

Monitoring White-tailed Deer Impacts:

The Ten-tallest Method

Thomas J. Rawinski



U.S. Department of Agriculture, Forest Service
Northeastern Area State and Private Forestry
11 Campus Boulevard, Suite 200
Newtown Square, PA 19073
www. _____

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Introduction

Forest ecosystems contain plants, animals, fungi and microbes interacting with each other and their physical environment in a complex system of energy and matter exchanges. The purpose of this document is to describe a way to better understand one aspect of this dynamic, the influence of white-tailed deer (*Odocoileus virginianus*) herbivory on vegetation (Figure 1).



Figure 1. A white-tailed deer feeding in a meadow. Photo courtesy of Paul D. Curtis.

White-tailed deer, at high population densities, can alter ecosystems in ways that diminish forest-related values. Throughout the United States, deer populations are managed using a variety of often integrated approaches to achieve population levels compatible with forest health. Common to all approaches is the need for effective long-term monitoring of the understory vegetation to detect improving or deteriorating conditions. Consistent with the principles of integrated pest management (IPM), deer are judged to be at an acceptable level when plants of many species are able to reach full growth potential. For trees, this means that many species are able to grow above the reach of deer to regenerate a forest.

The ten-tallest method is novel in its simplicity. It follows the growth, browse damage and reproductive condition of plant populations that serve as indicators of changing levels of browse impact. Except with the plotless application of the method, plants are not individually marked.

The method was developed for landowners, students, citizen scientists and natural resource professionals. It should be used where deer are obviously impacting the understory vegetation. It can also be used in adjacent fenced areas to reveal growth potential in the absence of browsing. It involves minimal cost and generates data that are easy to collect and manage.

Small tree saplings are a prime focus, but the method can also be applied to shrubs and herbs. It can be used beyond forests, in clearings and scrub.

The prime metric is plant height. Are tree saplings on trajectories to grow above the reach of deer? Is browse damage increasing or decreasing? Are understory shrubs and herbs producing more flowers? Answering these questions takes time – many years of monitoring.

The ten-tallest method doesn't address all needs in the realm of deer impact monitoring or research. For close scrutiny of individual plants or for community-level inquiries, other methods can and should be used. Every method has its intended purpose.

Much of what follows relates to the data form appearing in Appendix 1. It is an Excel document available via this URL:

(.....)

Plot Selection

Walk through a forest, observing the plant life and the impacts of deer browsing. Look for places where deer-preferred trees, shrubs or herbs are most abundant and suitable for monitoring (Figure 2). Such plants tend to be most abundant where canopy gaps allow extra sunlight to reach the forest floor or where the more fertile soils exist. Root sprouts of American Beech are an exception because they are tolerant of shade and can thrive on poor soils. Feel free to monitor non-native species such as Winged Euonymus because these can serve the purpose as well as native species.

Which plant species are preferred by deer and which are not? Lists of each are found in the Forest Service publication, *White-tailed Deer in Northeastern Forests: Understanding and Assessing Impacts*.

http://www.na.fs.fed.us/pubs/2014/NA-IN-02-14_WhitetailedDeerNEForestsWEB.pdf



Figure 2. An understory of browse-suppressed Sugar Maple saplings, an ideal location for establishing a ten-tallest plot, Chenango County, NY.

Avoid forest edges and places of high human activity where deer impacts are not representative of those found in forest interiors.

Try to establish plots in different sectors of a forest and in different habitats. Deer impacts are never uniform

across the landscape. Some locations will experience heavier browse pressure than others. And, a plant species may grow better at some locations than others, owing to differences in light, moisture and soil fertility. Variability in height growth and browse impact across the landscape is to be expected, and that is why multiple plots are sampled. The observer is left to interpret growth data in terms of browse impact and other possible contributing factors.

Focus the sampling on two or three preferred species that are most abundant in a forest, but also monitor some of the less common or less preferred species if those species show browse damage.

How many plots per forest? There's no set rule, but the more plots the better, especially when the growth data are to be analyzed statistically using such tests as repeated measures ANOVA. Some forests will have many places suitable for sampling while other forests far fewer, e.g., where low-preference species such as Black Huckleberry or Hay-scented Fern dominate the understory (Figure 3).



Figure 3. Black Huckleberry, a low-preference species, dominates the understory of this Long Island woodland.

Available time often dictates the number of plots that can be established and monitored. At the 1,039 acre Rheinstrom Hill Audubon Sanctuary, for example, two people spend two days each year re-sampling 55 species populations at 25 stake locations (Figure 4).

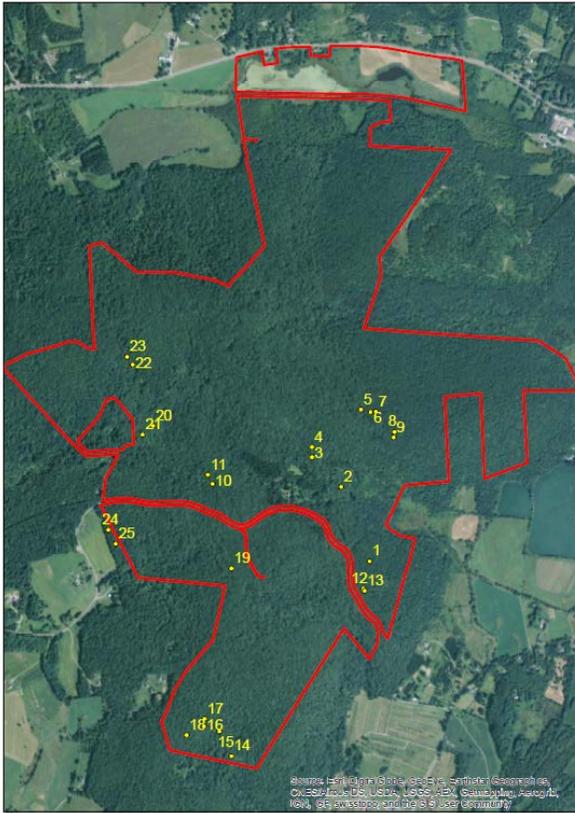


Figure 4. Ten-tallest plot locations at Rheinstrom Hill Audubon Sanctuary in Columbia County, NY.

Aggregating some of the plots, as shown on Figure 4, is acceptable, especially if different species are monitored in those plots. Ideally, all plots should be established in one year and re-sampled during the same time period in each subsequent year. Circumstances might prevent annual re-sampling. Skipping a year or two is acceptable. And there's nothing wrong with adding new plots each year.

Plot Sampling

A plot must contain at least ten individuals of a plant species of interest within an area of 1,076 square feet (100 square meters), which equates to a circle with an 18.5 feet (5.64 meters) radius. Confident that a place is suitable for a plot, drive a central stake into the ground. A section of $\frac{3}{4}$ inch diameter PVC pipe, 2.5 feet long, works well. Use a permanent marker or some other means to number the stake. Given a choice as to where to place the stake, consider the proximity of landmarks that could be helpful in relocating the stake.

A tape measure is pivoted around the central stake to mark the edge of the plot circle. Eight wire stake flags placed along the periphery of the plot are usually sufficient to eyeball the plot area. When uncertain whether a plant of interest is inside or outside the plot, run the tape measure to it. Leaving the wire flags in place saves time when re-sampling the plots, but if desired, the wire flags can be retrieved and reestablished with each sampling.

Record site name, location, plot number, date and observer information on the form. Each plot number has to be unique. Plot number consists of site name, stake number and species name, e.g., "Beaver Meadow 2 Sugar Maple". At large properties, one might add a subsite name into the plot number, e.g., "Montezuma NWR, Main Pool Forest 1 Buckthorn". Estimate the total number of individuals of the monitored species in the plot. If a shrub or herbaceous species is being monitored, count and record the total number of reproductive individuals in the plot, i.e., those with flower buds, flowers or fruit.

With a yardstick or a small tape measure, measure the height of the ten tallest individuals to the nearest half inch. Measure directly below the highest leaf blade of the plant. If sampled during the dormant season, measure to the top of the tallest living bud. Stems originating outside the plot but leaning into the plot are not measured. Examine the measured stems for any evidence of browse damage and indicate Yes (Y) or No (N) on the form (Figure 5). Use a question mark (?) when uncertain about the cause of plant damage.



Figure 5. Evidence of repeated browse damage to Arrowwood, Braintree, MA.

Where deer and moose coexist, browse damage from the two may be indistinguishable. Record such uncertainty in the Notes section. Drape a section of flagging tape over each plant that gets measured and evaluated.

Once ten plants have been measured, see if there are any plants in the plot that are taller than the shortest one measured. If such a plant is found, that shortest measurement gets crossed out and replaced by the new taller measurement. Continue this procedure, looking to “beat” the next shortest measurement until you are confident that the ten tallest have been measured.

Do not measure stems of woody plants that are greater than five feet tall, but indicate in the Notes section of the form that a certain number of these taller individuals exist in the plot. Record other observations in the Notes section, e.g., “White Ash saplings deformed by chronic browsing”, or “three Red-berried Elder plants in plot measuring 9, 12 and 16 inches tall”.

Multiple species may be sampled at a stake location. This is accomplished by removing the flagging draped across the first species and repeating the procedure for the next. Use a separate form, identifying this plot as “Beaver Meadow 2 White Ash”, for example. As defined here, a plot is really a species population monitored at a stake location.

The sampling goes quicker if two or more people are involved. Take photographs of the plots for future reference (Figure 6).

When all species populations have been measured, collect the draped flagging tape and proceed to the next stake location. The central stake stays in the ground, as will the wire flags, if so desired.

Re-sample the plots in future years near the date when first sampled. Because none of the plants are individually marked, the ten tallest individuals measured in one year may not be same individuals measured the next year. This is fine, and to be expected; the method monitors attributes of *plant populations*, not individual plants. Returning each year near the same date is especially important if herbaceous plants are being monitored to ensure that the plants are in the same stage of development (Figure 7).



Figure 6. Measuring a Red Oak sapling at stake no.16 at Rheinstrom Hill Audubon Sanctuary, Columbia County, NY. The strip of flagging tape will be draped across the sapling once it has been measured and evaluated for browse damage.



Figure 7. This flowering Bunchberry plant was photographed on May 24, 2012 in York County, ME.

A list of equipment needed follows.

- A map and/or aerial photograph of the area.
- Clip board with blank forms and writing implement.
- GPS unit or phone with GPS capability.
- Camera or phone for taking photographs.
- ¾ inch diameter PVC pipe stakes, 2.5 feet long, or other such stakes for permanent marking of plot centers.
- Permanent marker or numbered tags for numbering plot stakes.
- A hammer, for driving stakes into the ground.
- Large tape measure, for establishing plot edges.
- A supply of wire stake flags for marking plot edges.
- Small tape measure or yard stick, for measuring plant heights.
- Strips of flagging tape, about one foot long, to drape across measured plants.
- Numbered metal tags for use in the plotless application.

Plotless Application of the Method

The plotless application is especially suited to situations where deer have radically altered the understory, or where low preference species dominate. With little to monitor via the plot-based approach, the focus turns to the sprouts arising from the base of such species as Witch Hazel, Spicebush, Winterberry, Azalea and

Musclemwood (Figure 8). When heavily browsed, those sprouts may not be able to grow above the reach of deer to replace the older stems. Sprout growth, or lack thereof, can provide an early indication of diminishing or increasing deer impact.

Locate an area where the shrubs or trees of interest are fairly abundant. One may have to travel alongside a small brook, for example, to find ten suitable Spicebush plants. Affix a numbered tag to one of the mature stems of each plant and measure the tallest basal sprout. Return at about the same time of year to re-measure the tallest sprout at each individually identified plant. Use the standard form for entering the height data, but indicate in the Notes that such measurements were from the plotless application of the method.



Figure 8. Heavily browsed basal sprouts of Spicebush. For the plotless application of the method, one of the mature stems would have a numbered tag, and the tallest basal sprout measured.

Data Entry and Storage:

The Excel document, “Ten-tallest Form 2018”, serves as the template for entering data collected in the field. It is a workbook containing 11 worksheets. Upon entering data, the document should be saved as a new document, e.g., “Beaver Meadow Ten-tallest Data”. Make as many copies of the blank worksheet as necessary to accommodate all plots sampled at a site (right click the last blank worksheet tab, select *Copy, Move to End*, and click the box for *Create a Copy*). Rename the worksheet tabs by right-clicking the tab and selecting *Rename*. To

print all worksheets, right-click any tab and click *Select All Sheets* before hitting *Print*.

After entering information on the first worksheet, much of that information, such as site name, location, observer and date, can be copied and pasted onto the next worksheets. When all data have been entered, you may wish to generate a map of the stake locations using the GPS coordinates.

Each form accommodates five measuring events. Begin a new Excel document after these five measurements have been entered. Notice that average height is calculated automatically, which, over time, provides some instant insight into growth trends.

Interpreting Data:

Ten-tallest data can be tabulated, graphed or analyzed statistically to reveal height growth over time within and among species (Table 1, Figure 9). It may take several years to judge whether height growth trends are positive, negative or static (Figures 10 and 11).

The standardized form allows a species' growth data from one site to be compared with that from another to judge which has greater deer impact. Beech sprout height growth has been commonly used for this purpose.

When does monitoring stop? When enough of the tree saplings have grown above the reach of deer, i.e., five feet tall. Such occurred in a plot on Long Island where

nine of the ten tallest American Beech sprouts exceeded five feet tall after five growing seasons.

When shrubs or herbs are being monitored, one can judge improvement by taller plants or by increased flowering, but a clear stopping point usually doesn't exist.

Monitoring herbaceous plants such as White Trillium can be challenging because the deer feed on them continuously. During warm springs, the trilliums flower earlier than during cool springs, so relying on a single date for re-sampling can lead to varying results. A revealing example is shown from ten trillium plots monitored from 2009 to 2017 (Figure 12). In 2009 and 2010, the trillium flowers were counted on May 7. Spring came early in 2010, so the numbers were low. In 2011 and 2012, the sampling took place twice during the spring, about ten days apart. The trillium numbers were about halved during that short period of time. Despite these challenges, Figure 12 shows that the trilliums increased during the period of 2013 to 2016, but declined in 2017. It all suggests that browse pressure can wax and wane over time and not necessarily follow a linear projection model.

In conclusion, the ten-tallest method can provide useful information about plant-herbivore dynamics in forest ecosystems. With relative ease, managers can collect, curate and analyze this information and use it to inform management decisions

Table 1. Summary of ten-tallest data for seven understory woody species monitored at Rheinstrom Hill Audubon Sanctuary, Columbia County, NY.

Stake No.	Sugar Maple			Downy Shadbush			White Ash			Hop-hornbeam			White Oak			Red Oak			Maple-leaf Viburnum		
	2015	2016	2017	2015	2016	2017	2015	2016	2017	2015	2016	2017	2015	2016	2017	2015	2016	2017	2015	2016	2017
21	6.4	6.2	5.95				6.25	6.55	6												
24	7.3	7.15	6.35	14.45	15.85	12.35	8.5	8.7	8												
25	10.45	10.8	10.8				11.35	11.4	10.15							8.95	9.2	7.75			
2				20.95	21.9	19.3				15.1	14.2	14.85									
3				19.35	19.65	18.95															
4				18.05	15.95	16.3	12.7	12.95	11.8	11.9	15.25	13.35									
17				26.6	33.3	17.05										8.7	9.45	8.9	10.7	10.95	10.7
18				28.45	28.9	26.45															
20				13.3	11.95	12.25															
22							11.4	13.45	12.35										22	25.4	23.45
15							13.2	11.7	10.85												
6							11.6	11.25	10.75	10.7	11.45	11.2									
7							11.25	10.95	9.55	10.3	9.6	10.7									
9							10.25	9.95	9.1										11.75	10.7	10.35
14							10.95	9.25	8.9										17.4	16.75	15.3
23							9.3	9.1	8.5										13.35	14.6	13
5										12.45	11.15	10.35									
1													5.75	6.2	5.85				7.1	6.45	5.9
10													19.85	23.55	26.5	16.4	17	16.55			
11													21.55	19.5	23.95	17.7	19.4	19.2			
13													14.6	13.7	11.4	17.9	16.7	15.35			
16													16	15.1	13.1	13.1	14.55	14.6	9.95	9.95	9.75
8																			8.6	7.55	7.7
19																			20.4	23.35	21.65
Species Avg. Hts.	8.05	8.05	7.7	20.16	21.07	17.52	10.61	10.48	9.632	12.09	12.33	12.09	15.55	15.61	16.16	13.83	14.38	13.73	13.47	12.79	12.02

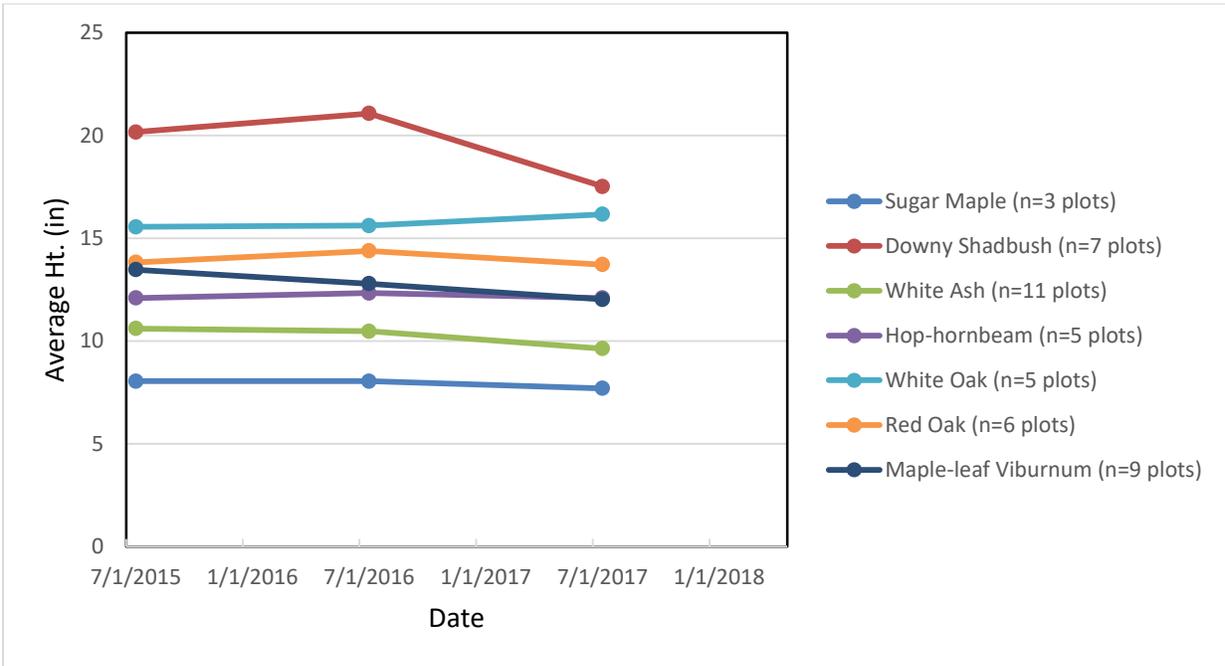


Figure 9. Graph of the Table 1 summary data, showing little or no height growth after two growing seasons. Continued re-sampling will give a clearer picture of growth trajectories and deer impact.

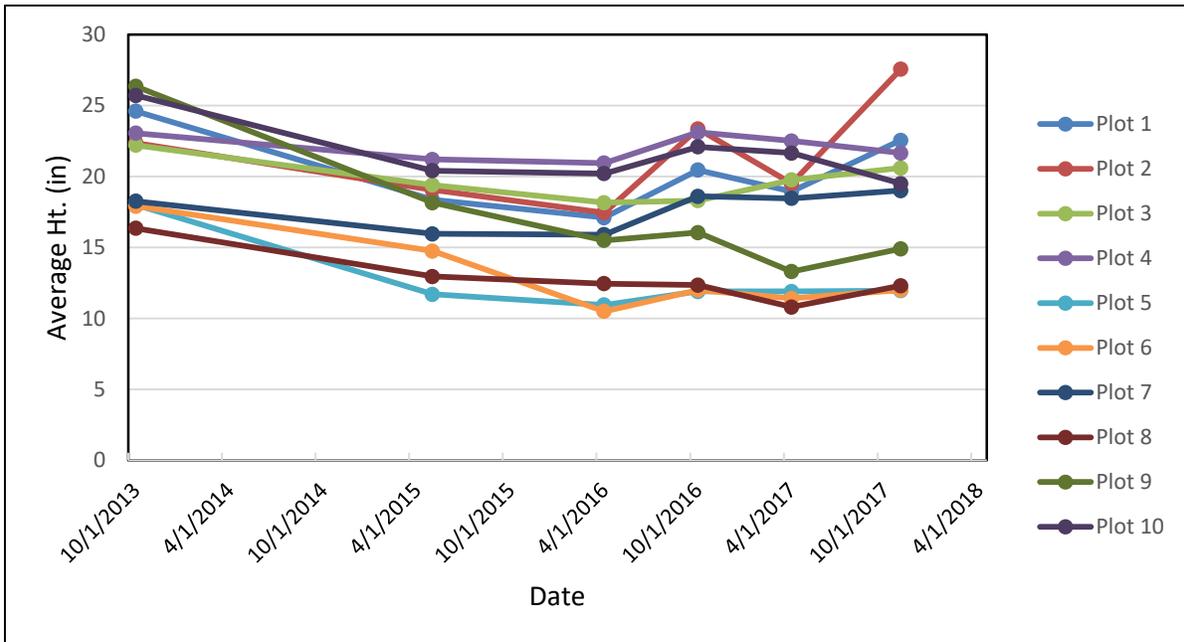


Figure 10. Ten-tallest data from ten Maple-leaf Viburnum plots in Andover, MA. Note the variability that exists among the plots. After four growing seasons, little if any height growth has occurred, suggesting little change in deer impact.

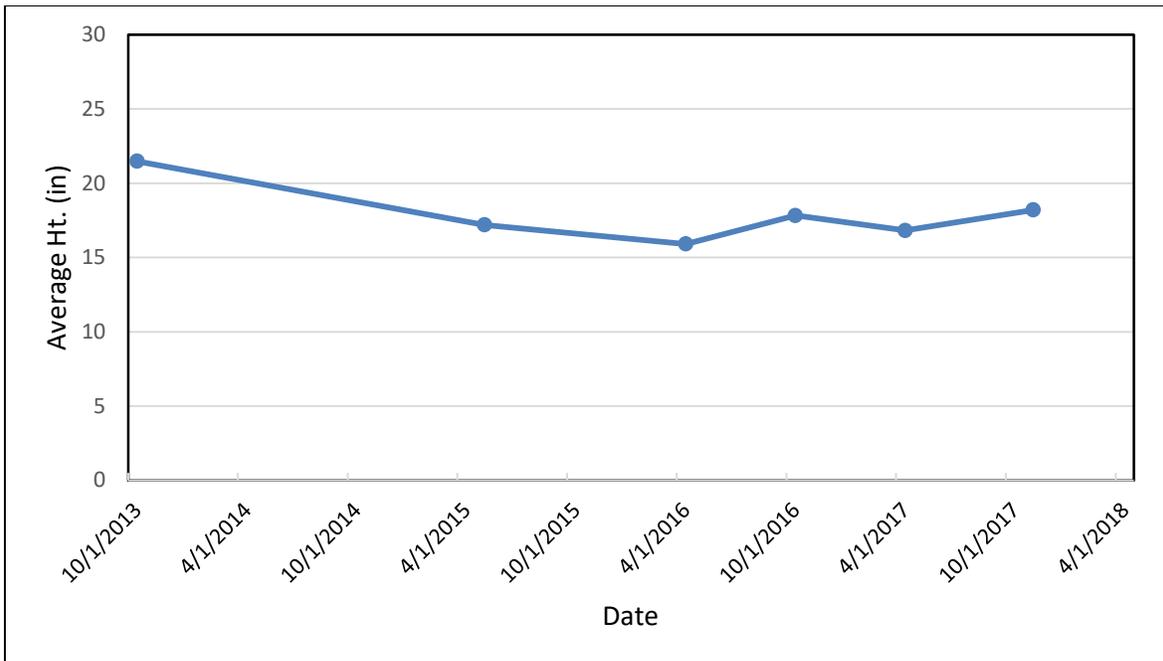


Figure 11. Height data from Figure 9 averaged into a single line on a graph.

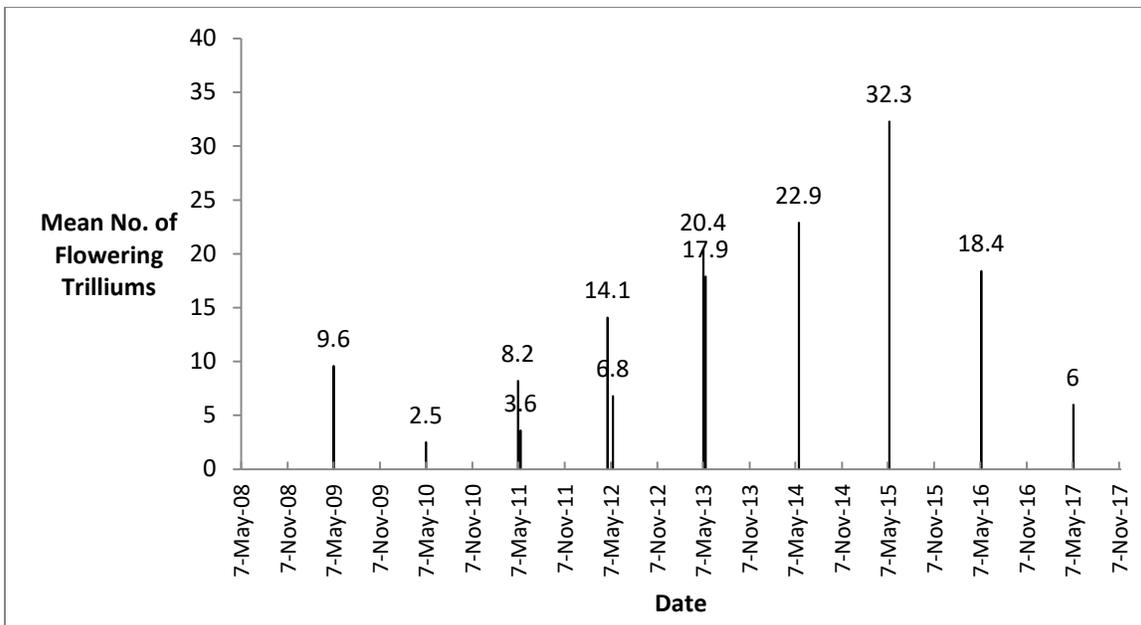


Figure 12. Flowering White Trillium plants in ten plots, Cayuga County, NY. Deer impact may have diminished during 2013 to 2015.

Appendix 1. The blank form and a completed example.

Ten-tallest Method for Deer Impact Monitoring

This form is used to document and monitor understory plant populations for height growth, reproductive condition, abundance and browse damage.

Data are typically gathered from a circular 100 square meter plot (5.64 m or 18.5 ft. radius) marked by a central numbered stake.

Site Name	
Site Location	State: _____ County: _____ City, Town or Village: _____
Plot Location	
Latitude:	Longitude:

Plot Number
<i>(Note: Plot number consists of site name, stake number and species, e.g., Rheinstrom 1 White Oak.)</i>

Plot Center Marked with:

Species Monitored

Number of Individuals in Plot:	10-20	21-50	51-100	>100	Actual Count:
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Observer(s)	Observer(s)	Observer(s)	Observer(s)	Observer(s)

Date:	Date:	Date:	Date:	Date:
-------	-------	-------	-------	-------

No. of Reproductive Individuals in Plot				

Height of the Ten Tallest Stems, and Evidence of Browse Damage

Plant No.	Ht. (in)	Browsed? (Y/N/?)	Plant No.	Ht. (in)	Browsed? (Y/N/?)	Plant No.	Ht. (in)	Browsed? (Y/N/?)	Plant No.	Ht. (in)	Browsed? (Y/N/?)	Plant No.	Ht. (in)	Browsed? (Y/N/?)
1			1			1			1			1		
2			2			2			2			2		
3			3			3			3			3		
4			4			4			4			4		
5			5			5			5			5		
6			6			6			6			6		
7			7			7			7			7		
8			8			8			8			8		
9			9			9			9			9		
10			10			10			10			10		
Avg. Ht.	#DIV/0!		Avg. Ht.	#DIV/0!		Avg. Ht.	#DIV/0!		Avg. Ht.	#DIV/0!		Avg. Ht.	#DIV/0!	

Notes

Ten-tallest Method for Deer Impact Monitoring

This form is used to document and monitor understory plant populations for height growth, reproductive condition, abundance and browse damage.

Data are typically gathered from a circular 100 square meter plot (5.64 m or 18.5 ft. radius) marked by a central numbered stake.

Site Name **Beaver Meadow State Forest**

Site Location State: NY County: Chenago City, Town or Village: Otselic

Plot Location

About 0.3 mile south of Graham Road, near the eastern edge of the state forest boundary.

Plot amid a grove of larger sugar maple trees.

Latitude: 42.70275 Longitude: -75.69776

Plot Number **Beaver Meadow 2 White Ash**

(Note: Plot number consists of site name, stake number and species, e.g., Rheinstrom 1 White Oak.)

Plot Center Marked with: 3/4 inch diameter PVC pipe.

Species Monitored **White Ash (*Fraxinus americana*)**

Number of Individuals in Plot: 10-20 21-50 51-100 >100 Actual Count:

Observer(s)	Observer(s)	Observer(s)	Observer(s)	Observer(s)
Chris Sprague	Andy Blum	Tom Rawinski		
Brian Burlew	Brian Burlew			
Tom Rawinski	Tom Rawinski			

Date: 14-Aug-15 Date: 9-Aug-16 Date: 20-Jun-17 Date: Date:

| No. of Reproductive Individuals in Plot |
|---|---|---|---|---|
| 0 | 0 | 0 | | |

Height of the Ten Tallest Stems, and Evidence of Browse Damage

Plant No.	Ht. (in)	Browsed? (Y/N/?)	Plant No.	Ht. (in)	Browsed? (Y/N/?)	Plant No.	Ht. (in)	Browsed? (Y/N/?)	Plant No.	Ht. (in)	Browsed? (Y/N/?)	Plant No.	Ht. (in)	Browsed? (Y/N/?)
1	36	Y	1	37	Y	1	28	Y	1			1		
2	33	Y	2	36	Y	2	28	Y	2			2		
3	21	Y	3	26	Y	3	25.5	Y	3			3		
4	28	Y	4	23	Y	4	22.5	Y	4			4		
5	23	Y	5	30	Y	5	20.5	Y	5			5		
6	27	Y	6	25	Y	6	23.5	Y	6			6		
7	21	Y	7	25	Y	7	22.5	Y	7			7		
8	24.5	Y	8	21	Y	8	23	Y	8			8		
9	21	Y	9	21	Y	9	21	Y	9			9		
10	20	Y	10	24	Y	10	20.5	Y	10			10		
Avg. Ht.	25.45		Avg. Ht.	26.8		Avg. Ht.	23.5		Avg. Ht.	#DIV/0!		Avg. Ht.	#DIV/0!	

Notes

There is a white ash sapling in the plot, about 6 feet tall, that was not measured - too tall.