SUBURBAN WILDS

2022 Project Update – Year 1

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Selection of pictures from wildlife cameras in studied towns

Goals and Scope

The goal of this report is to provide an update to municipalities, organizations, and individuals participating in the Suburban Wilds research project—a multi-year interdisciplinary project that explores the social and environmental dynamics of wildlife in suburban and urban communities of Massachusetts and New York. This report is intended to familiarize readers with the project, give basic information about deer management histories of participating towns, and provide an update on our social and ecological research in progress in each town. The data and figures presented in this report are preliminary and should be understood as an initial look into the work conducted in 2021. Interpretation of these early results may change as the project continues and we accumulate and analyze more data.

Project Background and Overview

In North America, wild species—such as turkeys, geese, alligators, coyotes, beavers, and white-tailed deer—have grown in numbers in residential areas (e.g., Rooney and Waller, 2003; Koons et al., 2014; Rozhkova-Timina et al., 2018; Gibb et al. 2020). White-tailed deer (*Odocoileus virginianus*) are an increasingly common sight in the streets and backyards of communities across the states of Massachusetts (MA) and New York (NYS). Several factors have contributed to the growth in deer populations, including the lack of predators and abundant food supplies in suburban yards (Etter et al., 2002; Garrott et al., 1993). The growing number of deer in suburban and urban communities have caused a mixture of interest and concern from residents and officials across both states.

To improve our understanding of deer population dynamics in urban and suburban contexts and municipal discussions about deer, the Suburban Wilds research project investigates white-tailed deer in New York and Massachusetts and examines how communities make decisions regarding these changes by combining ecological and social science research. We are an interdisciplinary group of researchers based at Boston University, University of Wisconsin-Madison, Texas A&M University, and Colorado State University. This project is a multi-year investigation into the social and ecological dimensions of deer management funded by awards from the National Science Foundation (Award #1832191 and Award #1923668).

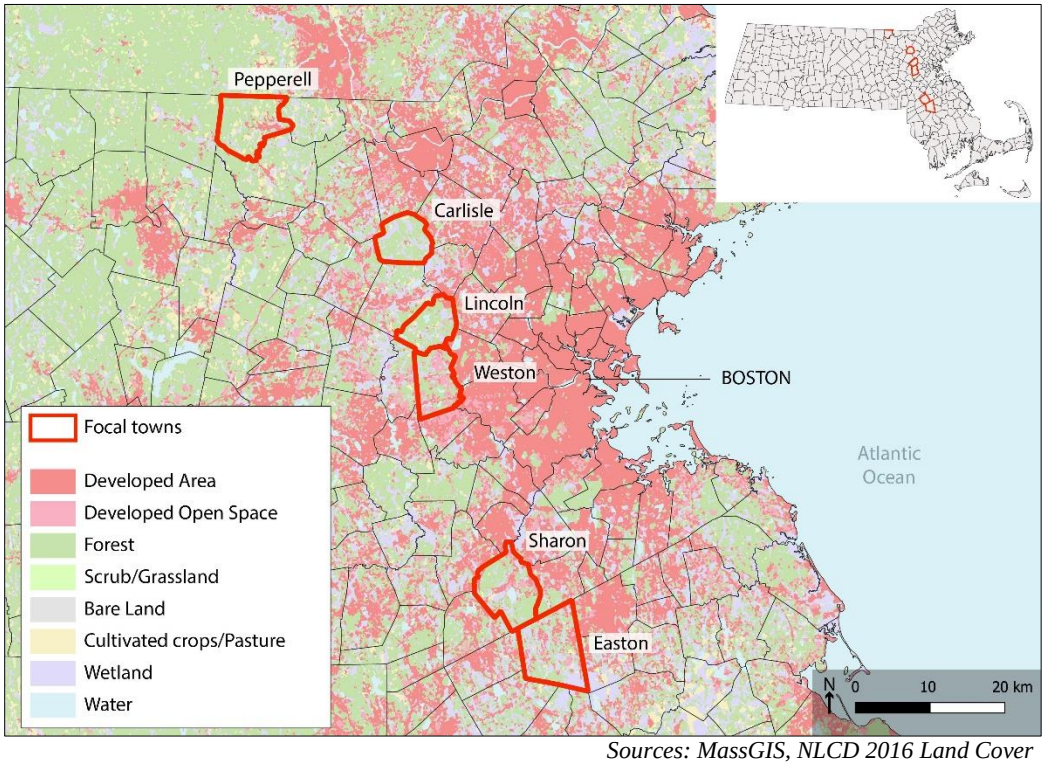
The ecological research component combines camera traps, vegetation browse surveys, and information about local deer management to understand relationships between deer, impacts to understory plant communities, and hunter harvests or culling activity. The social science

component consists of qualitative and quantitative research activities, such as surveys of town officials, hunters and residents, hunting logs, in-depth interviews with people engaged in deer management, focus groups with residents, and review of key documents. The goal of this portion of the work is to understand how different groups of people understand and respond to white-tailed deer and how and why strategies for wildlife management differ by locations. Together, the ecological and social science research activities will inform agent-based decision models that investigate local deer management scenarios.

Study Town Descriptions

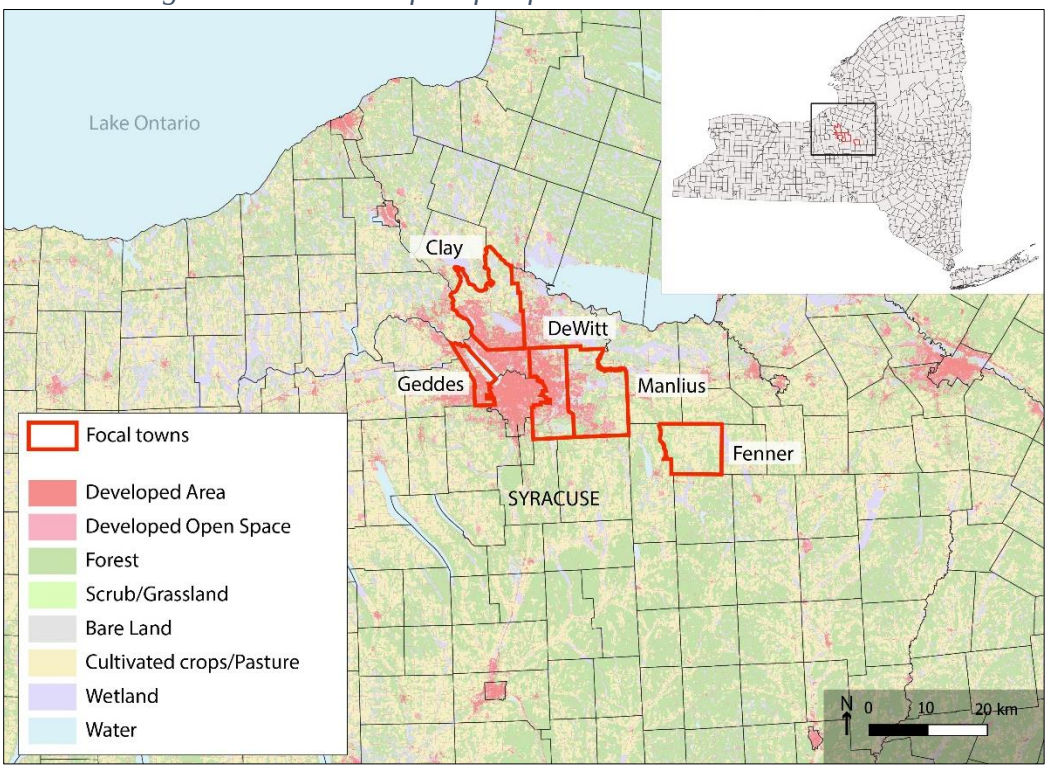
We are currently working in six towns in Middlesex and Norfolk counties of eastern Massachusetts (Fig. 1) and five towns in Onondaga and Madison counties of central New York (Fig. 2). Spanning a suburban-to-exurban gradient, these towns have varying histories of and approaches to deer management. Table 1 offers an overview of each town, their demographic, socioeconomic, and landscape characteristics, and their concerns about and actions towards deer. Sources to table 1 can be found in the Appendix.

Figure 1 - Location of the six focal towns in Massachusetts



Sources: MassGIS, NLCD 2016 Land Cover

Figure 2 - Location of the five focal towns in New York State



Sources NYS GIS Clearinghouse, NLCD 2016 Land Cover

Table 1 – Profile of selected towns in the states of Massachusetts and New York

	Town	County	Surface (km^2)	Population	Population density (km^2)	Median age of population	Median household income	Forested area (%)	Protected open space (%)	Deer concern to municipal official[1]	Municipal deer management[2]
MASSACHUSETTS	Pepperell	Middlesex	60.07964	11,604	190	42.9	$90,029	55%	18%	No	No
	Carlisle	Middlesex	40.1781	5,237	128	50	$170,703	56%	33%	Yes	Volunteer bow hunt in 2018-2019 (paused in 2020)
	Lincoln	Middlesex	38.79592	7,014	173	41.4	$134,211	51%	41%	Yes	No
	Weston	Middlesex	44.89172	11,851	267	44.4	$196,651	40%	24%	Yes	Volunteer bow hunt
	Sharon	Norfolk	63.17687	18,575	289	43.1	$132,734	46%	34%	Yes	No
	Easton	Bristol	75.71019	25,058	317	40.1	$105,380	36%	33%	No	No
NEW YORK	Geddes	Onondaga	30.23843	17,088	555	43.5	$55,870	8%	7%	Yes	No (sharpshooting program in village of Solvay started in 2021)
	DeWitt	Onondaga	87.50887	26,074	293	42.3	$65,665	18%	3%	Yes	Sharpshooting
	Manlius	Onondaga	129.1814	33,712	293	44.7	$79,158	32%	8%	Yes	Sharpshooting
	Clay	Onondaga	126.8031	60,527	470	39.5	$69,227	20%	7%	Yes	No
	Fenner	Madison	80.56671	1,686	20	46.3	$66,250	36%	<1%	No	No

[1] As expressed by respondents of the municipal deer surveys conducted in MA and NYS

[2] Deer management is defined as action taken by individuals or organizations to change the population of deer and/or their impacts through increasing, maintaining, or reducing current population levels.

Social Science Update

Municipal Deer Survey

The social science team has been conducting research activities across New York and Massachusetts, at both the state and municipality levels. In 2017 and 2020, we conducted two municipal deer surveys across all towns, cities and villages of MA and NYS. These online surveys aimed to understand how concerns about deer, responses to deer, and local bylaws vary across both states. The survey collected information about the perceived change in deer populations in the past ten years, local concerns about deer, municipal bylaws pertaining to hunting, municipal deer management strategies in use or under consideration, and the ways municipalities have learned about deer and deer management. Results and descriptive statistics of these surveys can be found on the "resources and documents" page of our website. These surveys informed subsequent research activities in the 11 focal towns.

Document Analysis

To learn more about how deer management programs form and how information about deer management is shared between municipalities, we collected three hundred and forty-nine documents from a subset of towns with deer management programs in Massachusetts[3] including meeting minutes, presentations, reports, and web pages regarding deer and deer management. Work in this area is ongoing to understand the range of municipal experiences with deer management, and how information flows through municipal networks through qualitative coding of these documents.

Hunter Surveys

To get a better understanding of hunters and their role in deer population changes, we implemented a pilot hunter survey in 2020 in Massachusetts. The goal of this survey was to gather information on hunter demographics, hunting activities, and hunting access concerns. We asked respondents questions about their hunting sites and ease of access as well as questions about deer and other wildlife sightings and the number of deer taken during the season. We also asked them to log details about their hunting activities to understand how their efforts change across the hunting season. Hunters were recruited through sportsmen's clubs across Massachusetts. Sixty hunters responded to this survey. This research activity offered insight on the primary concerns of

[3] The subset of towns was selected from municipal survey respondents in Massachusetts who reported receiving advice on deer management and had attempted or conducted a deer management program.

hunters regarding changing access to hunting sites. These responses informed expanded statewide survey efforts. Working with MassWildlife, the state wildlife agency, we generated questions about hunter access for the 2021 Annual Hunter Survey. Additionally, a targeted survey of hunters in Central NY has been prepared and planned for Summer 2022.

In-depth Interviews and Focus Groups

To deepen our understanding of how and why deer management programs are formed and contested at the municipal level. We conducted 28 in-depth interviews and focus groups with key actors engaged with debates about deer management. Interview respondents included municipal officials, town residents, and people working at land trusts and nonprofit organizations. Respondents included those who supported local deer management activities as well as those who opposed deer management. We identified participants through purposive and snowball sampling. Recruitment was conducted over emails and through exposure of our research project during town meetings and in the local newspaper. During our interviews, we inquired about the ways discussions about deer started and unfolded. Questions elicited responses about who engaged in these discussions, what concerns were expressed, by whom, what decisions were made and for what reasons. Further, we asked interviewees about their role within these discussions, and offered them the opportunity to reflect on their municipality's engagement with deer. Our goal was to unravel the circumstances in which these decisions happened. Efforts to conduct interviews will continue.

Resident Survey

To understand the range of resident views on deer management, we conducted a survey of residents in a focal town where deer management was an outstanding concern in Spring 2022. We asked residents about their experiences with deer, their concerns regarding deer and deer management, and their involvement in town discussions of managing deer. Surveys were sent to 1000 residents, with a response rate of 36%.[4] Results from this survey will be shared in future reports.

Ecology Update

During our first season of ecological field work (May-October 2021), we acquired access to properties and established sampling sites. In each study town, we selected 4-6 focal areas based on a statistical analysis. These focal areas serve as a representative sample of the diversity of

[4] Data entry still underway

landscape characteristics specific to each study town. Specifically, we used data representing land use and land cover (NLCD 2016), an index of human development called Wildland-Urban Interface (see http://silvis.forest.wisc.edu/data/wui-change/), and hunting access. We chose these three characteristics based on a review of scientific literature and expert opinion. Each focal area is 1 km^2 which is approximately equal to the average home range size for female deer in the Northeast suburbs.

Within each focal area, we attempted to gain access to 5 locations to survey the vegetation for deer browsing impacts and place wildlife cameras. This would have produced 20-30 camera/survey sites per town (depending on the number of focal areas). However, inability to gain access to properties prevented achieving a complete camera/survey site array in some towns.

In total, we placed 225 wildlife cameras throughout the 11 study towns and conducted a browse survey at each camera location. We plan to return to each camera sited at approximately 6-month intervals to download photos and replace batteries. We will conduct repeated vegetation surveys at the sampling sites during each summer of this study (2021, 2022, and 2023). Additionally, we developed a road-based survey method to investigate deer impacts to landscaping plants. Using this method, we conducted 60 surveys to investigate deer impacts to landscaping plants. In this current report, we are presenting ***preliminary data*** from the vegetation surveys and the road-based landscape plant surveys.

Browse Survey Methods

We conducted twig-age browse surveys within a ~150 m radius of each camera location (Waller et al., 2017). Using this method, we recorded the age of two randomly selected twigs on 30 seedlings at each site. Additionally, we only measured twigs that were within the reach of white-tailed deer (>20 cm and <160 cm). We restricted sampling to the maple (*Acer*) and oak (*Quercus*) genera based on the recommendation of Waller et al. (2017). We terminated searching when we had recorded measurements from 30 saplings, or we had been searching for 1 hour. The full methodology and vegetation sampling protocols are described in the appendix.

For the road-based browse survey, we surveyed each focal area for two common landscaping plants, northern white cedar (*Thuja occidentalis*) and hostas (*Hosta* spp.). We conducted surveys by walking or driving along roads. Surveys concluded when either 30 landscaped areas were surveyed or there were no more landscaped areas in the focal area. “Landscaped areas” were usually residential yards, but also included areas such as landscaping around businesses and streets. We did not survey newly constructed/landscaped areas.

Browse Survey Preliminary Results

First and foremost, these are preliminary results, and should be viewed as an incomplete comparison that doesn't capture all of the nuance in the data. For example, we sampled four oak species and four maple seedlings for our twig-age analyses. Not all species were present within a single survey site or even a single town. Additionally, these species vary in their palatability to deer. Therefore, the results might not be directly comparable across locations because different species make up the sample, however, we combined all tree species for this report. In future analyses, we will examine the differences between deer browsing among species.

We compiled four metrics of deer browsing for this first report. The first index is the percentage of seedlings browsed during the current growing season (we did not record browse from previous years due to inaccuracies in determining the source of the browsing). Because we only considered browsing during the current growing season, the percentage of seedlings browsed is an indicator of browse pressure during the summer sampling occurred. Second, we considered the average age of twigs. Twig age is an indicator of deer browse over the course of the entire year and gives insight into browsing that has occurred over about 5 years prior to sampling. Third, we looked at percentage of cedars trees that had been browsed by deer. Cedar browsing reflects winter browsing pressure, and can indicate longer-term browse pressure. However, since this is a new method, the amount of time it takes for cedars to respond to browsing is still unknown. The last browse indicator in the tables below is browsing pressure on hostas. Like seedling browsing, the percentage of hosta browse serves as an indicator of summer browse, but may be fundamentally different due to differences in risks associated with foraging near houses compared to foraging in wooded areas. There are two important caveats of the survey of landscape plants. First, the sample sizes are relatively small. Second, some landowners use deer repellents or plant deer-resistant cultivars to discourage deer browsing.

In the tables below, we first offer a summary of these four indicators at the town and state level (Table 2). We then report on these indicators within each focal area across the studied towns, along with town-specific maps showing the location of the focal areas.

Table 2 - Browse survey results in each studied town and state averages

Town	% Seedlings browsed	Average twig age	% Cedars browsed	% Hostas browsed
Pepperell	30.1%	2.39	22.2%	1.5%
Carlisle	30.7%	1.90	44.1%	15.7%
Lincoln	27.5%	2.48	47.4%	10.9%
Weston	28.8%	2.34	30%	45.5%
Sharon	36.6%	1.78	34.3%	5.5%
Easton	23.8%	1.83	13.6%	3.1%
MA Average	**29.6%**	**2.12**	**31.9%**	**13.5%**
Fenner	21.5%	2.46	50%	12.5%
Clay	37.0%	1.83	25.6%	1.5%
Manlius	28.0%	2.35	44.4%	9.3%
DeWitt	25.9%	2.00	31.7%	9.5%
Geddes	57.7%	1.89	18.2%	0%
NY Average	**34.0%**	**2.11**	**34.0%**	**6.6%**

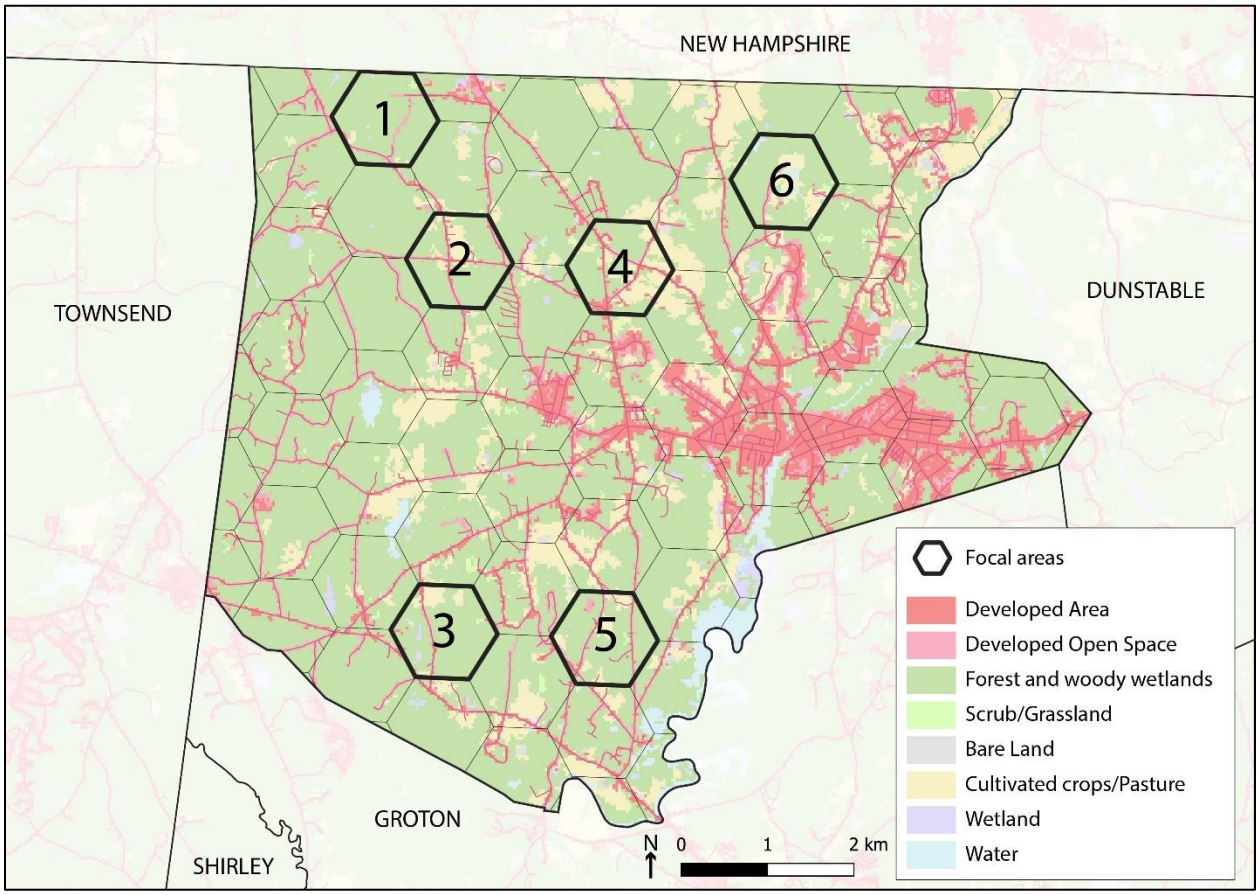
Future Directions and Plans

We plan to distribute another annual report in spring 2023 and a final report at the end of the project. In future reports, we will continue to explore the browse indicators. Additionally, we will build on the knowledge of the vegetation in the study towns by presenting results from understory and overstory vegetation sampling efforts. We also anticipate presenting data that is currently being gathered by the wildlife camera network established in 2021. Wildlife cameras will provide useful information about the deer and other wildlife species present in each town.

Our efforts to understand the social dimensions of deer management will continue over the next two years. We will continue to analyze the documents collected from municipalities with deer management programs and data collected from our survey efforts on resident perspectives, hunter access concerns, and municipal actors. We will also continue to speak with stakeholders in focal towns about their interests and concerns regarding deer management. Along with these activities, we are planning opportunities to engage with community members about these topics.

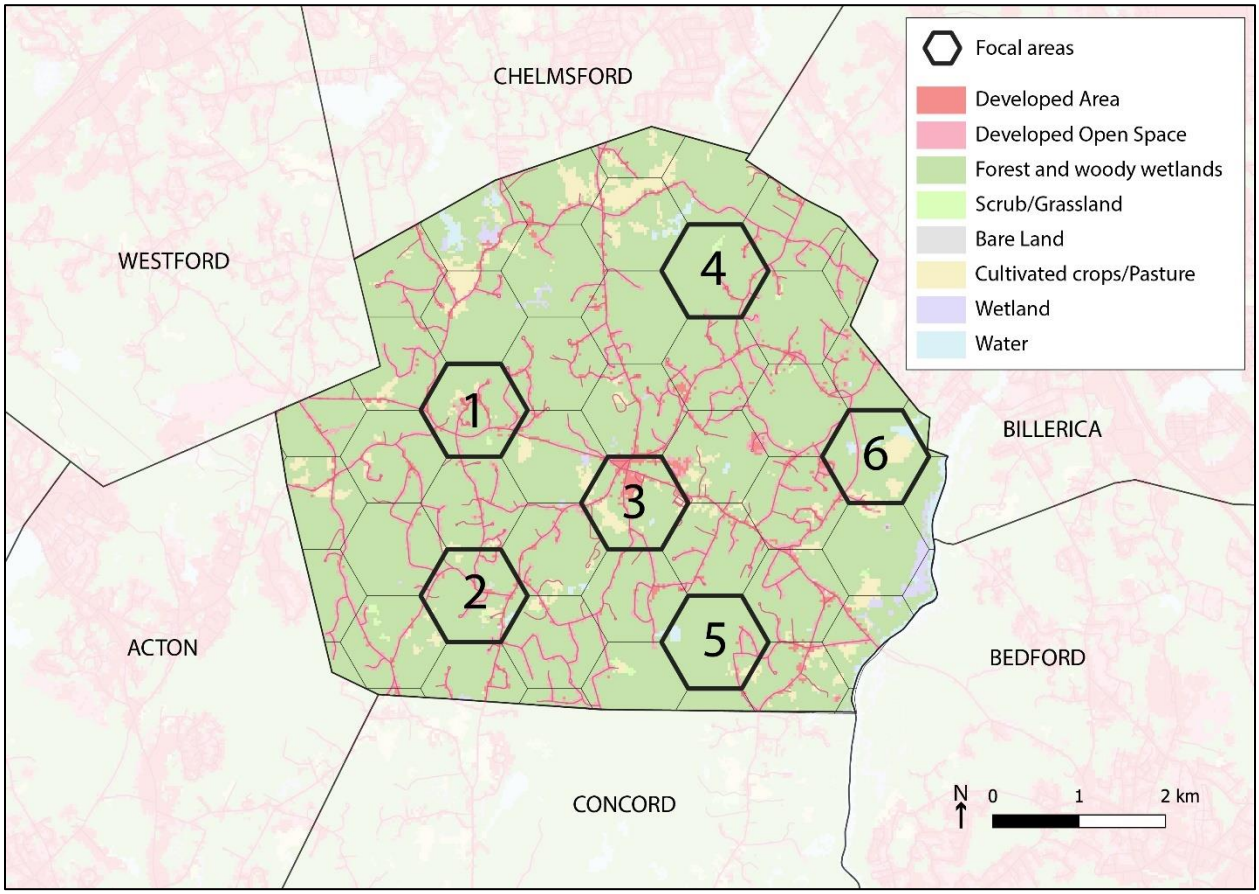
Preliminary Results - Massachusetts

Pepperell



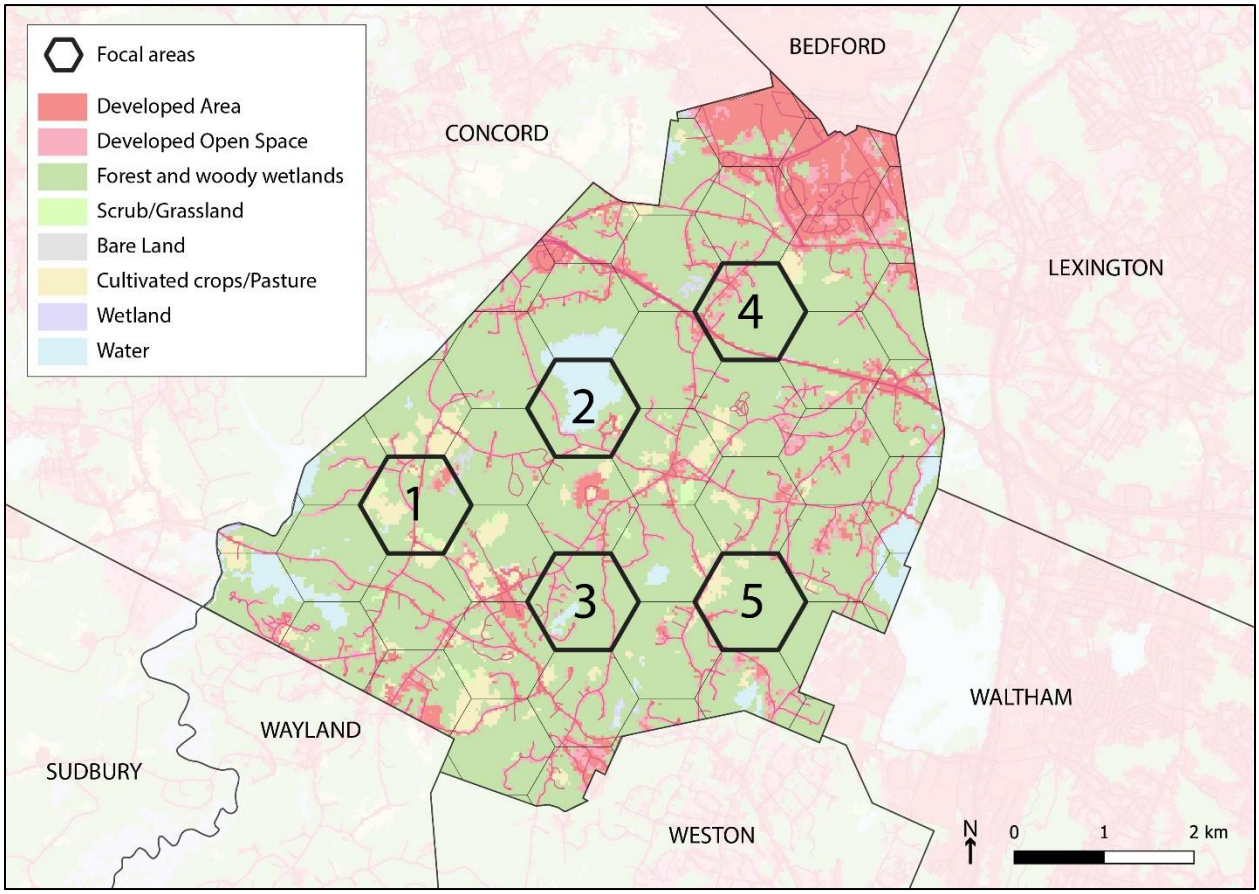
Grid	*% Seedlings browsed*	*Average twig age*	*% Cedars browsed*	*% Hostas browsed*
1	150 (31%)	2.35	10 (30%)	14 (7%)
2	120 (17%)	2.52	14 (50%)	12 (0%)
3	149 (23%)	2.59	10 (30%)	11 (0%)
4	150 (39%)	2.12	14 (7%)	10 (0%)
5	134 (31%)	2.76	10 (20%)	12 (0%)
6	150 (37%)	2.06	14 (0%)	10 (0%)
Total	**853 (30.1%)**	**2.39**	**72 (22.2%)**	**69 (1.5%)**

Carlisle



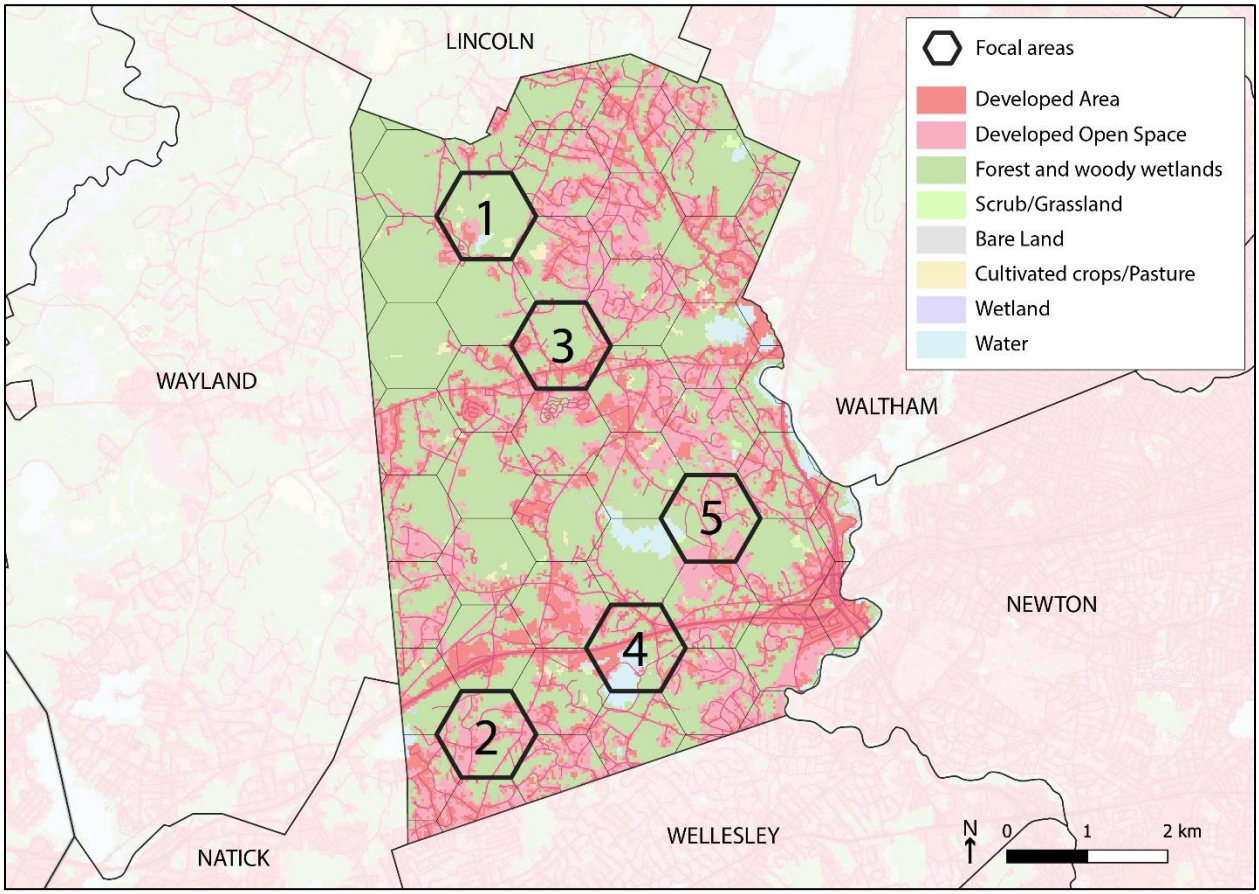
Grid	*% Seedlings browsed*	*Average twig age*	*% Cedars browsed*	*% Hostas browsed*
1	142 (35%)	1.75	11 (27%)	15 (7%)
2	68 (37%)	1.85	2 (50%)	9 (22%)
3	98 (31%)	1.85	7 (14%)	10 (10%)
4	122 (33%)	1.87	5 (80%)	4 (25%)
5	144 (23%)	2.12	7 (57%)	7 (29%)
6	150 (29%)	1.89	2 (100%)	6 (17%)
Total	**724 (30.7%)**	**1.90**	**34 (44.1%)**	**51 (15.7%)**

Lincoln



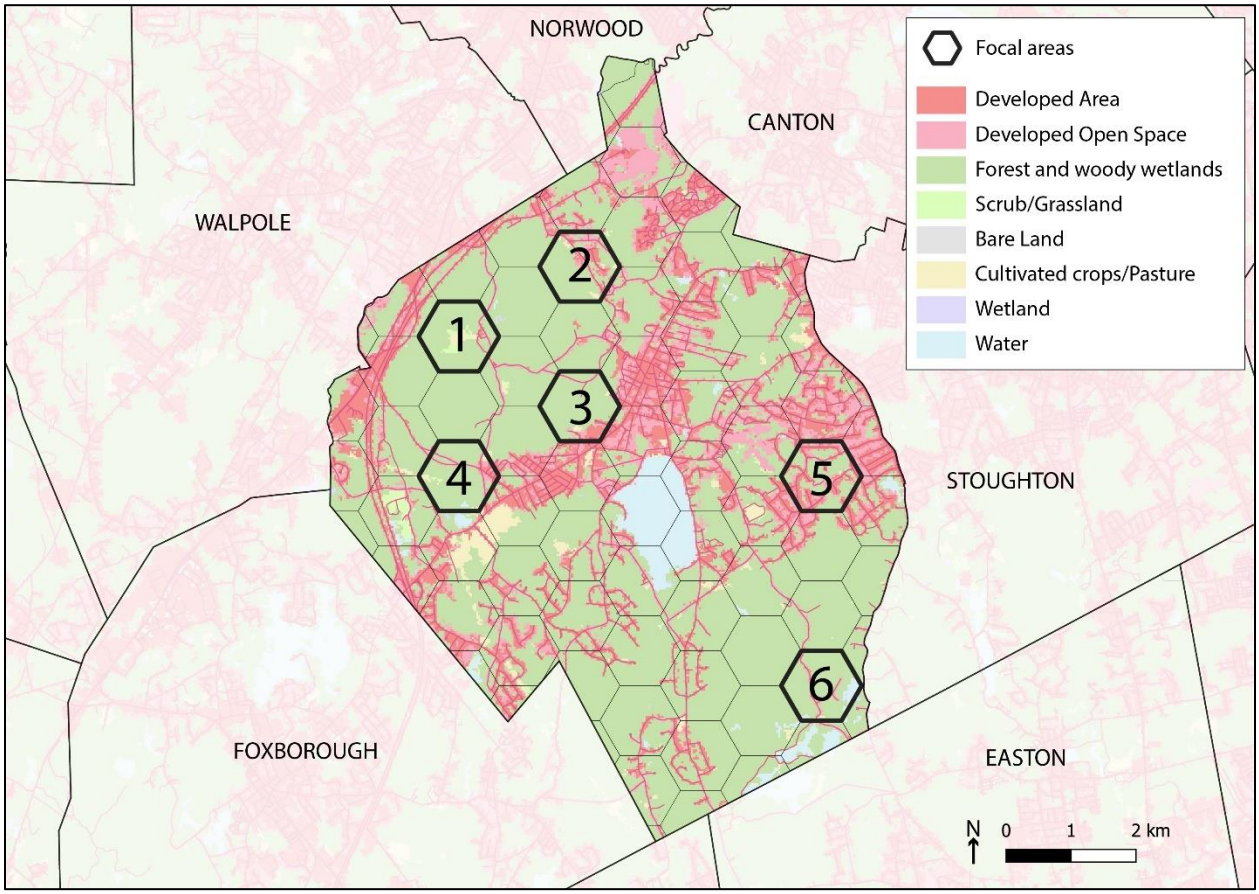
Grid	*% Seedlings browsed*	*Average twig age*	*% Cedars browsed*	*% Hostas browsed*
1	150 (23%)	2.52	5 (60%)	16 (13%)
2	131 (18%)	2.74	5 (40%)	3 (0%)
3	150 (36%)	2.44	2 (50%)	12 (8%)
4	139 (35%)	2.28	2 (50%)	15 (13%)
5	122 (24%)	2.42	5 (40%)	9 (11%)
Total	**692 (27.5%)**	**2.48**	**19 (47.4%)**	**55 (10.9%)**

Weston



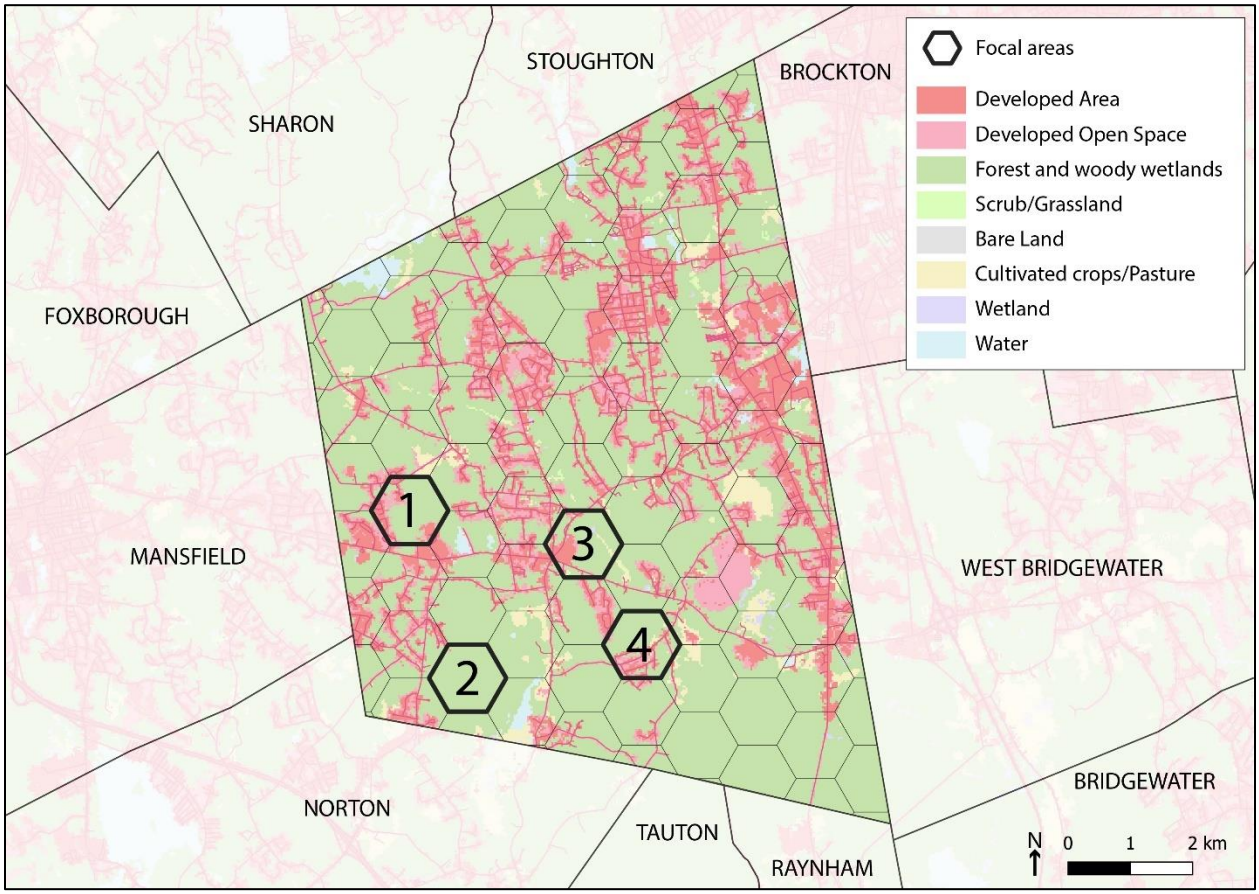
Grid	*% Seedlings browsed*	*Average twig age*	*% Cedars browsed*	*% Hostas browsed*
1	150 (23%)	2.49	8 (50%)	14 (14%)
2	35 (18%)	2.18	NA	NA
3	150 (36%)	2.19	14 (36%)	11 (36%)
4	121 (35%)	2.38	4 (0%)	4 (25%)
5	120 (24%)	2.35	4 (0%)	15 (87%)
Total	**576 (28.8%)**	**2.34**	**30 (30%)**	**44 (45.5%)**

Sharon



Grid	*% Seedlings browsed*	*Average twig age*	*% Cedars browsed*	*% Hostas browsed*
1	150 (25%)	1.99	NA	NA
2	104 (50%)	1.66	10 (30%)	11 (0%)
3	150 (25%)	2.03	2 (0%)	11 (8%)
4	124 (38%)	1.49	3 (67%)	15 (13%)
5	132 (48%)	1.79	35 (20%)	18 (11%)
6	136 (39%)	1.63	NA	NA
Total	**796 (36.6%)**	**1.78**	**35 (34.3%)**	**55 (5.5%)**

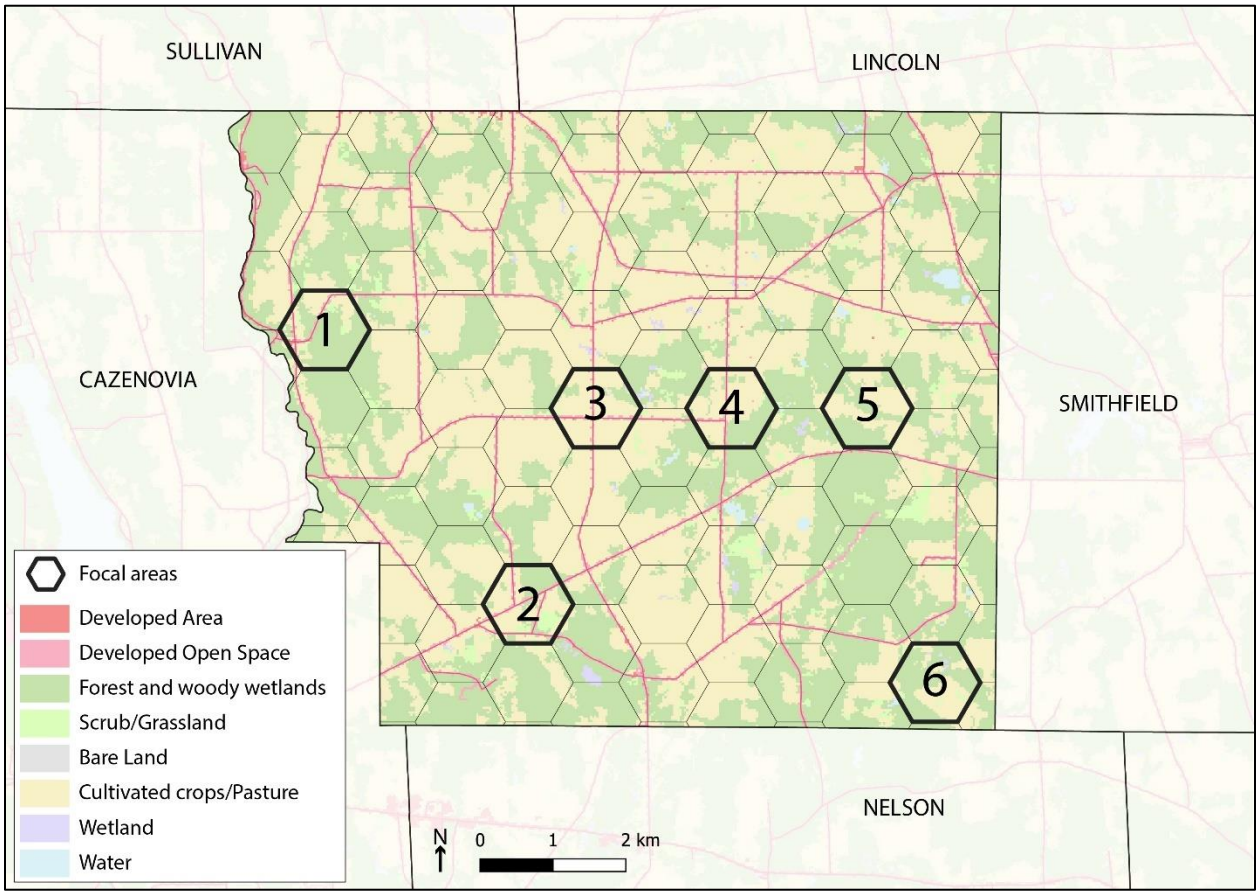
Easton



Grid	*% Seedlings browsed*	*Average twig age*	*% Cedars browsed*	*% Hostas browsed*
1	67 (28%)	1.75	6 (0%)	15 (17%)
2	138 (21%)	1.86	2 (0%)	12 (0%)
3	76 (21%)	1.59	9 (0%)	20 (0%)
4	84 (27%)	2.04	5 (60%)	17 (0%)
Total	**365 (23.8%)**	**1.83**	**22 (13.6%)**	**64 (3.1%)**

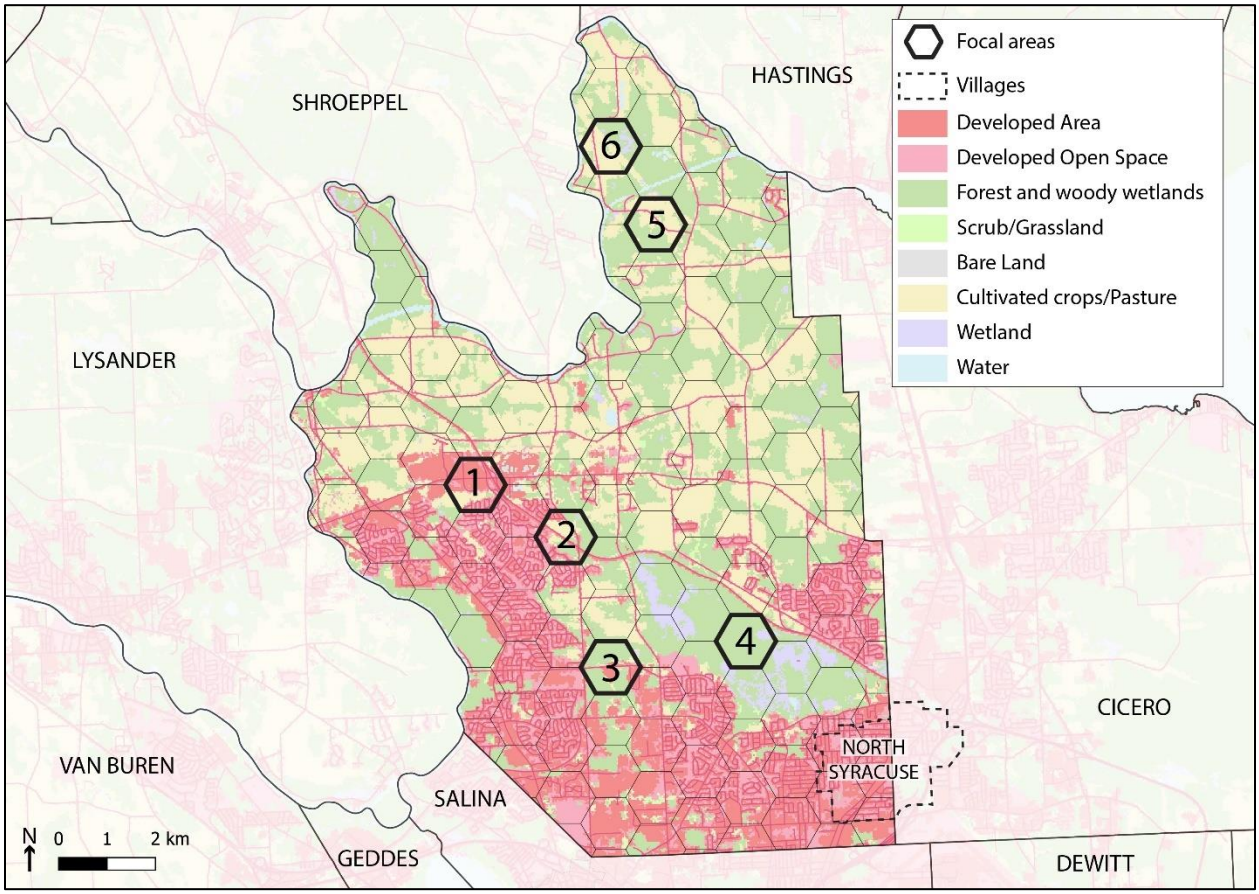
Preliminary Results – New York

Fenner



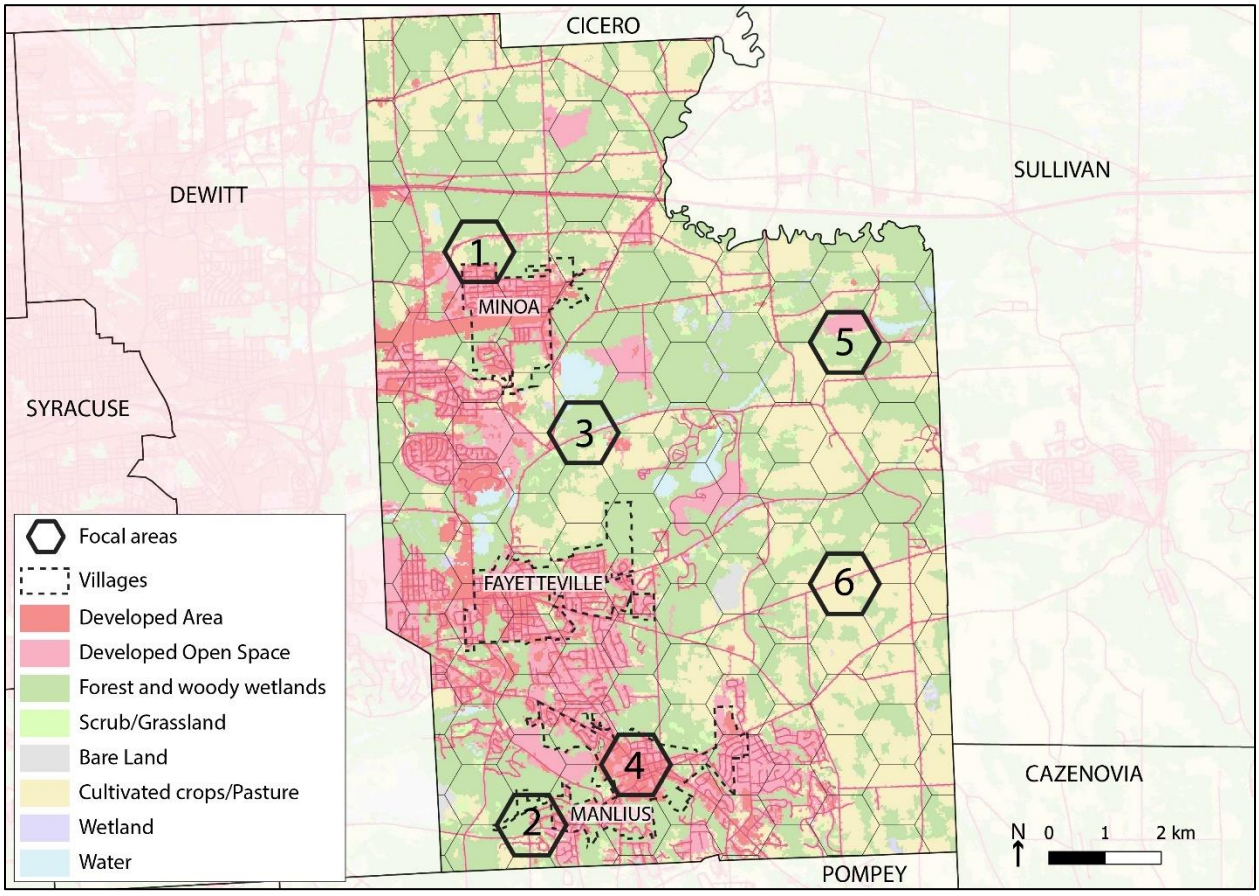
Grid	*% Seedlings browsed*	*Average twig age*	*% Cedars browsed*	*% Hostas browsed*
1	90 (17%)	2.56	4 (50%)	7 (0%)
2	98 (32%)	2.33	0	8 (13%)
3	NA	NA	1 (100%)	6 (17%)
4	119 (17%)	2.50	2 (50%)	2 (50%)
5	NA	NA	1 (0%)	1 (0%)
6	NA	NA	NA	NA
Total	**307 (21.5%)**	**2.46**	**8 (50%)**	**24 (12.5%)**

Clay



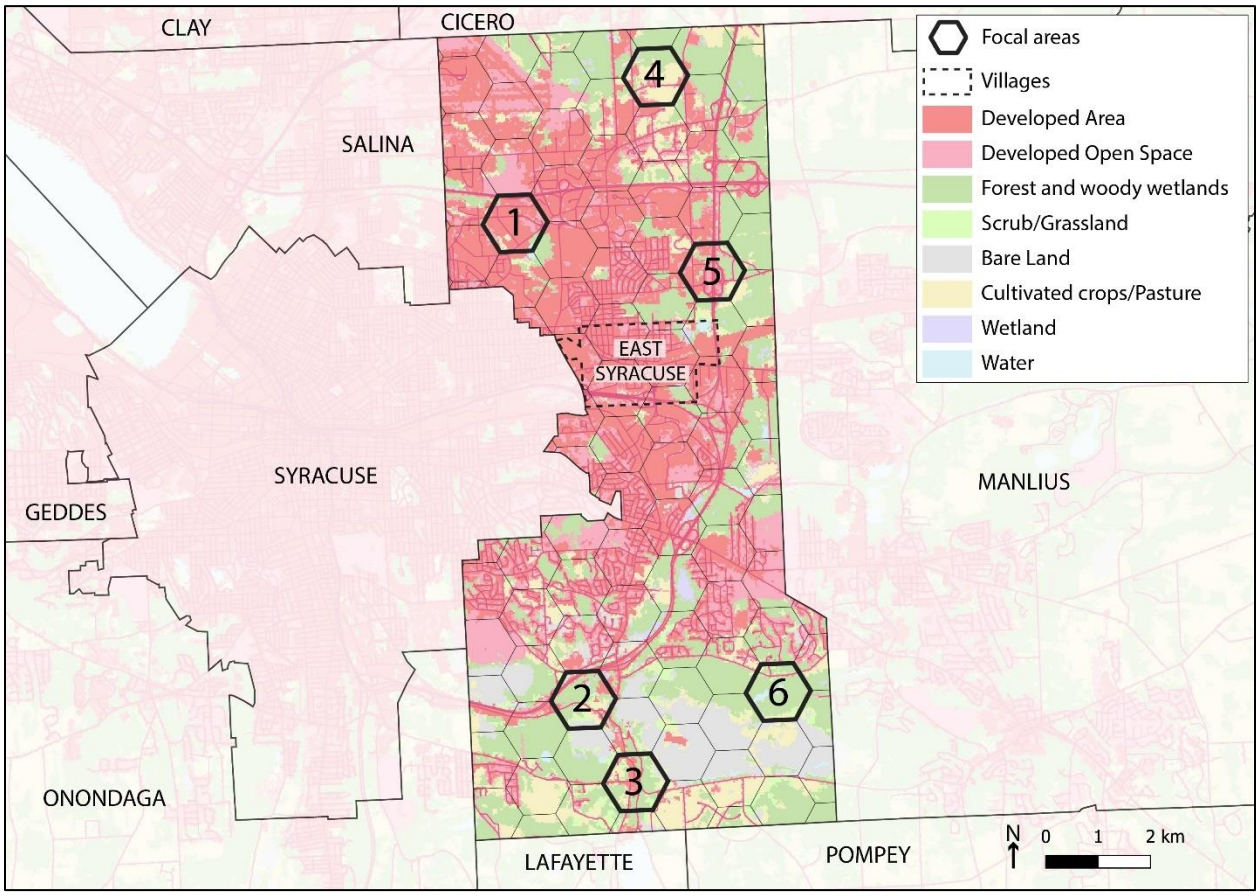
Grid	*% Seedlings browsed*	*Average twig age*	*% Cedars browsed*	*% Hostas browsed*
1	43 (7%)	1.83	7 (0%)	12 (0%)
2	45 (7%)	2.76	12 (8%)	13 (0%)
3	NA	NA	6 (17%)	12 (0%)
4	26 (15%)	2.04	12 (75%)	13 (0%)
5	76 (59%)	1.43	3 (0%)	6 (0%)
6	119 (50%)	1.69	3 (0%)	9 (11%)
Total	**309 (37.0%)**	**1.83**	**43 (25.6%)**	**65 (1.5%)**

Manlius



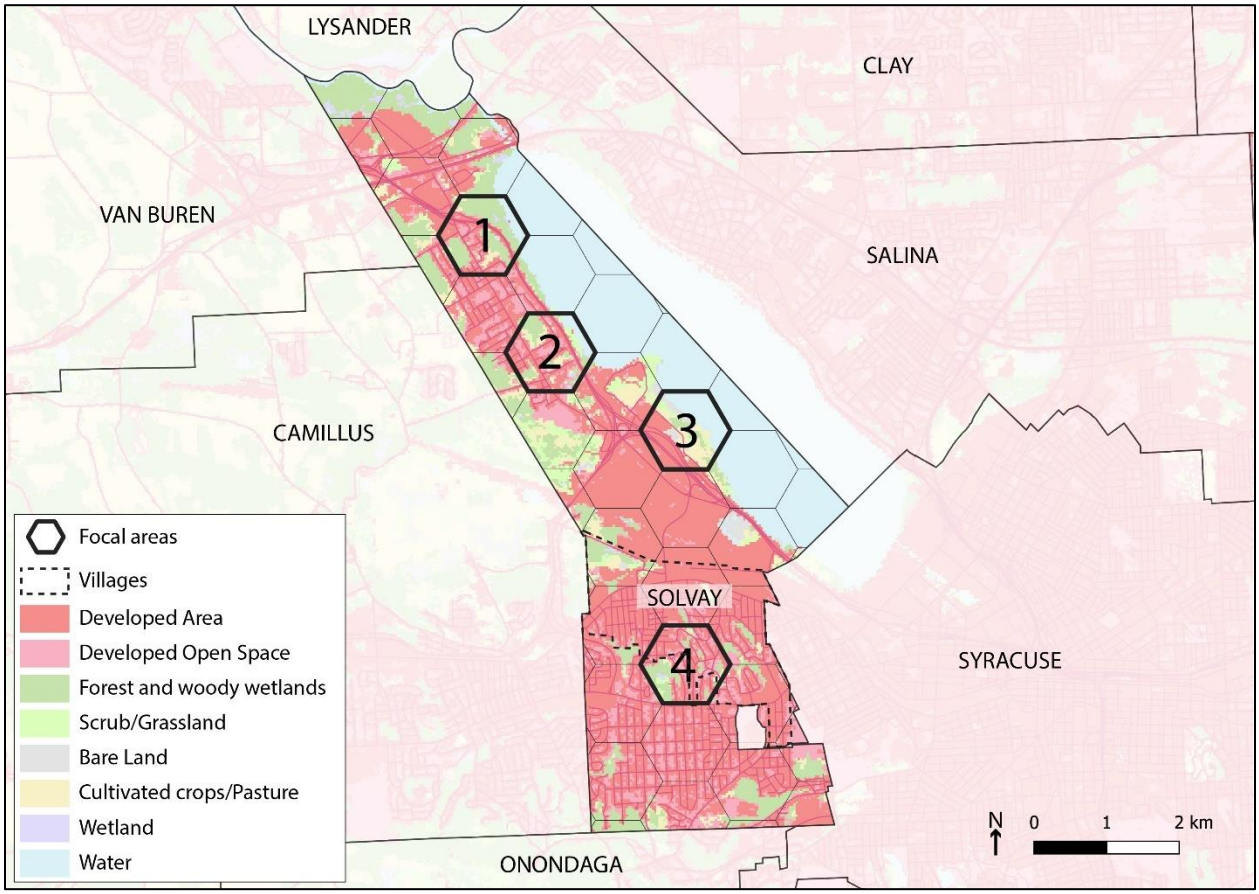
Grid	*% Seedlings browsed*	*Average twig age*	*% Cedars browsed*	*% Hostas browsed*
1	60 (62%)	1.95	7 (28.6%)	18 (0%)
2	107 (9%)	3.07	1 (0%)	10 (10%)
3	65 (38%)	1.32	1 (0%)	1 (0%)
4	1 (0%)	1.00	5 (60%)	14 (21%)
5	34 (65%)	1.37	3 (100%)	7 (0%)
6	90 (8%)	2.89	1 (0%)	4 (25%)
Total	**357 (28.0%)**	**2.35**	**18 (44.4%)**	**54 (9.3%)**

DeWitt



Grid	***% Seedlings browsed***	***Average twig age***	***% Cedars browsed***	***% Hostas browsed***
1	7 (14%)	1.93	5 (0%)	7 (14%)
2	62 (23%)	2.34	5 (20%)	9 (0%)
3	NA	NA	6 (17%)	17 (6%)
4	NA	NA	6 (50%)	6 (0%)
5	6 (17%)	2.75	9 (11%)	13 (0%)
6	41 (34%)	1.39	10 (70%)	11 (36%)
Total	**116 (25.9%)**	**2.00**	**41 (31.7%)**	**63 (9.5%)**

Geddes



Grid	***% Seedlings browsed***	***Average twig age***	***% Cedars browsed***	***% Hostas browsed***
1	NA	NA	4 (0%)	10 (0%)
2	6 (33%)	1.58	5 (20%)	16 (0%)
3	NA	NA	NA	NA
4	46 (61%)	1.93	2 (50%)	1 (0%)
Total	**52 (57.7%)**	**1.89**	**11 (18.2%)**	**27 (0%)**

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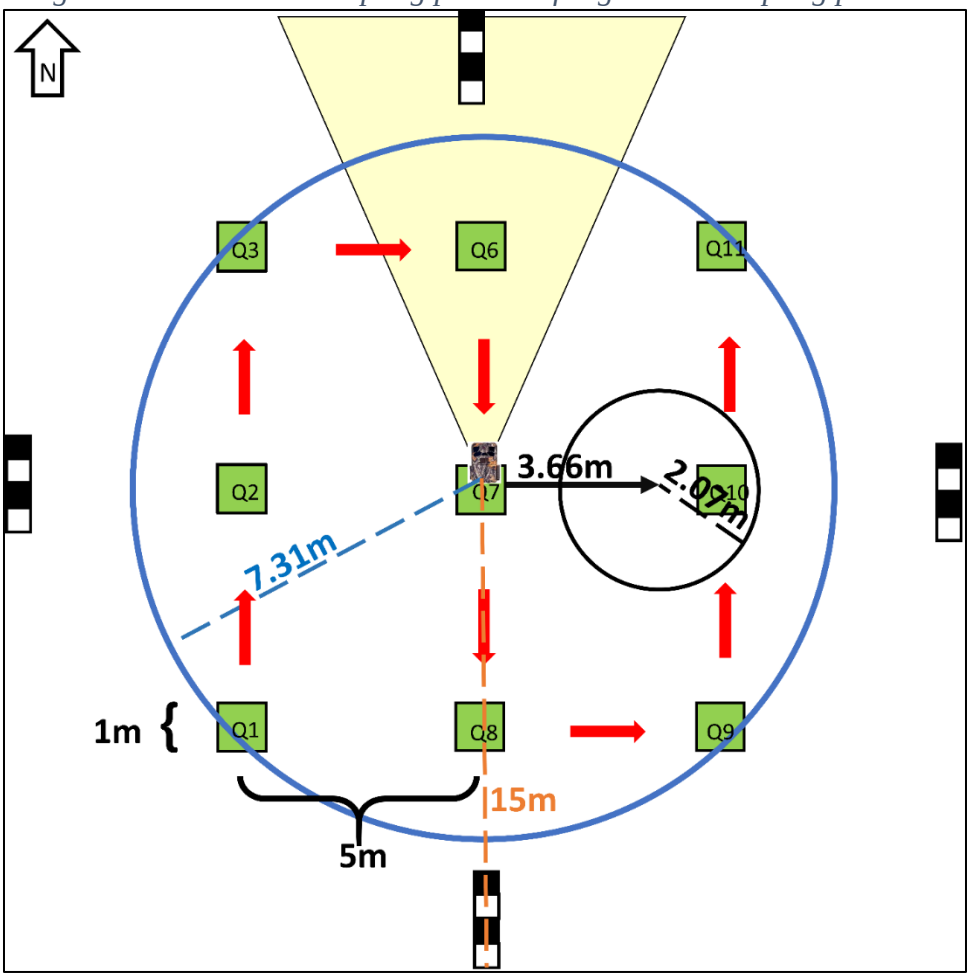
Appendix

Vegetation Sampling Protocol

The vegetation sampling protocol for this study incorporated four different measures to assess vegetation and deer browse intensity at each site. The vegetation sampling protocol was implemented following camera site selection. The camera location served as the plot center (Fig. 3).

Figure 3 - Plot-based sampling portion of vegetation sampling protocol



We implemented four general procedures at each site:

- Nine $1m^2$ understory quadrats to assess vegetation species and diversity at the ground level
- A single forestry inventory analysis (FIA) fixed radius subplot and microplot to assess tree demographics
- Four Nudds board readings to assess vegetation cover
- Twig ages for 30 *Acer or Quercus* seedling/sapling trees

Below, we describe each procedure in detail.

Understory quadrats

The nine understory quadrats ( ) were used to assess the vegetative composition of the understory. To establish the first quadrat (Q1), we navigated ~10.6 m southwest of the plot center (trail camera), placed the quadrat frame on the ground, and recorded the measurements described below. Once sampling was completed at Q1, we moved 5m due north and placed the quadrat frame at Q2. We systematically placed quadrats Q1-Q16 at 5m increments as indicated by the green squares in Fig. 3. The red arrows indicated observer movement direction along 4 parallel 15m transects.

At each understory quadrat location, we recorded the following:

- Percentage of canopy cover (estimated using the CanopyCapture app or visually)
- Percentage of grass/sedge coverage
- Percentage of coverage for each species of forb
- Percentage of shrub coverage and the species of shrub that is dominant
- Percentage of bare ground

Because plants can overlap, the total coverage was sometimes greater than 100%. For example, estimated values for the quadrat in Fig. 4 might be estimated as:

- 30% grass
- 40% Green forb, 15% Gray forb, 5% Blue forb
- 0% Shrub, No dominant shrub
- 25% bare ground

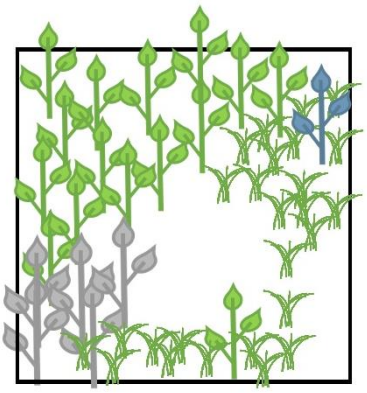


Figure 4 - Example of vegetation assessment in fictional quadrat

Fixed Radius

Fixed radius plots ( ) were used to assess tree species richness and diversity which gave insight into legacy effects of land use and deer browse. The fixed radius plots in this protocol are based on the Forest Inventory Analysis (FIA) protocol which is used widely in the Northeastern United

States. The following sampling procedure is taken directly from the FIA protocol. The blue circle in Fig. 3 is the subplot and the black circle is the microplot.

- Measure and identify to species all trees ≥ 5 in (12.7 cm) in diameter at 4.5 feet above ground (DBH) in each subplot.
- Measure sapling trees, those with a DBH from 1- 4.9 in (2.54-12.7), in each microplot.
- Record species, DBH, status (live or dead), and estimate total height for each sapling.
- Count live tree seedling, DBH < 1 in (2.54 cm) in each microplot.

Nudds board

Cover Estimate-vegetation profile (Nudds) ( ) were measured according to Nudds 1977. The following protocol is taken directly from Nudds 1977.

- The Nudds board is a 0.5 m wide by 2 m tall board that is painted with four 0.5 m tall sections that alternate between black and white (Fig. 5).
- At a distance of 15 m, observers record the proportion of each 0.5 m interval that is covered by vegetation.
- Nudds recommended using "density scores" to bin the percent cover, but we will record ***exact estimated values***, bins can be applied later if desired.

For example, the cover board reading for Fig. 5 might be estimated as:

- 43% for 0-0.5m
- 25% for 0.5-1.0m
- 20% for 1.0-1.5m
- 0% for 1.5-2m

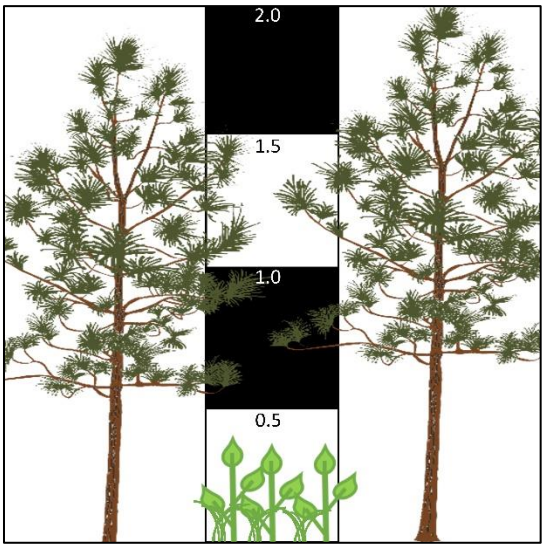


Figure 5 - Example of cover board reading using Nudds protocol

Twig Age Method

The twig age method is a plotless method used to assess deer browsing intensity that focuses on plant populations rather than individual plants. We used the method described by Waller et al. 2017.

- Twig ages were measured for maples (genus *Acer or Quercus*)
- We located seedlings and/or saplings near the camera location with leaves 20-160 cm above the ground. To systematically sample the population of the area, we avoided resampling by choosing a starting location and working through the area systematically. We attempted to sample saplings that were at least 1m apart.
- We sampled two twigs per tree from 30 seedling/sapling trees according to the method described by Waller et al. 2017 below.

The following protocol is taken directly from Waller et al. 2017.

- Find a **sapling** with at least 2 live twigs to count. Each will have a tuft of leaves (Fig. A2).
- Use your tape or meter stick to measure the sapling's **height** up to 2m and record on your data sheet (or note "2+m"). This is the vertical distance between the ground and its top-most plane of leaves.
- Choose a random twig with leaves and then work backwards down the stem counting terminal bud scale scars (TBSS's) to **age** that **twig** until you come to a "parent" twig that was browsed or is otherwise missing its tip (Fig. A3). Record this age under "**Twig 1**" on the data sheet as a number between 1 and 5. Do not try to count beyond 5 years.

Figure A2. *Red maple (Acer rubrum) sapling with five terminal twigs*

Detailed explanation: The live green twig holding this year's leaves is new and has age 1. It has emerged from either the tip or the side of a "parent" (last year's) twig and is separated from it by a **terminal bud scale scar** (TBSS – Fig. A4). These TBSS's extend all the way around the twig and are bigger than simple bud-scale scars where a leaf grew out last year. Twigs often change color across these TBBS's. If the fresh green twig emerges from the <u>side</u> of its parent twig and the parent twig has been browsed or broken off, you are done – record a twig age of 1 (Fig. A5). If your twig instead connects in a line with its parent twig (reflecting simple extension growth along the same axis), you have a twig 2 years old that was not browsed. Trace this twig back past the 2nd TBSS and examine how it connects to its parent twig. If it connects at an angle and the twig from 3 years ago terminates in a browsed or broken tip, you have an age of 2. Continue counting years backwards down this axis of twig/branch until you reach an <u>angled</u> connection to a parent twig that was browsed or is missing, noting the number of unbrowsed years back to a browsed parent twig – up to a maximum age of 5 years. In cases that are ambiguous, try sampling another twig or sapling.

Figure A3. *Successive "parent" branches on a striped maple missing their tips because of repeated browsing. The living twig on the right is aged back to only to its immediate "parent" twig, the top-most browsed stem shown here.*

- Next, choose a random 2nd live terminal twig on the opposite side of the plant and repeat c). Record its age under "**Twig 2**." Try not to sample a twig descended from the same parent twig as your first twig – unless you have no choice.
- Finally, check the sapling for any evidence that the sapling was (freshly) browsed this year. If this is the case, check the last column in the data sheet for "Fresh browse."
- Continue by moving on to successive sapling stems until you reach your target number of 50-60 saplings. When you finish, record your **ending time** and add any observations you feel are pertinent to your field notes.

5. Continue sampling if you have any further species or other plots / locations to sample, moving to them and repeating the sampling procedure steps 2-4.

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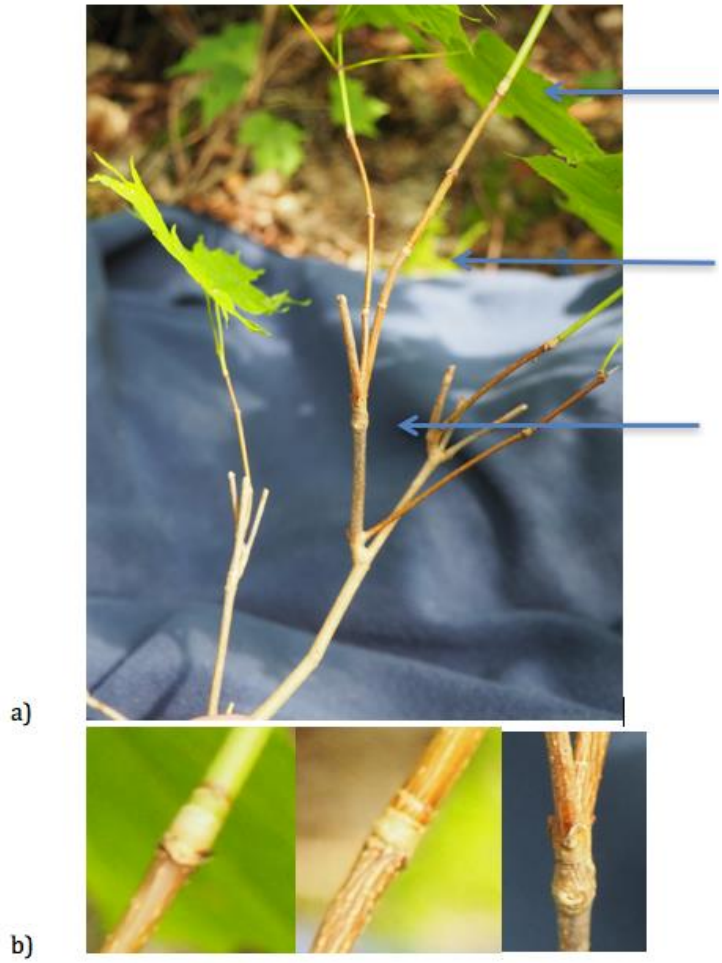

Figure A4*. a) The twig of a sugar maple (Acer saccharum) sapling in 2015. Arrows show the locations of terminal bud scale scars. This twig has an age of 3. b) Enlargements of the successive terminal bud scale scars in photo a) showing transitions across 3 years on this branch for (from left to right): 2014-15, 2013-14, and 2012-13. Note differences in diameter and bark color and texture between each TBSS. These facilitate our ability to age twigs. Photos: DMW.*

Sources for Table 1: Descriptions of Focal Towns

Variable	Description	Source
Surface	Area of town in square kilometers	
Population	Total Population per town (5-year estimate (2013-2017))	U.S. Census Bureau (2013-2017). Total Population American Community Survey 5-year estimates. Retrieved from https://censusreporter.org
Population Density	Population Density (5-year estimate 2013-2017)	U.S. Census Bureau (2013-2017). Total Population American Community Survey 5-year estimates. Retrieved from https://censusreporter.org
Median Income	Median household income in the Past 12 months (In 2017 inflation-adjusted dollars) per town (5-year estimate)	U.S. Census Bureau (2013-2017). Median Household Income in the Past 12 Months (In 2017 Inflation-adjusted Dollars) American Community Survey 5-year estimates. Retrieved from https://censusreporter.org
Median Age	Median Age by Sex per town - 5-year estimates (2013-2017)	U.S. Census Bureau (2013-2017). Median Age by Sex American Community Survey 5-year estimates. Retrieved from https://censusreporter.org
Forested Area	Forest Cover (%)	Percent of Forest Cover in 2016 - combination of classes: Evergreen, deciduous and mixed forest - 2016 NLCD retrieved from: https://www.mrlc.gov/data/nlcd-2016-land-cover-conus
Protected Open Space (MA)	Public protected and recreational open space per town (%)	Computed using the protected and recreational open space datalayer which contains the boundaries of conservation lands and outdoor recreational facilities in Massachusetts. Retrieved from: https://docs.digital.mass.gov/dataset/massgis-data-protected-and-recreational-openspace
Protected Open Space (NY)	Public protected and recreational open space per town (%)	Computed using the New York Protected Area Database, which contains the boundaries of lands protected, designated, or functioning as open space, natural areas, conservation lands, or recreational areas in New York State. Retrieved from: https://www.nypad.org/
Deer concern	Expressed deer concern by municipal officials who responded to the NYS and MA municipal survey	Taken from responses from the MA and NYS municipal deer survey conducted by the social science team