Monitoring Deer Impacts

on Natural Vegetation in Ann Arbor:

A Pilot Study of Red Oak Seedlings

as Experimental Indicators of Deer Browse Intensity

Across 10 city parks

REVISED DRAFT REPORT WITH PRELIMINARY DATA

DO NOT QUOTE, CITE, OR REPRODUCE

November 2015–October 2016

Jacqueline Courteau, Ph.D.
Consulting Biologist/Ecologist, NatureWrite LLC
17 October 2016

BACKGROUND

One component of the Ann Arbor deer management plan is to monitor impacts of deer on natural vegetation. This pilot study for the City of Ann Arbor presents preliminary data focused on two interrelated questions:

- What are baseline levels of deer browse damage to vegetation in natural areas in Ann Arbor city parks?

- What metric can be used to periodically assess deer browse intensity and examine how deer management efforts are affecting it?

After considering various study methods, we chose to do an experimental planting of red oak seedlings across natural areas in 10 city parks, initiated in November-December 2015. This report presents **preliminary** results from the first 9-10 months of monitoring. A final report will be completed in December after seedlings have been in place for one year.

EXPERIMENTAL METHOD: RED OAK SEEDLINGS AS BROWSE INTENSITY INDICATOR

There are various methods for assessing deer impacts on diverse plant species over time. We selected an ***experimental browse intensity indicator*** method—planting red oak seedlings across a range of sites and monitoring them for browse damage over the course of the year. This method offers a clear and repeatable metric with the following characteristics:

- Provides initial **local** and **site-specific** data on deer browse intensity.

- Offers **standardized measurement in a single clear metric** across a range of sites.

- **Distinguishes deer damage from other sources of vegetation change**.

- Can be repeated annually to assess how deer management efforts are altering deer impacts on vegetation.

The experimental design used in this study was developed by Blossey and others for use in Ithaca (the “Cornell study,” Blossey 2014), and have been applied in various other communities and park systems. This researcher used similar methods to assess impacts of deer and other mammalian herbivores on two native tree species (Courteau 2005).

Why use red oaks?

Red oak (*Quercus rubra*) was selected as the experimental species for several reasons:

- The species naturally occurs in ALL city natural areas assessed.

- It comprises an ecologically meaningful measurement because it represents a key Ann Arbor ecological community (oak/hickory forests) and important ecological functions (tree & forest regeneration, habit, food source for many species).

- Oak regeneration has been declining in much of Michigan and the northeastern U.S., concerning many forest scientists and conservation managers (Lee & Kost 2008, Abrams 2003).

- Red oak is a species of **intermediate** deer preference—not the first and most nutritious food to be browsed by deer, so doesn't represent the most sensitive species (MI DNR), but not the last food either (Blossey 2014). Because this species is not the most preferred, it offers a somewhat conservative indicator.

- Nursery seedlings and acorns of Michigan genotype are readily available.

Deer browse damage on oak seedlings can be distinguished from small mammal damage.

While deer browse may affect many wildflower species that are also of interest for their ecological importance (providing resources for pollinators including butterflies and bees, as well as various species of birds), the advantage of using a woody species such as red oak is that deer browse damage on woody stems can be readily distinguished from browse damage by other mammals that eat tree seedlings.

- Deer lack upper front teeth (incisors), so their browsing leaves a ragged edge with a "shreddy" appearance. Browsing most often occurs at heights of 2–3 feet, but may be done at heights as low as 2" or as high as 6.'

- Rabbits and woodchucks have large and sharp incisors that leave clean cuts, generally at a 45° angle. Browsing most often occurs at heights of 3–16", but may be done at heights of up to 3' in years with heavy snow cover.

- Voles chew on bark and may chew through whole stems, within 3" of ground level or below-ground.

Figure 1. Deer browse in comparison to rabbit and vole damage. Deer produce "shreddy" cut, in contrast to clean, clearly angled rabbit (or woodchuck) damage and the toothy gnawing by voles.

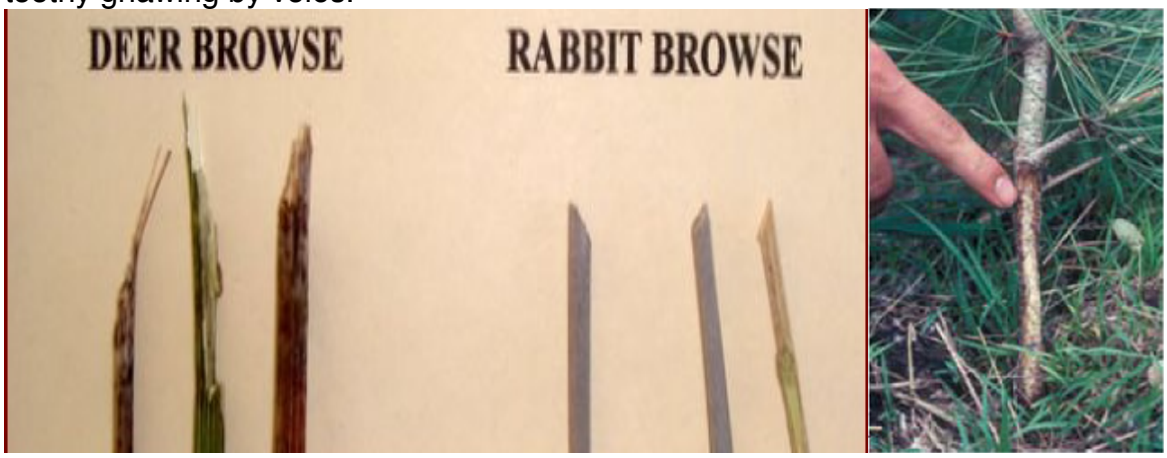


Photo credits: Deer vs. rabbit browse, http://octrackers.com/analyzingtherabbittrack.htm; vole browse, http://extensionpublications.unl.edu/assets/html/g887/build/g887.htm.

Figure 2. a. Photos from Ann Arbor experiments. a. Deer browse with shreddy edge. b. Rabbit browse with angled edge. c. Seedling gnawed through by vole, near ground level; stem left behind.

a. b. c.

Photos: J. Courteau.

PLANTING AND SITE SELECTION

We planted a total of 370 red oak seedlings in 10 city park natural areas from November 30–December 16, 2015, as shown in Figure 3 and Table 1 (p. 7). One city park natural area (Bird Hills) was large enough that seedlings were planted in 2 separate areas of the park, indicated as Bird Hills Newport (near M-14 and the Newport Road park entrance) and Bird Hills Bird Road (near Huron River Drive and the Bird Road park entrance).

In addition to city parks, University of Michigan Nichols Arboretum (Bob Grese, director) contracted a separate study of deer impacts in the Arb using the same monitoring protocol with 50 red oak seedlings, and they have generously agreed to share their data. In this report, I am reporting on results for both studies, a total of 420 seedlings.

Sites were selected with several criteria:

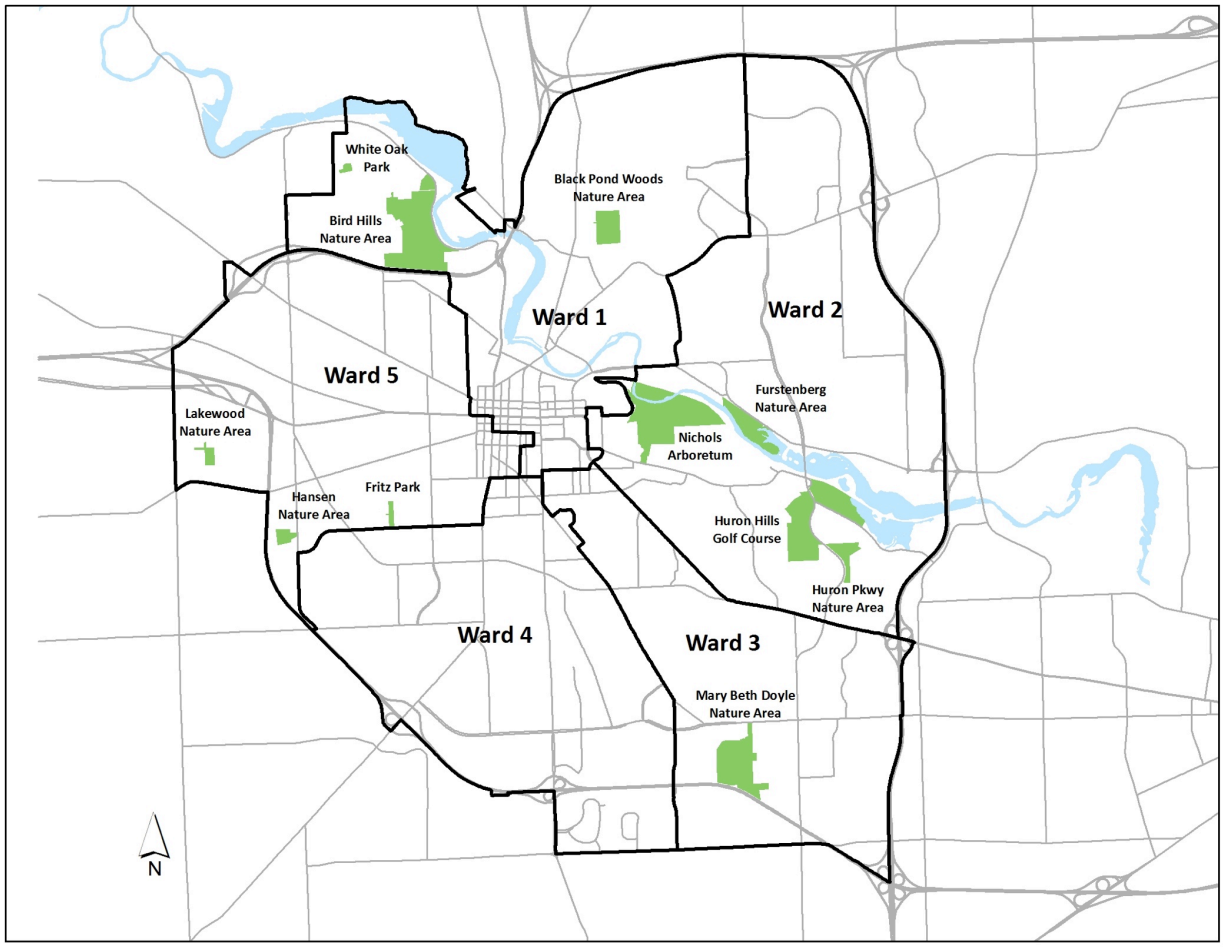
- to encompass a range of large and smaller parks, including those with high-quality natural areas (such as Bird Hills, Mary Beth Doyle, Black Pond Woods);

- to represent areas found in the 2015 aerial survey to have a higher and lower deer densities; and

- to achieve geographical coverage of the city.

However, natural areas are not evenly distributed throughout the city, and we were not able to assess any natural areas in Ward 4, which lacks public spaces with mature oak forests other than Pioneer Woods (which is owned by Ann Arbor Public Schools).

Figure 3. Experimental planting sites (monitoring locations).



Map: Natural Area Preservation

PLANTING AND MONITORING DETAILS

Seedling planting locations and height were documented on ArcCollector, and a photo was taken to show initial condition and allow for comparison to later measurements (Figure 4). Seedlings were monitored four times to evaluate survival and condition, and to assess browse damage (Table 2, next page), and will be assessed again one year after planting.

Browsed seedlings were examined carefully using a 10X hand lens to characterize browse damage (height, number of branches browsed), and identify the browser (deer vs. small mammal, including rabbits/woodchucks, voles, and squirrels/chipmunks) and a photo was taken. Additional notes were taken on insect damage, wilt or dieback (likely from drought), and other parameters.

For this pilot study, one half of the seedlings were planted within fences to protect them from deer browse but allow other mammalian browsers. Results in this preliminary report focus on the unfenced seedlings. The final report will present data for all seedlings.

Figure 4. Before and after photos of red oak experimental seedling. a. At planting time, December 2015. b. At second monitoring time, April 2016. Red arrows indicate the browsed branch. In photo b., shredded bark is just visible at right edge where deer browse buds and part of stem.

a. b.

Photos: J. Courteau.

Table 1. Sites and seedling numbers. Half of the seedlings at each site were fenced to protect them from deer but allow small mammals. This preliminary report presents deer browse data for unfenced seedlings only.

WARD	SITE	# OAK SEEDLINGS
1	Bird Hills/Bird Road	20
1	Bird Hills/Newport	50
1	Black Pond Woods	40
1	White Oak	20
2	Arboretum	50
2	Furstenberg	40
2	Huron Hills Golf Course	20
2	Huron Parkway	40
3	Mary Beth Doyle	40
5	Fritz	20
5	Hansen	40
5	Lakewood	40
	TOTAL	420

Table 2. Planting and monitoring dates for red oak experimental seedlings.

Planting:	Nov 30–Dec 16	2015
Monitoring 1:	Jan 6–Feb 5	2016
Monitoring 2:	Mar 14–April 6	2016
Monitoring 3:	May 29–Aug 1	2016
Monitoring 4:	Aug 4–Sept 21	2016
Monitoring 5:	TO COME, Nov–Dec	2016

How does deer browsing affect red oak seedlings? Why is the proportion of seedlings browsed important?

Numerous studies over the past two decades have reported that deer browsing leads to forest regeneration declines (a list of references can be provided on request). Although many plant species can tolerate some levels of herbivore damage, deer browse on woody plant buds and branch tips is likely to affect the apical meristem tissue key to plant growth (Reznicek, pers. comm., June 2015). Mammalian browse damage makes seedlings more susceptible to drought, disease, and insect attacks. My own research has shown that browsing on tree seedlings by any mammalian herbivore (generally, when full stems are clipped) leads to a significant increase in mortality in the following season (Courteau 2005). Others have found that browsing that affects 50% or more of woody sapling buds or branches is likely to lead to mortality (Winchcombe 2016).

The metric used in this report—the proportion of experimental oak seedlings browsed by deer—provides a useful indicator of current deer browse intensity and offers a clear metric that can be repeated annually to track how browse intensity responds to deer management efforts.

As noted in the Blossey (2014) study, tree regeneration declines when more than 15% experimental seedlings in a given site are browsed per year:

> An individual oak seedling may need 10–20 years to grow out of reach of a deer under a forest canopy, and even longer to get into the canopy. In many instances, seedlings/saplings need to spend extended periods in the understory waiting for their chance to grow should the overstory be damaged (or harvested). Considering this early life history, more than an occasional browsing event on oak sentinels (damage to >3 of 20 [15%] seedlings) in any given year would indicate deer populations in the area are too high to achieve forest regeneration.

Oak seedlings may be a conservative gauge of deer browse damage on the full suite of forest species. As noted in the Blossey (2014) report,

> …[M]ore preferred and browse-sensitive species, such as red and white trilliums (*Trillium erectum* and *Trillium grandiflorum*, respectively…), are severely browsed even in places where we see good survival of oak seedlings.

The Blossey study did monitor trillium in place, rather than through experimental plantings, and many other urban areas and parks, such as Montgomery County, Maryland, Swarthmore College, and Cuyahoga Valley National Park, and have included trillium in assessments of browse damage.

A separate study to assess deer browse damage on trillium in Ann Arbor natural areas was initiated in spring 2016, and preliminary results will be available in 2017.

KEY FINDINGS

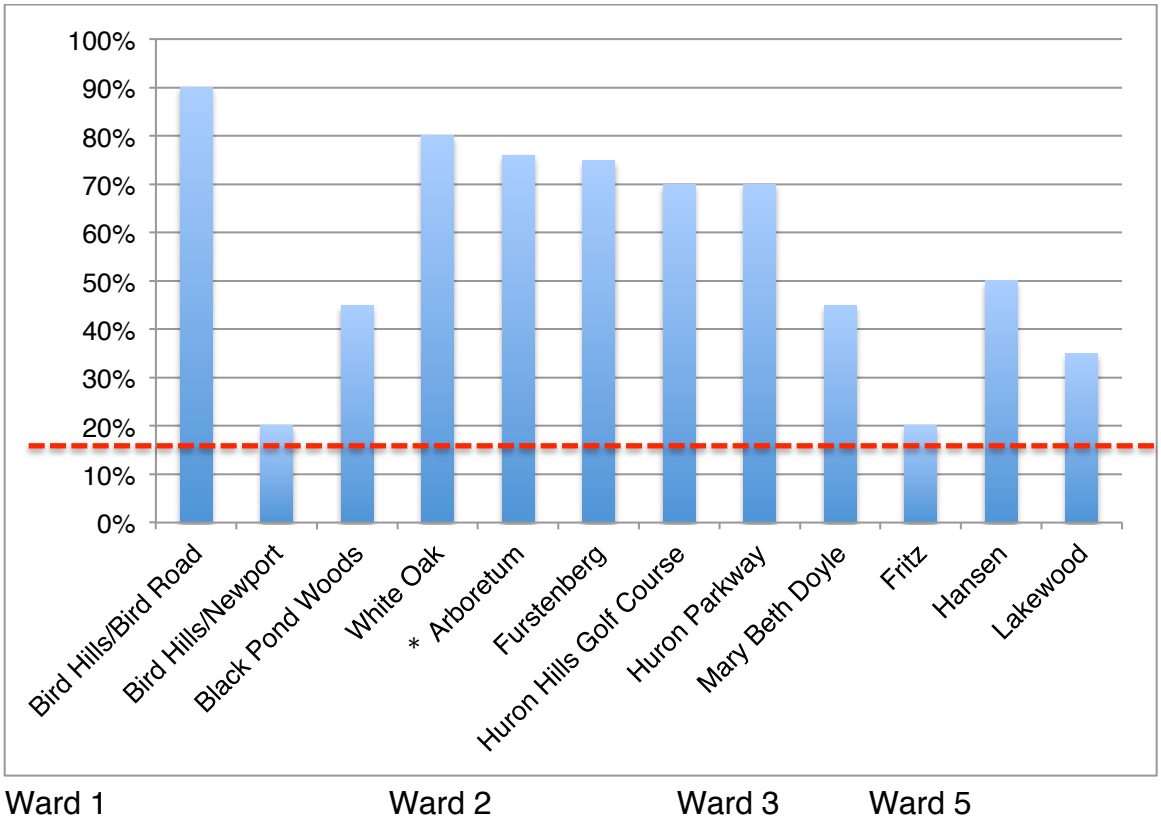
NOTE: This is a preliminary data analysis. Final analysis will be completed in December after seedlings have been monitored for one year. Numbers for individual parks may change, but overall findings will likely remain the same.

Proportion of experimental red oak seedlings browsed by deer

Overall, 54% of seedlings planted in the open (unprotected by fencing) were browsed by deer at least once. Additional analysis will be completed to assess how many seedlings were deer-browsed multiple times.

Browse damage ranged from 20%–90% across sites, with half of the sites having 60% or more seedlings browsed.

Figure 4. Proportion of experimental red oak seedlings browsed by deer. The dotted red line indicates that "damage to >3 of 20 [15%] seedlings in any given year would indicate deer populations in the area are too high to achieve forest regeneration" (Blossey 2014).



*NOTE: Monitoring in the Arboretum was a separate study, commissioned and paid for by MBGNA; data are included here for reference, courtesy of Nichols Arboretum.

Amount of browsing by deer vs. other mammalian browsers

Out of 210 unfenced experimental seedlings, 131 showed signs of mammal damage. Deer alone damaged 76% of those seedlings, while another 11% of browsed seedlings were affected by both deer and small mammals (Table 3). Small mammals only were responsible for 9% of the browsed seedlings. Small mammals that damaged seedlings included rabbits/woodchucks, voles, and squirrels/chipmunks. Insect damage was assessed separately and will be analyzed in the final report.

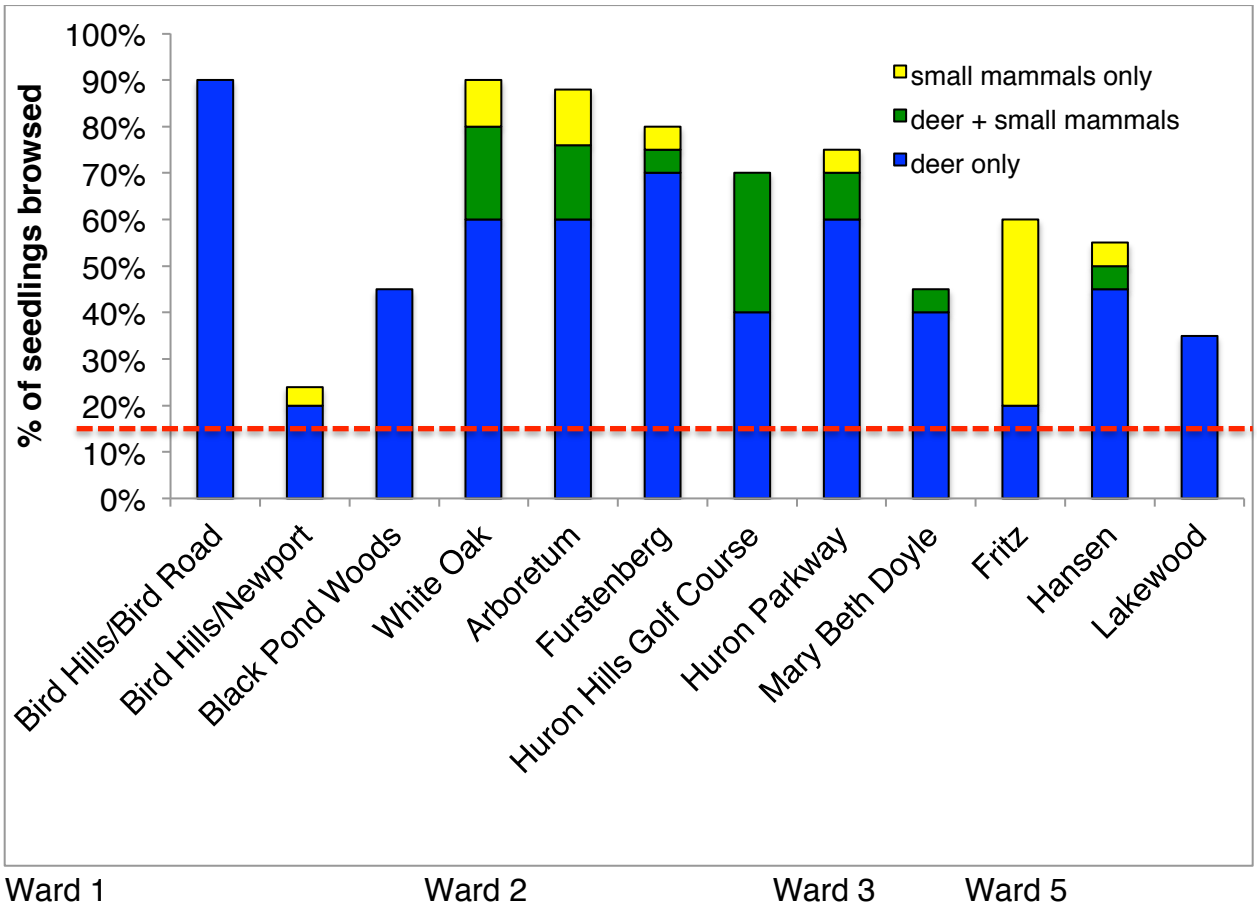
Table 3. Number of cases of browse by deer compared to other browsers. A total of 131 out of 210 unfenced seedlings were browsed at least once by a mammalian browser. Some seedlings were browsed more than once, either by deer, by deer and small mammals, or in a few cases, by different small mammals. The "Other" category includes a several cases that could have been deer browse but could not be classified with certainty.

Browser identity	# seedlings browsed	% of all browsed seedlings
Deer only	100	76%
Deer + small mammal	14	11%
Small mammal only	12	9%
Other/not clearly identifiable	5	4%
Total # seedlings browsed (out of 210 unfenced)	131	

Proportion of seedlings browsed by small mammals

Small mammals as well as deer damaged the experimental red oak seedlings, but the proportion of seedlings browsed by small mammals was much lower than deer overall (Figure 5). Some small parks (such as Fritz and White Oak) show relatively larger proportions of seedlings damaged by small mammals. (Small urban parks often lack predators that reduce small mammal populations in larger parks and natural areas.)

Figure 5. Proportion of experimental red oak seedlings browsed by deer vs. small mammals. Some seedlings were browsed by both deer and small mammals. In many cases, rabbits browsed seedlings over the winter, seedlings resprouted, then deer browsed the resprouts. Additional data will be provided in the final report to show proportions of different mammalian browsers (rabbit, chipmunk/squirrel, vole). The dotted red line indicates that "damage to >3 of 20 [15%] seedlings in any given year would indicate deer populations in the area are too high to achieve forest regeneration" (Blossey 2014).



SUMMARY

This pilot experimental study, in which red oak seedlings were planted and monitored in 10 city parks (and in a separate study at the Arboretum), found that deer are browsing 20–90% of tree seedlings, a level that exceeds the 15% recommended in existing scientific literature as allowing for sustainable tree regeneration (Blossey 2014).

Overall, deer alone were responsible for 76% of the browse-damaged seedlings, with an additional 11% browsed by both deer and small mammals. A total of 9% of seedlings were browsed by small mammals only; including seedlings also browsed by deer, 20% of seedlings showed evidence of small mammal browse.

Although many studies in the literature have found that intense deer browsing can lead to declining forest regeneration levels, the 15% level proposed by Blossey (2014) is the only published figure to date that gives a specific number for the proportion of seedlings browsed per year that indicates that deer browse is too high to achieve tree regeneration. Waller (2016) notes that this is an area of active research and additional results will likely be published soon; he suggests that because site types and conditions vary, the acceptable level of browsing could be somewhat higher in some sites—but could be lower in others. However, the proportion of seedlings browsed by deer per year will still serve as a useful metric, and the accumulation of Ann Arbor data over time will allow us to understand browse impacts on tree regeneration in local sites.

Red oaks were chosen as experimental browse damage indicators because they are intermediate in browse preference. Thus, the levels documented here may not fully indicate the browse damage on more sensitive species, such as trillium and other spring wildflowers. Trilliums are being assessed in a separate study established in 2016 for which preliminary data will be available in 2017.

RECOMMENDATIONS FOR FUTURE MONITORING

Experimental plantings of red oak seedlings offer a clear metric—proportion of seedlings browsed by deer—for gauging deer browse intensity. This protocol can be repeated annually to gauge how deer management efforts are affecting deer damage on vegetation.

To fully understand how deer management affects vegetation within and across the city's natural areas, more red oak seedlings could be planted and tracked at more locations within the larger parks (a need suggested by the differences within Bird Hills) and across more parks. In particular, Ward 4 should be represented in the survey, but was not because the major natural area within the ward (Pioneer Woods) belongs to the Ann Arbor Public Schools, rather than the city parks. A collaborative effort with the schools could cover Pioneer Woods and possibly additional school-owned natural areas (Skyline and Eberwhite) with the aim of understanding forest regeneration and furthering environmental education in "control" areas where deer will not be managed.

Because red oaks are of intermediate browse preference, they do not indicate damage to the most sensitive species. This study focused on documenting current browse intensity with straightforward measurements in a clear, timely way. Future monitoring should be expanded to include more species, such as trillium, either in experimental plantings or by using browse damage surveys on existing plants, to supplement the standard metric provided by red oaks. A preliminary study is underway to assess trillium in 4 parks, but this effort could be expanded to additional species (e.g., wildflowers of importance to pollinators) and additional parks.

LITERATURE CITED [This is a partial list; will be completed for final draft.]

Abrams, M. 2003. Where has all the white oak gone? *BioScience* 53(10): 927–933.

Blossey 2014. JR Boulanger, PD Curtis, and B. Blossey, 2014. *An Integrated Approach for Managing White-Tailed Deer in Suburban Environments: The Cornell University Study.* Cornell University Cooperative Extension and the Northeast Wildlife Damage Research and Outreach Cooperative. 34 pp. Accessed online: http://wildlifecontrol.info/deer/Documents/IDRM_12-5-2014.pdf.

Courteau, J.B. 2005. Direct, indirect, and interacting effects of overabundant deer and invasive autumn olive on native vegetation. University of Michigan. Ph.D. dissertation.

Lee, J.G., and M.A. Kost. 2008. Systematic evaluation of oak regeneration in Lower Michigan. Report to the Michigan Department of Natural Resources Wildlife Division. Report Number 2008-13. Michigan Natural Features Inventory, Lansing, MI. 127 pp + appendices.

Waller, Donald M. Dept. of Botany, University of Wisconsin. Personal communication, 10 October 2016.