 124)	
		%		%		%
<b>Barrier to tick surveillance</b>						
Funding constraints	100	57%	25	48%	75	60%
Lack of trained personnel	96	55%	23	44%	73	59%
Competing priorities for limited program resources (e.g., mosquito, flea, bed bug)	44	25%	13	25%	31	25%
Limitations in facilities/equipment	76	43%	19	37%	57	46%
Lack of access to testing labs/resources	64	36%	19	37%	45	36%
Coordination among agencies/units	47	27%	16	31%	31	25%
Lack of guidelines for best practices	58	33%	15	29%	43	35%
Lack of evidence-based large-scale tick management practices	54	31%	15	29%	39	31%
<b>Barrier to tick control</b>						
Funding constraints	79	45%	20	38%	59	48%
Lack of trained personnel	67	38%	17	33%	50	40%
Competing priorities for limited program resources (e.g., mosquito, flea, bed bug)	39	22%	12	23%	27	22%
Limitations in facilities/equipment	58	33%	17	33%	41	33%
Lack of access to testing labs/resources	46	26%	15	29%	31	25%
Coordination among agencies/units	32	18%	12	23%	20	16%
Lack of guidelines for best practices	43	24%	12	23%	31	25%
Lack of evidence-based large-scale tick management practices	45	26%	13	25%	32	26%

## Tick Perceptions

There is a significant difference between the Midwest and Northeast regions for all five measures of tick perception. On all measures, survey respondents from the Northeast reported higher prevalence, as measured by frequency, estimated likelihood of encounter on both measures, and the belief that ticks are increasing in prevalence. The vast majority of

respondents in both regions believed that tick prevalence had either stayed the same or increased during their time at the land trust they served, with a nearly fifty-fifty split between those two options, and only four respondents (3%) stating that they believed tick prevalence had decreased during their tenure with the land trust. Respondents in the Northeast were more likely to say that tick prevalence had increased (55%, n = 64), while Midwest respondents were more likely to report that prevalence had remained the same (66%, n = 29).

Approximately half of Northeast respondents (48%, n = 66) reported that the likelihood of a tick encounter on their property was “high” or “very high” and a similar number within that region reported that they encountered a tick on their property “almost always” or “frequently” (54%, n = 68). In the Midwest, about one-third of respondents reported encountering ticks “almost always” or “frequently” (31%, n = 17) in the field, though estimated the public’s likelihood as slightly lower, with only about twenty percent (18%, n = 10) putting the odds at “high” or “very high”, however, that number nearly doubled when they considered the site on their property where they had seen the greatest number of ticks (34%, n = 19). This indicates that Midwest land managers perceive a greater difference in tick prevalence between specific sites within their managed land compared to Northeast respondents who rated the general likelihood of a tick encounter and the likelihood of a tick encounter at the site with greater tick prevalence at roughly the same (48% and 54%, respectively).

Table 4

*Tick Perceptions*

	Total		Midwest		Northeast	
	n	%	n	%	n	%
Tick frequency, past 12 months						
Almost always or frequently	<b>85</b>	<b>46.7%</b>	17	30.9%	68	53.5%
Sometimes, rarely, or never	<b>97</b>	<b>53.3%</b>	38	69.1%	59	46.5%
General likelihood of tick encounter among public						
High or very high	<b>76</b>	<b>39.0%</b>	10	17.9%	66	47.5%
Very low, low, or moderate	<b>119</b>	<b>61.0%</b>	46	82.1%	73	52.5%
Highest likelihood of tick encounter among public (at property they manage with the most ticks)						
High or very high	<b>95</b>	<b>48.5%</b>	19	33.9%	76	54.3%
Very low, low, or moderate	<b>101</b>	<b>51.5%</b>	37	66.1%	64	45.7%
Perceived change in tick population						
Increase during time at land trust	<b>78</b>	<b>48.8%</b>	14	31.8%	64	55.2%
Stayed the same	<b>78</b>	<b>48.8%</b>	29	65.9%	49	42.2%
Decrease during time at land trust	<b>4</b>	<b>2.5%</b>	1	2.3%	3	2.6%



## Personal Protective Behaviors

Overall, 56% of respondents indicated that their land trust warns users of the risk of tick encounter on their organization's managed land and/or trails, however, this percentage differs considerably between Northeast land trusts, at 68% (n = 92), and Midwest land trusts, at 27% (n = 15). Of organizations that suggest land users engage in tick-related personal protective behaviors, conducting a thorough tick-check after recreation (Midwest = 83%, n = 10 and Northeast 89%, n = 77) and utilizing insect repellent (Midwest = 92%, n = 11 and Northeast 78%, n = 68) were the most frequently recommended behaviors; walking only on established trails and avoiding adjacent vegetation was another highly recommended behavior, primarily among Northeast region respondents, at 80% (n = 70) versus 58% (n = 7) in the Midwest. See Table 5 for a full list of surveyed behaviors.

Table 5

### Personal Protective Behaviors

	Total		Midwest		Northeast	
	n	%	n	%	n	%
<b>Warn users?</b>	<b>n = 190</b>		n = 55		n = 135	
Yes	107	56%	15	27%	92	68%
No	80	42%	39	71%	41	30%
I'm not sure	3	2%	1	2%	2	1%
<b>Suggested behavior<sup>1</sup></b>	<b>n = 99</b>		n = 12		n = 87	
Walk on established trails and avoid contact with adjacent vegetation	77	78%	7	58%	70	80%
Wear light colored clothing	65	66%	7	58%	58	67%
Wear long-sleeved shirts and pants	70	71%	8	67%	62	71%
Tuck shirt into pants and pants into socks	65	66%	7	58%	58	67%
Use bug spray (insect repellent)	79	80%	11	92%	68	78%
Treat outdoor clothing with a special bug spray such as Permethrin	42	42%	4	33%	38	44%
Conduct a thorough check of clothing and body for ticks after returning from the outdoors	87	88%	10	83%	77	89%
Shower or bathe immediately after returning from the outdoors	41	41%	4	33%	37	43%
Check your dog for ticks after spending time outdoors at your property	61	62%	3	25%	58	67%

<sup>1</sup>Categories reflect multiple selection item; sum of percentages greater than 100.

## Open-Ended Feedback

Responses to open-ended prompts provide crucial context to data analyzed quantitatively. Example quotes are provided in Table 6. With respect to *Tick Surveillance*, when these efforts were undertaken, comments referenced collaborative efforts with outside institutions, such as a nearby university or medical center. Among tick control efforts, some example quotes illustrate that the prevalence of ticks in their area dissuades them from actively seeking to control populations. With respect to *Tick Control* and in other qualitative responses, concern regarding non-natural (e.g., chemical) control methods were expressed as incongruous to land trusts' missions, which generally prioritize the preservation of natural ecosystem and flora/fauna preservation, rather than infectious disease prevention. Two example comments related to *Tick Control* indicate keeping trails mowed and/or wide to prevent tick exposure to recreationists. Still, other examples related to *Barriers to Programs* indicated that staffing and/or funding resources prevented desired tick surveillance or control efforts. *Tick Perceptions* regarding risk also indicated that the perceived risk has and/or will be increasing with time, which might influence tick-related actions, however respondents also suggested an element of personal responsibility in that many visitors know—or should know—of risks associated with ticks. With respect to *Personal Protective Behaviors*, signage for visitors and more intentional efforts for employees or volunteers were suggested. However, such efforts must be balanced with a caution to instilling excessive fear and dissuading people from participating in outdoor recreation.

Table 6

Quotes Related to Survey Content Categories

<b>Category &amp; Example Quote</b>
<b>Tick Surveillance</b>
A few years ago, we aided in a tick count and identification study by [a nearby medical center]. They found that approximately one-third of the ticks collected carried Lyme disease. – <i>Northeast Land Trust respondent</i>
Due to limited staffing/expertise, tick surveillance has not been a priority for us... – <i>Northeast Land Trust respondent</i>
Any tick surveillance done on our properties is done by partner agencies. Because of other tasks that our staff need to do, we have not put tick surveillance as a high priority. – <i>Northeast Land Trust respondent</i>
While we do not have a tick surveillance program, we do keep a record of the species of ticks found on our preserves. – <i>Midwest Land Trust respondent</i>
The tick surveillance that has happened recently on our properties has been a result of academic researchers approaching us to request access/survey permission. We haven't conducted formal surveillance of any kind in-house. – <i>Midwest Land Trust respondent</i>
<b>Tick Control</b>
We try to keep our pathways wide, but land trusts protect natural ecosystems - we can't go around spraying chemicals or altering habitats to control ticks. We just try to educate with signage at the trailheads. – <i>Northeast land trust respondent</i>
Where they are most prevalent, Japanese Barberry, we cut the bushes away from the trails. In our two meadows, we keep the trails mowed. – <i>Northeast land trust respondent</i>
Without really knowing anything about tick control chemicals, I have concerns about the harm they may cause to beneficial arachnid and insect populations. – <i>Midwest land trust respondent</i>
We know that the ticks are out there. They are in ALL the woods in the region. We warn visitors, but we have no resources to actively manage the tick population. – <i>Northeast land trust respondent</i>
Both Deer Ticks and Lone Star Ticks are so prevalent [in our area] our land trust conserves that we engage in preventive education rather than activity to reduce the tick population. – <i>Northeast land trust respondent</i>
<b>Barriers to Action</b>
Tick control is a whole barrel of worms. We are a land trust to protect rivers, providing public access is an additional value, but secondary. One of the threats we have identified to our rivers is pesticide use. We won't be spraying for ticks now or ever. We focus on making the public aware of the risk and them personally managing those risks. Further, ticks are part of the ecosystem and native to this region. – <i>Northeast land trust respondent</i>
We don't engage in any tick surveys because of limited time and funding. – <i>Northeast land trust respondent</i>
Would love to do more on surveillance and control – [we] just don't have the resources available to us. Ticks are a huge issue in our area - we have so many! Every time I go for a run with my dog in the woods' trails, we both have at least several ticks on us. – <i>Northeast land trust respondent</i>
We know ticks are here, but there just isn't the capacity to do something like this as a small, growing nonprofit. – <i>Northeast land trust respondent</i>
We have worked with our county entomologist on this issue and have not been advised to do any sort of spraying or large-scale surveying of properties. We have been told that sweeps are not easy, and the populations are hard to track. We educate everyone about the risks of ticks.... This survey seems biased to taking larger actions and that larger... actions are required. We use our volunteer trail crews to keep our trails 4ft wide and mow paths when we need to. Ticks are a part of our lives here...and it doesn't seem that they will be going away so we have learned to live with them. [Also] we do not have the resources or expertise to tackle something bigger than our education awareness campaign at this time. – <i>Northeast land trust respondent</i>

## Category & Example Quote

If there are opportunities to have an academic partner in tick management...we would welcome the opportunity to have a discussion about possibilities. – *Northeast land trust respondent*

### Tick Perceptions

Risks and public knowledge about ticks have greatly increased in the last 10 years...it is common knowledge that you are assuming risks... - *Midwest Land trust respondent*

The presence of ticks in the woods is well known and publicized given the prevalence of Lyme Disease. People who go in the woods know the risks. – *Northeast Land Trust respondent*

As climate change continues and the tick population increases in the region, perhaps we would be more interested in these types of programs...to keep our visitors safe. – *Northeast Land Trust respondent*

Understanding how tick populations are changing and the risks they play to people may increase the [desire] to do tick monitoring at [our] properties; however, I don't believe we will ever be at a point where we will go so far as managing tick populations, [beyond] that of prescribed fire as a general ecological tool. My opinion is that ticks are a natural part of the community and, while their populations may be increasing/their impact on humans may be getting more severe (in terms of tick-borne diseases), habitat restoration and supporting healthy floral and faunal communities should keep tick populations in check. - *Midwest Land trust respondent*

### Personal Protective Behaviors for Ticks

We all recognize we're in the epicenter for Lyme Disease and are or have loved ones who've suffered. We aren't all on the same page about what we can do. We've described tick-management goals when we've reduced the deer herd, implemented prescribed fire, and treated barberry thickets. But most of us are skeptical these practices really help, so embrace them half-heartedly. We buy permethrin for volunteers and warn those folks to shower and check for ticks, but don't want to discourage visitors from connecting with nature. - *Northeast land trust respondent*

Volunteers are advised to wear protective clothing and we provide repellent and tick-check advice. Trails are mowed wide where possible to reduce brush exposure. People who stay on trails do not seem to encounter too many ticks; trail workers do. – *Northeast land trust respondent*

We do address ticks and diseases while training our volunteers who work outside. We also ensure all staff can identify ticks as well as provide and encourage the use of bug spray and permethrin to apply to clothing. – *Northeast land trust respondent*



## DISCUSSION

The results of this project indicate that most land trust managers are highly knowledgeable about ticks, tick-borne disease, and how and when tick-borne diseases are spread. With respect to tick surveillance, just under 30% of land trusts practice any form of active or passive tick surveillance; to that end, the majority of respondents did not express a desire to practice a form of tick surveillance. With respect to efforts to control tick abundance or presence, more than one-third of respondents practice vegetation modification, at least in part to prevent human-tick encounters (e.g., trail mowing or maintaining wide trails). More than one fifth of respondents practice host species reduction programs, such as deer population culling. Several barriers to tick surveillance and control practices were identified by respondents. With respect to both tick surveillance and control, the most frequently selected barriers include funding constraints, the lack of trained personnel, limitations in facilities or equipment available, and lack of access to testing labs or resources. Given that the work of Rissman & Butsic (2010) indicated that, in a nationwide survey of more than 200 land trusts, the median annual budget was \$60,000, the median staffing level was 1.5 individuals, and 37% of land trusts reported being entirely volunteer run, these reported constraints regarding staffing and resources are validated.

Despite the relatively low reported practice of tick surveillance or control efforts, nearly half of respondents said they “almost always” or “frequently” see ticks on publicly accessible properties managed by their land trust. Furthermore, about half of respondents estimated that the tick population had stayed the same during their tenure at their land trust, whereas another half reported it has increased. This aligns with evidence of geographic expansion of tick species, particularly the blacklegged tick (deer tick), along the Eastern seaboard and the Upper Midwest (Eisen & Eisen,



2023). Land trusts in the Northeast were more likely to report perceived increases in tick populations. Similarly, nearly two-thirds of northwestern land trusts reported warning or communicating with the public about the risk of ticks on site, in contrast to less than 30% among Midwestern land trusts; the difference in this practice between these two regions aligns with extant literature that shows that tick prevalence and abundance is most common in the northwest (Eisen & Eisen, 2023). Land trusts typically suggest multiple protective behaviors to the public, including walking on established trails, using insect repellent, and conducting a tick check of oneself, among several other measures.

Open-ended feedback provided key context to the quantitative survey results. In several cases, barriers to tick surveillance, such as limited capacity (i.e., staffing), resources, and lack of expertise, were reported. Some respondents expressed previous work with or future desire to collaborate in this area, such as with an academic institution or local entomologist. However, several other respondents shared that they do not desire to engage in intentional tick surveillance or control measures, identifying concerns such as (a) the futility of

attempting these efforts in high-tick population regions and (b) misalignment between some practices, like insecticide spraying, and their natural landscape preservation mission. To that end, many respondents were candid about the risk of ticks and public health concern they pose, and while they may engage in some efforts (mowing, encouragement of personal protective behaviors), they acknowledge that ticks are a natural and unavoidable aspect of their local ecosystem. This line of reasoning also aligns with other perceptions that whereas some forms of pest control are frequently viewed as a “community responsibility,” preventing tick-borne disease is often characterized by an “individual responsibility” (Eisen, 2020).

## CONCLUSION

Preserving fifty million acres across the United States, land trusts are crucial spaces for protecting natural and cultural landscapes, and in many cases, are vital spaces that facilitate outdoor recreation opportunities for the general population. Like other outdoor natural ecosystems, they are also a site of human-pathogen encounters, and in the case of this project—ticks. Whether or not land trusts are able to, or desire to, engage in tick surveillance or control efforts—due to a variety of factors such as capacity, resources, or mission-alignment—this study importantly sought to better understand the frequency and desirability of these activities in two regions of the country, the Midwest and Northeast, with high tick prevalence and abundance, as well learn about perceptions regarding ticks among land trust representatives.



Given the public health threat of ticks due to their status as the primary driver of vector-borne disease diagnoses in the United States, we believe it is crucial to document key tick-related measures land trusts undertake, especially as these measures among these groups were not well understood in comparison to other public health and land management agencies. Consequently, this data can be used by both land trusts and other entities (academic institutions, disease prevention organizations) to understand current and desired tick surveillance, control, and communication practices among land trusts, as well as understand knowledge and perceptions of land trust representatives regarding ticks.

## APPENDIX

### Survey Items and Response Options

Category & Variable	Item Text & Response Options
<b>Tick knowledge</b>	
<b>Tick identification</b>	Please identify the tick from the pictures below [several photos provided, of which one was a tick]
<b>Period of highest tick exposure</b>	The period with the highest risk for tick exposure is: <ul style="list-style-type: none"> <li>• May to October</li> <li>• November to April</li> <li>• I'm not sure</li> </ul>
<b>Tick disease &amp; humans</b>	Do you think ticks can spread diseases to humans? <ul style="list-style-type: none"> <li>• Yes</li> <li>• No</li> <li>• I'm not sure</li> </ul>
<b>Tick disease transmission</b>	Diseases caused by ticks can be transmitted to humans... (select all that apply) <ul style="list-style-type: none"> <li>• Through a tick bite</li> <li>• Through close contact with a person with a tick-borne disease</li> <li>• Through close contact with an animal with a tick-borne disease</li> <li>• I'm not sure</li> </ul>
<b>Tick perception</b>	
<b>Tick frequency - 12 months</b>	During the past 12 months, how frequently did you see ticks on publicly accessible properties managed by your land trust? <ul style="list-style-type: none"> <li>• Never</li> <li>• Rarely</li> <li>• Sometimes</li> <li>• Frequently</li> <li>• Almost Always</li> </ul>
<b>Tick frequency - 3 months</b>	During the past 3 months, how frequently did you see ticks on publicly accessible properties managed by your land trust? Frequency options as above
<b>General likelihood of tick encounter among public</b>	Generally, how would you estimate the likelihood of a tick encounter on publicly accessible properties managed by your land trust? <ul style="list-style-type: none"> <li>• Not applicable / None of our properties are known to have ticks</li> <li>• Very low – A member of the general public visiting one of our properties will almost certainly NOT encounter a tick <ul style="list-style-type: none"> <li>• Low</li> <li>• Moderate</li> <li>• High</li> </ul> </li> <li>• Very High – A member of the general public visiting one of our properties WILL almost certainly encounter a tick</li> </ul>
<b>Highest likelihood of tick encounter among public</b>	Consider the property your land trust manages with the most ticks that is also open to the public. How would you describe the likelihood of a tick encounter on that property?

Category & Variable	Item Text & Response Options
	Likelihood options as above
<b>Perceived change in tick population</b>	<p>Have you perceived a change in the number of ticks across the publicly accessible properties managed by your land trust, during your time at your land trust?</p> <ul style="list-style-type: none"> <li>• Not applicable / None of our properties are known to have ticks</li> <li>• No – tick populations have generally stayed the same during my tenure</li> <li>• Yes – tick populations have generally DECREASED during my tenure</li> <li>• Yes – tick populations have generally INCREASED during my tenure</li> </ul>
<b>Tick surveillance</b>	
<b>Current conducted form of tick surveillance</b>	<p>Please describe your organization's level of tick surveillance on publicly accessible properties managed by your land trust (select all that apply).</p> <ul style="list-style-type: none"> <li>• Routine, regularly implemented active tick surveillance</li> <li>• Irregular / ad hoc active tick surveillance</li> <li>• Passive tick surveillance</li> <li>• No, we are not interested in developing or restarting a tick surveillance program</li> </ul>
<b>Desired form of tick surveillance</b>	<p>Is your organization interested in further developing or restarting one of the following forms of tick surveillance? Surveillance options as above</p>
<b>Objectives of tick surveillance</b>	<p>Please indicate the objectives of your tick surveillance program.</p> <ul style="list-style-type: none"> <li>• Detect the presence of ticks by species</li> <li>• Evaluate tick abundance by species</li> <li>• Monitor the current distribution of tick species</li> <li>• Monitor the geographic spread of tick species</li> <li>• Monitor the emergence of new tick species</li> <li>• Detect the presence of tick-borne pathogens in ticks</li> <li>• Evaluate the prevalence of tick-borne pathogens in ticks</li> <li>• Evaluate the prevalence of tick-borne pathogens in reservoir hosts</li> <li>• Monitor the abundance of ticks that are of public health concern</li> <li>• Assess infection rates of ticks that are of public health concern</li> <li>• Evaluate or calculate risk of tick-borne illness to humans</li> <li>• Other (please describe):</li> </ul>
<b>Funding</b>	<p>Generally, how are tick control methods funded?</p> <ul style="list-style-type: none"> <li>• Self-funded through fundraising / donations</li> <li>• Funded through another nonprofit / foundation grant</li> <li>• State funding source</li> <li>• Federal funding source</li> <li>• Other (please describe):</li> <li>• Not applicable</li> </ul>
<b>Tick surveillance partners</b>	<p>Does your program work with other partners to conduct tick surveillance?</p> <ul style="list-style-type: none"> <li>• Academic institutions</li> <li>• Other land trusts</li> <li>• Private organizations or other nonprofits</li> <li>• Local land management organization</li> <li>• County land management organization</li> </ul>

Category & Variable	Item Text & Response Options
	<ul style="list-style-type: none"> <li>• State land management organization</li> <li>• Federal land management organization</li> <li>• Local public health agency</li> <li>• County public health agency</li> <li>• State public health agency</li> <li>• Federal public health agency</li> <li>• Other (please describe):</li> </ul>
<b>Barriers to tick surveillance</b>	<p>What are the most significant barriers to developing and/or enhancing tick surveillance and control in your organization?</p> <ul style="list-style-type: none"> <li>• Funding constraints</li> <li>• Lack of trained personnel</li> <li>• Competing priorities for limited program resources (e.g., mosquito, flea, bed bug)</li> <li>• Limitations in facilities/equipment</li> <li>• Lack of access to testing labs/resources</li> <li>• Coordination among agencies/units</li> <li>• Lack of guidelines for best practices</li> <li>• Lack of evidence-based large-scale tick management practices</li> <li>• Other (please describe):</li> </ul>
<b>Tick control</b>	
<b>Current conducted form of tick control</b>	<p>Please indicate the forms of tick control used by your program:</p> <ul style="list-style-type: none"> <li>• Application of conventional or synthetic chemical pesticides</li> <li>• Application of botanical pesticides/biopesticides</li> <li>• Host species reduction program (e.g., deer culling)</li> <li>• Host species exclusion program (e.g., deer fencing)</li> <li>• Treatment of host species with pesticides (e.g., rodent bait boxes, deer four-posters)</li> <li>• Host species exclusion</li> <li>• Vegetation modification</li> </ul>
<b>Communication</b>	
<b>Inform users</b>	<p>With respect to your publicly accessible managed properties, do you inform users of the risk of a tick encounter, such as through informational signage at a trailhead?</p> <ul style="list-style-type: none"> <li>• Yes</li> <li>• No</li> <li>• I'm not sure</li> </ul>



Category & Variable	Item Text & Response Options
<b>Personal protective measures</b>	<p>With respect to your publicly accessible managed properties, do you suggest to users that they engage in any of the following personal protective measures, such as through informational signage at trailhead, specifically because of concern for ticks? (Select all that apply)</p> <ul style="list-style-type: none"><li>• Walk on established trails and avoid contact with adjacent vegetation, such as grasses and low shrubs during the summer months</li><li>• Wear light colored clothing to enable you to identify and remove ticks when outdoors</li><li>• Wear long-sleeved shirts and pants</li><li>• Tuck shirt into pants and pants into socks when outdoors during the summer months</li><li>• Use bug spray (insect repellent) when outdoors</li><li>• Treat outdoor clothing with a special bug spray such as Permethrin</li><li>• Conduct a thorough check of clothing and body for ticks after returning from the outdoors</li><li>• Shower or bathe immediately after returning from the outdoors</li><li>• Check your dog for ticks after spending time outdoors at your property</li></ul>

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