White-tailed deer (*Odocoileus virginianus*) browse damage in Ann Arbor, Michigan Bird Hills Nature Area, Winter 2015

Jacqueline Courteau, Ecologist (jbcourteau@gmail.com)
Moriah Young, University of Michigan, Independent Study Research (moriahy@umich.edu)

Introduction

White-tailed deer (*Odocoileus virginianus*) are abundant throughout eastern North America (Côté et al. 2004). After population declines due to overhunting during the 19th and early 20th centuries, wildlife management policies to control hunting, along with habitat management and changes in land use, have allowed populations to rebound. By some estimates, current deer populations significantly greater than before European settlement, so that deer are considered "overabundant" (McShea et al. 1997, Horsley et al. 2003, Côté et al. 2004).

Documented impacts of deer overabundance in forest and old field areas include reduced tree regeneration and recolonization, reduced abundance and flowering of native spring flora, and alterations in vegetation structure (Côté et al. 2004, Rawinski 2008, Ferker et al. 2014). Deer have been dubbed a "keystone herbivore" because they can exert wide-ranging influences on the distribution and abundance of other species at various trophic levels, altering plant community structure, with potential consequences for pollinators (bees and butterflies), birds, and small mammals (DeCalesta 1994, Waller and Alverson 1997, Côté et al. 2004, Rooney and Waller 2003).

Deer impacts have also been widely reported in urban and suburban areas starting in the 1990s (McAninch 1997). Deer have adapted well to suburban and even urban areas that lack a top predator and provide ample food resources (Hobbs et al. 2000, Rooney & Waller 2003). Deer interact with landscapes and habitats already fragmented by roads and housing developments; it can be hard to tease apart the impact of deer on plant and animal species in natural areas already affected by human disturbance and invasive species. However, many communities have concluded that deer are affecting vegetation in public parks as well as in private lawns and gardens, and have taken steps to assess and manage deer populations and impacts (e.g., Ithaca, New York, described in Boulanger et al. 2013, in Indianapolis, described in Indy.gov 2015, and in the Washington DC suburban area, Montgomery County Parks 2004; additional information in Doerr at al. 2001, Indiana Department of Natural Resources 2011).

A first step in any deer management program is to assess deer populations. However, deer populations can be difficult to assess accurately, and deer population counts are often unreliable (Morellet 2001). Population counts using aerial flyovers with human observers often miss some animals under dense cover, especially in areas with conifers (Potvin and Breton 2005), and only

provide snapshot of deer in the area on a given day, whereas deer may bed down and move across territories of several dozen to several hundred acres or more over the course of a season. Accuracy of counts with human observers ranged from 37–83% of known populations in a deer exclosure study (Potvin and Breton 2005).

Even accurate deer population counts, however, cannot alone indicate the impact of deer on natural and planted vegetation. A small population of deer that browse repeatedly in a small area due to barriers (roads, fences, etc.) or because of the lack of predators may damage vegetation as much as a larger population that ranges more widely. Therefore, assessing actual browse damage can serve to monitor deer impacts and indicate population levels (Morellet 2001).

White-tailed deer have recently become an issue of concern in Ann Arbor, Michigan. The City has started to develop a deer management policy, and has held public meetings and conducted citizen surveys to assess the problem, as well as hosting a web site for reported deer sightings (a2gov.org 2015, Ann Arbor Chronicle 2014, Armentrout 2014–2015, Stanton 2014, Leary 2015, WC4EB 2015).

City officials conducted aerial deer surveys on 10 February and 6 March 2015 and counted 115 and 168 deer, respectively, with slightly different areas covered on the two dates. However, to date there have been no formal studies of how deer are affecting vegetation in local parks and natural areas within areas administered by the City's Natural Areas Preservation (NAP) program. Informal observations by park staff and concerned citizens suggest that deer are browsing both woody plants (trees and shrubs) and wildflowers, but no monitoring data have been compiled.

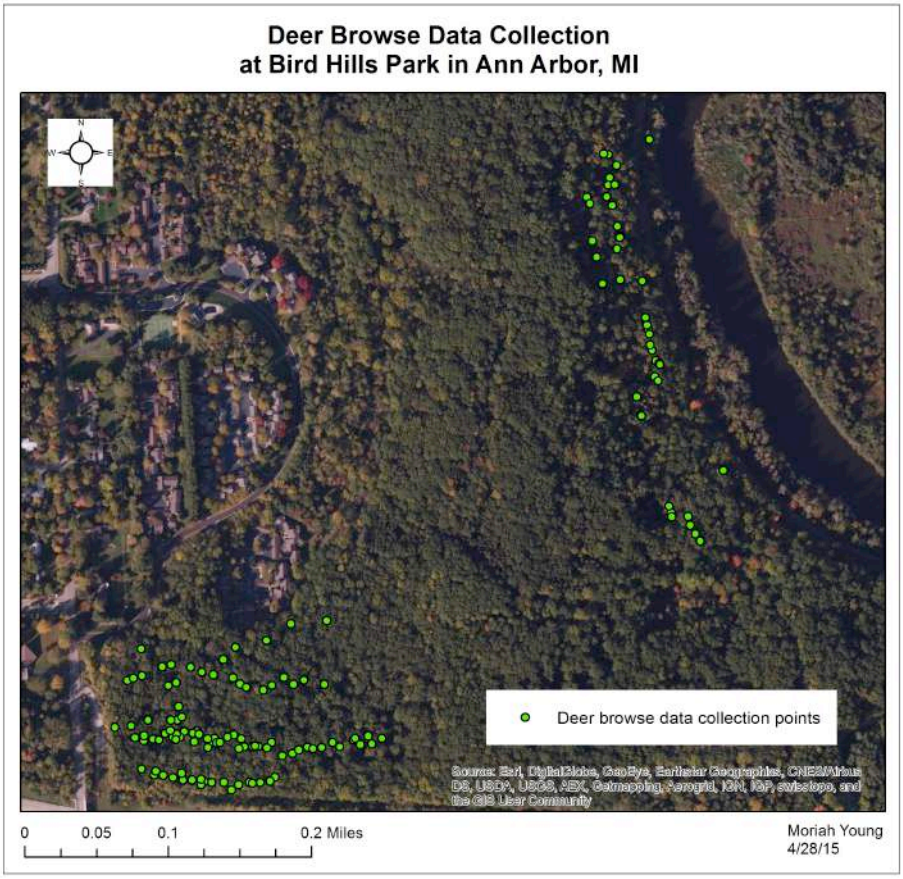
As a first step in assessing deer impacts in Ann Arbor parks, we conducted a systematic GIS-linked browse damage survey of woody plants in one of the city's largest and highest quality natural areas, Bird Hills Nature Area, during the period from 7 February through 14 April 2015. To gain an initial view of browse impacts, we did not choose indicator species but instead assessed browse damage on all species of woody seedlings and saplings encountered at 10-meter intervals along transects through two areas of the park with the most mature forest. This survey provides a snapshot of browse impacts on native tree saplings, native shrubs and small understory trees, and invasive shrubs.

Methods

To assess deer impacts on vegetation at Bird Hills Nature Area, we selected two sampling areas that aerial photos show are intact mature stands of forest—one at the southwest corner of the park, bordered by Newport Road on the west and M-14 to the south, and a second on the eastern side of the park on steep hilly slopes adjacent to Huron River Drive (Figure 1). Informal conversations with present and former NAP staff suggested that these were the highest quality

areas from the perspective of botanical species represented and relative lack of disturbance; both areas have been managed by manual invasive shrub removal and prescribed burns.

Figure 1. Deer browse data collection. Individual plants were assessed at 10-meter intervals along transects in mature forest stands in the southwestern corner and along the eastern edge of Bird Hills Nature Area in Ann Arbor, MI, from 7 February to 14 April 2015.



We assessed deer browse damage on 142 individual woody plants of all species (including native tree saplings, native shrubs and understory shrubs, and invasive shrubs) encountered at 10-meter intervals along transects through the two forest stands from 7 February through 14 April 2015. We used ArcGIS Collector on an iPad or iPhone to collect spatial data linked to each plant assessed. We initially surveyed 9 trailside plants, then ran 4 transects east-west through the southwest forest stand and 2 transects roughly north-south through the eastern stand. Transects were initially spaced at 20-30 m intervals, but because this was intended to be a quick survey, we did not lay out a precise grid.

At every 10 meters along the transect, we chose the nearest living tree sapling or shrub that had twigs below 2 m (within the reach of browsing deer) and assessed whether it had been

browsed by deer or other mammalian browsers. Many studies of deer browse damage focus on a few indicator species (e.g., Winchcombe 2015), but we used a broader approach of assessing browse damage on all species encountered so that we could examine which species are present in large enough numbers to be potentially useful indicator species for future studies.

Deer browse damage on woody plants can be reliably distinguished from that of other mammalian herbivores (woodchucks, rabbits, voles) by the characteristic shredded bark and a broken appearance of the twig, because deer tend to rip and tear plant material, in contrast to rabbits and woodchucks, which cut cleanly at a 45° angle (e.g., see MI DNR). Woody plants can show identifiable evidence of browse damage for one or two seasons after browsing occurs, but over time the markings may degrade as twigs recover or die; we only counted damage that could be clearly attributed to either deer, rabbits and wood chucks, or voles. Browse damage surveys on woody plants may comprise a cumulative tally of damage from one or two seasons, or even more. Therefore, these results should be interpreted as likely showing damage from 2013–2015.

For each plant assessed, we noted the species and recorded an estimate of the percentage of twigs or buds browsed by deer (for simplicity, we used categories: 0%, 5%, 10%, 25%, 50%, 75% or 100%). In most cases, the estimated browse % was accompanied by a count of the actual number of branches browsed and unbrowsed; inconsistencies in data recording made this data difficult to analyze, but the estimated browse % was lower than the actual count in all analyzable data. We took photos of browse damage on most individuals, which are linked to spatial data and browse measurements.

We analyzed and graphed the numbers and proportions of plants of different species that were browsed by deer, along with the average amount of browse damage, with Microsoft Excel. The analysis grouped species into four broad categories:

1. **Native trees.** These species indicate the process of forest regeneration.
2. **Native shrubs and understory trees.** These plant species provide food and habitat for many native pollinators, birds, and small mammals.
3. **Invasive shrubs.** These species may provide some resources to generalist insects and birds, but may displace native species and their interactions.
4. **Unidentified other species.** Some individual plants could not be positively identified due to poor condition of winter twigs and buds.

We did not analyze browse damage from other mammalian herbivores because only 9 of the 142 individuals were browsed by rabbits or wood chucks, and most were also browed by deer.

We used ArcGIS (Geographical Information Systems) online and ArcMap to show browse data superimposed on aerial photos of Bird Hills Nature Area. Future analyses will assess the spatial component of browsing to determine whether deer browsing was negatively correlated with proximity to roads and trails and steep slopes.

Results and Discussion

We assessed 142 individual plants representing 8 native tree species, 10 native shrub and understory tree species, and 4 invasive shrub species. Across all species, 80% of individuals showed clear signs of deer browsing; 51% had half or more twigs browsed (Figure 2, Table 1 at end).

Among 42 individual native tree saplings sampled, 86% had been browsed by deer, and 51% had half or more twigs deer-damaged. Although many plants can tolerate occasional and moderate amounts of browse damage, these numbers suggest that deer browsing has the potential to decrease forest regeneration and alter succession. Winchcombe (2015) has noted that when 50% or more twigs or buds are browsed on tree saplings less than 2 meters tall, browse damage can be fatal. Boulanger et al. (2014) suggest that browse damage on more than 5% of the seedlings of a species per year can place a generation of tree seedlings at risk.

Of the 74 native shrub and understory trees surveyed, 77% had been browsed by deer, with 46% of the individuals damaged on half or more of the twigs. Like other plant groups, shrubs are able to compensate for moderate levels of browsing, and may continue to survive and potentially reproduce. However, deer removal of large amounts of twigs and buds has been documented in some studies to lower resource availability for species in other trophic levels—e.g., fewer flowers mean less nectar for pollinators including native bees and butterflies, and fewer berries that can be important foods for birds and small mammals (Rooney and Waller 2003).

A total of 11 invasive shrubs were assessed. Of these, 8 (73%) showed signs of deer browsing, and 7 (64%) had 50% or more branches browsed. Some researchers have suggested that part of the reason invasive species are successful is that they are able to escape herbivory (e.g., Cincotta et al. 2009), but others note that generalist herbivores (such as deer) may exert more complex effects (e.g., Keane and Crawley 2002). Our data suggest that deer may be helping to limit growth of privet and Asian bush honeysuckles.

Maps of browse damage of all stems sampled (Figure 4) show that deer browsed a similar proportion of plants in both the southwestern and eastern sides of the park. Amount of browse damage per plant varies somewhat within each area, but is similar across the two sites. The map of the southwestern side of the park suggests that plants that are closer to the trail and parking lot may have less browse damage, and on the eastern side, we observed that there seemed to be less browse damage on the steepest slopes. Further GIS analysis is needed assess whether these spatial factors contribute significantly to browse damage patterns.

Although there were some variations in the proportions and average amounts of browse damage per species (Table 1), many of these are difficult to interpret because of the low numbers

of individuals encountered for most individual species. At the genus level, 3 genera had 20+ individuals surveyed: *Prunus*, including both tree and shrub species (*P. serotina* and *P. virginiana*); *Fraxinus,* including both *F. americanum* and *F. pennsylvanicum,* which were hard to conclusively differentiate on heavily browsed material; and *Viburnum,* which was all *V. acerifolium* except for one *V. lentago*. All other species had 5 or fewer individuals. There was some variation in the spatial distribution of these genera. Most of the *Prunus* and *Viburnum* occurred in the southwestern section of the park, while the eastern section was dominated by *Fraxinus* and a diverse mix of other species (Figure 4). However, browse damage levels did not appear to differ across the different genera in any clear spatial pattern. Among these three genera, *Viburnum* had both the lowest proption of individuals browsed (75%) and the lowest average damage (45%), while 84% of *Fraxinus* were deer-browsed and over half of had damage levels of 50% or more.

The deer browse figures compiled in this survey may underestimate actual browse damage in several ways. First, the survey excluded plants that were already dead or lacked live buds for identification. Many of the excluded plants showed clear signs of deer browse, which suggests that browse damage could be contributing to mortality, but estimating browse-related mortality was beyond the scope of this study. Numerous other studies suggest that browse damage over several decades may already have eliminated or greatly reduced populations of deer-preferred species (Côté et al. 2004, Rooney and Waller 2003, Ferker et al. 2014). Second, it is not possible to count how many buds are *missing* from a plant, so we focused on the number of branches browsed. However, some unbrowsed branches were counted even if they were quite small, while the portions of branches browsed off may have been larger than those that remained. Third, we assessed browse damage on all species, rather than on a set of species known to be preferred by deer; damage on preferred species could be even higher. Finally, this analysis rounds off browse damage totals into fixed categories (5%, 10%, 25%, 50%, 75%,100%), but those are the lower bound of the browse damage—that is, a plant with 80 out of 90 branches browsed (89% damage) was recorded as 75%. Data recording inconsistencies preclude complete analysis of the more precise branch-count data, but an analysis of the subset with unambiguous data suggests that browse damage was even higher.

Conclusion

This survey of 142 tree saplings (less than 2 meters tall) and shrubs in Bird Hills Nature Area shows that 80% have been browsed by deer, and 51% have half or more branches browsed. This level of browsing could interfere with forest regeneration and diminish the flowers and fruit available for birds, butterflies, and bees. Further monitoring would be necessary to track mortality, to reveal whether particular tree and shrub species of concern are browsed in future years, and to assess whether wildflower species are also being heavily browsed.

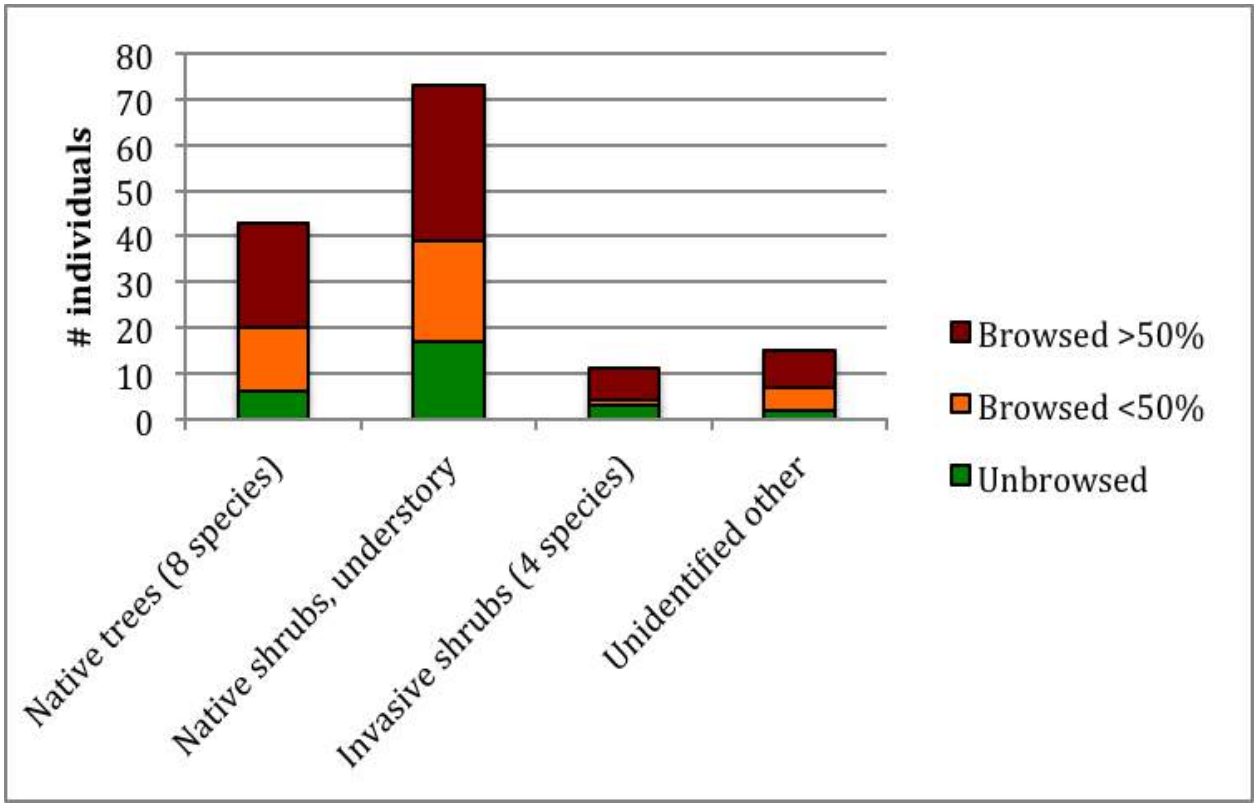
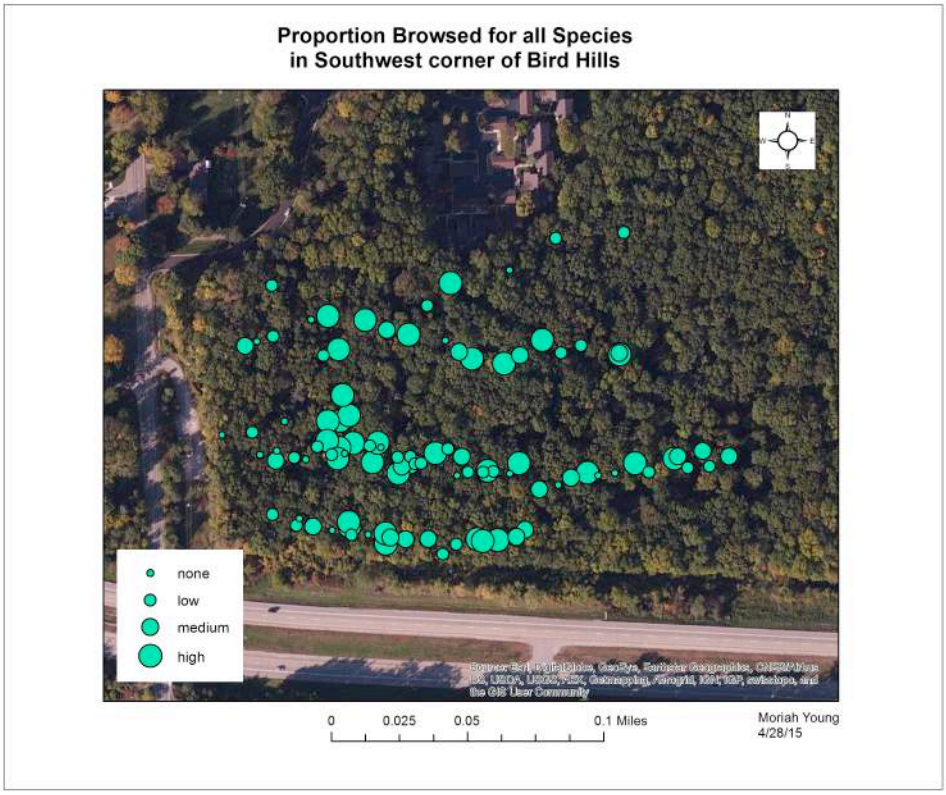


Figure 2. Deer browse damage on native tree seedlings and saplings, native shrubs/understory trees, and invasive shrub species. Most individuals of most species were browsed to some extent by deer. Browsing on more than 5% of tree seedlings per year is considered to have the potential to interfere with forest regeneration (Boulanger et al. 2014). Browse damage of 50% or more of twigs or buds is shown because it can lead to increased risk of mortality of tree seedlings (Winchcombe 2015) and reduce flowering and fruiting of shrub species that supply important nectar and food resources to native pollinators (bees and butterflies), birds, and small mammals.



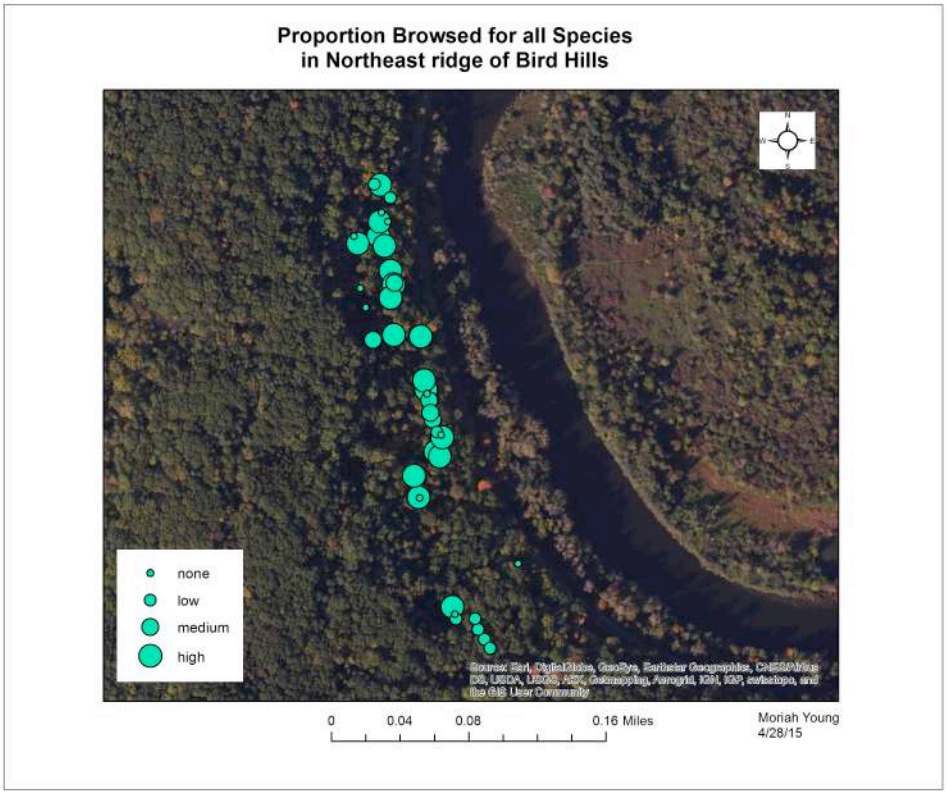
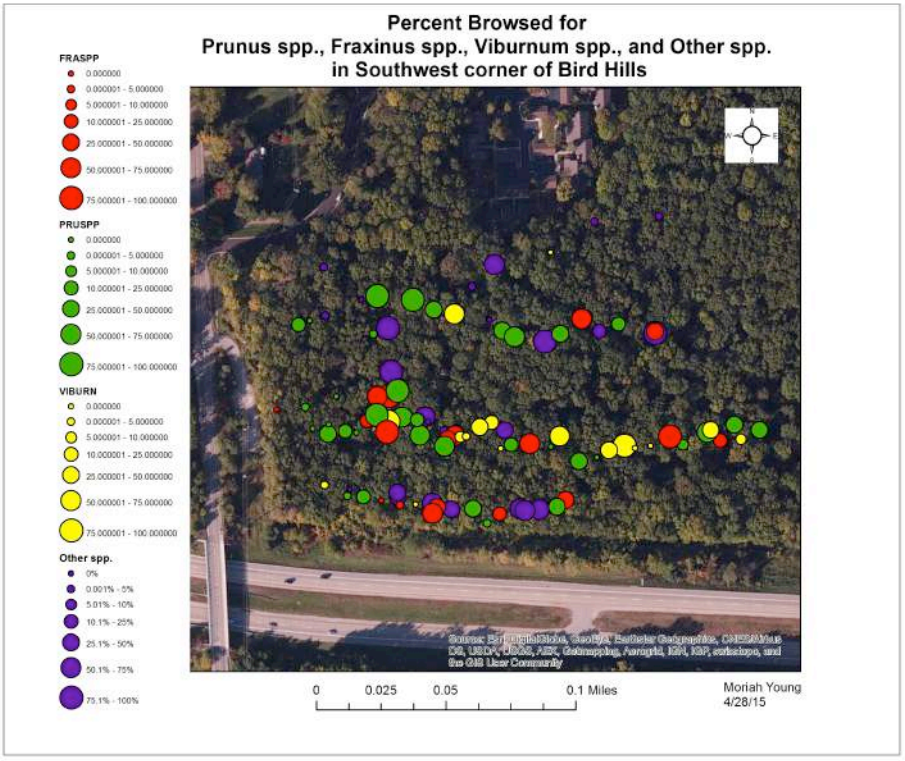


Figure 3. Amount of deer browse damage on all plants in the southwestern (above) and eastern (below) sections of Bird Hills Nature Area, Ann Arbor, MI. Larger circles show larger amounts of browse damage.



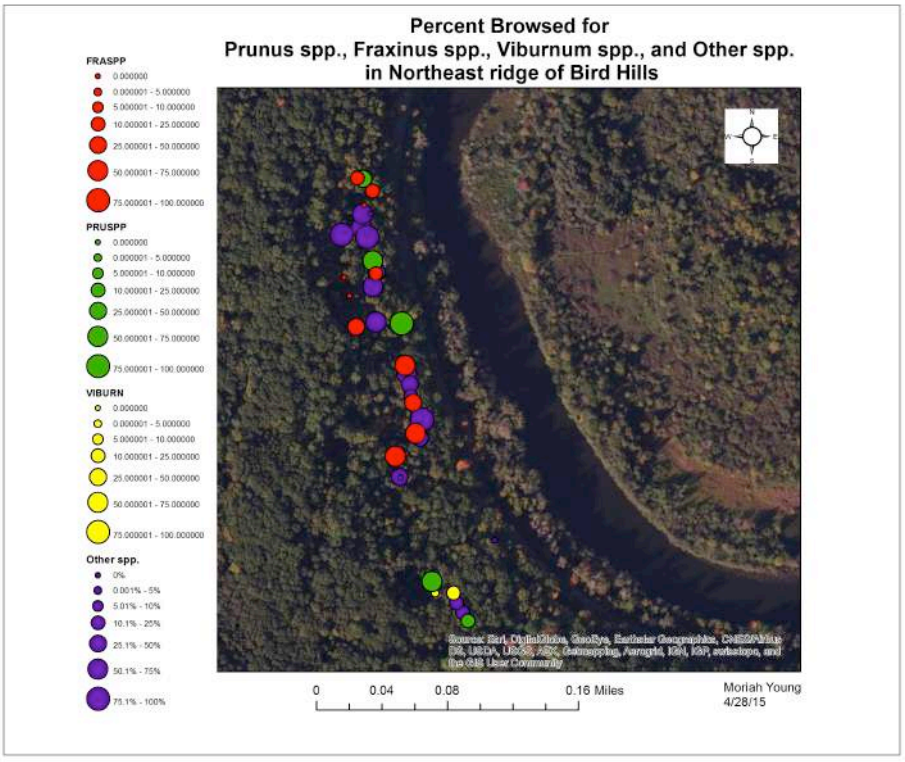


Figure 4. Amount of deer browse damage by species for *Prunus*, *Fraxinus*, and *Viburnum* in the southwestern (above) and eastern (below) sections of Bird Hills Nature Area, Ann Arbor, MI. The *Prunus* category includes both tree and shrub species (*P. serotina* and *P. virginiana*). *Fraxinus* includes *F. americanum* and *F. pennsylvanicum*. *Viburnum* is *V. acerifolium* plus 1 stem *V. lentago*. "Other" includes all species with 5 or fewer individuals.

Table 1. Deer browse damage by species. This table lists all species encountered in a systematic transect survey in two mature forest areas of Bird Hills Nature Area. Browse damage of 50% or more of twigs or buds is noted because it can lead to increased risk of mortality of tree seedlings (Winchcombe 2015) and reduce flowering and fruiting of shrub species that supply important nectar and food resources to native pollinators (bees and butterflies), birds, and small mammals.

Species	Common name	# individuals counted	# with deer browse damage	Proportion of all individuals browsed by deer	Proportion of all individuals with ≥50% twigs deer browsed	Average amount browse damage (% twigs or buds browsed)
Native tree seedlings and saplings						
Fraxinus species	ash, white and green	28	23	82%	54%	52%
Prunus serotina	wild black cherry	6	6	100%	67%	54%
Acer rubrum	red maple	2	2	100%	100%	50%
Ulmus americana	American elm	2	2	100%	50%	53%
Carya cordiformis	bitternut hickory	1	1	100%	0%	5%
Carya ovata	shagbark hickory	1	0	0%	0%	NA
Sassafras albidum	sassafras	1	1	100%	100%	50%
Tilia americana	linden, basswood	1	1	100%	0%	5%
Subtotal, trees		**42**	**36**	**86%**	**55%**	**51%**
Native undesrstory shrubs and trees						
Prunus virginiana	chokecherry	30	23	77%	53%	55%
Viburnum acerifolium	maple-leaved viburnum	23	17	74%	39%	45%
Cornus foemina	gray dogwood	5	5	100%	100%	75%
Rubus species	blackberry, black raspberry	5	4	80%	40%	53%
Cornus alternifolia	alternate-leaved dogwood	2	1	50%	0%	5%
Ostrya virginiana	hop hornbeam	2	2	100%	0%	25%
Sambucus canadensis	elderberry	2	2	100%	100%	63%
Zanthoxylum americanum	prickly-ash	2	0	0%	0%	NA
Corylus americanum	hazelnut	1	1	100%	0%	5%
Hamamelis virginiana	witch-hazel	1	1	100%	0%	5%
Viburnum lentago	nannyberry	1	1	100%	0%	5%
Subtotal, native shrubs		**74**	**57**	**77%**	**46%**	**50%**
Invasive shrub species						
Ligustrum vulgare	privet	4	4	100%	100%	75%
Lonicera species	Asian shrub honeysuckle (Amur, Morrow, Tatarian)	4	3	75%	75%	83%
Rosa multiflora	multiflora rose	2	1	50%	0%	25%
Berberis thunbergii	Japanese barberry	1	0	0%	0%	NA
Subtotal, invasive shrubs		**11**	**8**	**73%**	**64%**	**72%**
Unidentified species (no confirmed identifcation)						
OTHER*	various trees and shrubs	11	9	82%	50%	61%
Prunus species	cherry species, not categorized	4	4	100%	55%	28%
Subtotal, other species		**15**	**13**	**87%**	**53%**	**51%**
* Positive identification not possible due to poor condition of winter buds and twigs.						
Grand Total, all species		**142**	**114**	**80%**	**51%**	**51%**

Literature Cited

a2gov.org. 2015. City of Ann Arbor web site, Deer Management Project. Accessed online: http://www.a2gov.org/departments/community-services/Pages/Deer-Management-Project-.aspx.

Ann Arbor Chronicle. 2014. Ann Arbor Oks $20K to create deer plan. Accessed online: http://annarborchronicle.com/2014/08/18/ann-arbor-oks-20k-to-create-deer-plan/.

Armentrout, V. 2014–2015 blog posts. Local in Ann Arbor: What do we do about deer? Accessed online: http://localinannarbor.com/what-do-we-do-about-the-deer/.

Boulanger, J.R., P.D. 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

Cincotta, C.L., J. M. Adams, and C. Holzapfel. 2009. Testing the enemy release hypothesis: a comparison of foliar insect herbivory of the exotic Norway maple (*Acer platanoides* L.) and the native sugar maple (*A. saccharum* L.). *Biological Invasions* 11(2): 379–388.

Côté, S. D, T.P. Rooney, J-P. Tremblay, C. Dussault, D.M. Waller. 2004. Ecological impacts of deer overabundance. *Annual Review of Ecology, Evolution, and Systematics* 35(1): 113-147.

DeCalesta, D. 1994. Effect of white-tailed deer on songbirds within managed forests in Pennsylvania. *Journal of Wildlife Management* 58(4):711–718.

Doerr, M.L., J.B. McAninch, and E.P. Wiggers. 2001. Comparison of 4 methods to reduce white-tailed deer abundance in an urban community. *Wildlife Society Bulletin* 29(4): 1105–1113.

Ferker, K., A. Sabo, D. Waller. 2014. Long-term regional shifts in plant community composition are largely explained by local deer impact experiments. PLOS ONE online journal, http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0115843#abstract0. DOI: 10.1371/journal.pone.0115843.

Hobbs, N., Bowden, D., & Baker, D. 2000. Effects of fertility control on populations of ungulates: general, stage-structured models. *The Journal of Wildlife Management* 64: 473–473.

Horsley, S., Stout, S., & DeCalesta, D. 2003. White-tailed deer impact on the vegetation dynamics of a northern hardwood forest. *Ecological Applications* 13(1): 98–118.

Indy.gov. 2015. Deer management program: Eagle Creek Park. http://www.indy.gov/eGov/City/DPR/Pages/Deer-Management-Program.aspx.

Indiana Department of Natural Resources, Division of Fish and Wildlife. 2011?. *Urban Deer Technical Guide*. Accessed online: http://www.state.in.us/dnr/fishwild/files/fw-UrbanDeerTechnicalGuide.pdf.

Keane, R.M., and M.J. Crawley. 2002. Exotic plant invasions and the enemy release hypothesis. *Trends in Ecology & Evolution* 17(4): 164–170.

Leary, M. 2015. "Our deer are mostly Ann Arborites." *Ann Arbor Observer*, Feb. 2015, pp. 25–27.

McAninch, J.B., ed. 1995. *Urban Deer: A Manageable Resource?* Proc. of the 1993 Symposium of the North Central Section, The Wildlife Society.

McShea, W.J., H.B. Underwood, and J.H. Rappole, eds. 1997. *The Science of Overabundance: Deer Ecology and Population Management*. Washington, DC: Smithsonian Press. 432 pp.

MI DNR. "Forest foods deer eat." Michigan Department of Natural Resources. Accessed online: http://www.michigan.gov/dnr/0,4570,7-153-10370_12148-61306--,00.html).

Montgomery County Parks. 2004. *Comprehensive Management Plan for White-tailed Deer in Montgomery County, Maryland, August 1995 (Updated August 2004)*. Accessed online: http://www.montgomeryparks.org/PPSD/Natural_Resources_Stewardship/Living_with_wildlife/deer/documents/deerplan_update_aug2004.pdf.

Morellet, Nicolas, et al. 2001. The browsing index: new tool uses browsing pressure to monitor deer populations. *Wildlife Society Bulletin* 29(4): 1243–1252.

Potvin, F. and L. Breton. 2005. Testing 2 aerial survey techniques on deer in fenced enclosures: visual double-counts and thermal infrared sensing. *Wildlife Society Bulletin* 33(1): 317–325.

Rawinski, T.J. 2008. Impacts of white-tailed deer overabundance in forest ecosystems: an overview. U.S. Forest Service, Northeastern Area State and Private Forestry Service, U.S. Department of Agriculture. http://www.na.fs.fed.us/fhp/special_interests/white_tailed_deer.pdf.

Rooney, T., & Waller, D. 2003. Direct and indirect effects of white-tailed deer in forest ecosystems. *Forest Ecology and Management* 181(1):165–176.

Stanton, R. 2014. Ann Arbor residents express strong opinions for and against deer hunting in city. mlive.com, December 27, 2014. Accessed online: http://www.mlive.com/news/ann-arbor/index.ssf/2014/12/ann_arbor_residents_express_st.html.

Waller, D.M., and W.S. Alverson. 1997. The white-tailed deer: a keystone herbivore. *Wildlife Society Bulletin* 25: 217–226.

WC4EB. 2015. Washtenaw Citizens for Ecological Balance web site. Accessed online: http://wc4eb.org.

Winchcombe, R.J. 2015. Monitoring deer browsing. Cary Institute project description. Accessed online: http://www.caryinstitute.org/science-program/research-projects/monitoring-deer-browsing.