AVID

Assessing Vegetation Impacts from Deer

A Rapid Assessment Method for Evaluating Deer Impacts to Forest Vegetation

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Cornell University Cooperative Extension

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AVID Overview

AVID is a project for **A**ssessing **V**egetation **I**mpacts from **D**eer. Project participants evaluate the impact of deer browsing by tagging and measūring tree seedlings and/or wildflowers. Users of the AVID method can measure the impacts of deer browsing on New York forests, and document this aspect of forest health. Participants will learn forest and woodland ecology, how to identify important spring wildflowers and tree species, and develop an eye for recognizing signs of deer impacts.

This document describes the procedures to measure vegetation and quantify the impacts deer are having on woodland vegetation. These field methods can be used by volunteers, landowners, land managers, land trusts, foresters, and other natural resource professionals. Individuals will eventually use **AVID** via smart phone apps for either Apple or Android phones at Apple Store or Google Play Store, or by printing field data sheets and entering the data online at aviddeer.com.

Field data is being collected by individuals and organizations across New York State, and submitted to a central database to track tree, shrub, and wildflower responses to deer browsing over time. Other states have begun to implement the AVID protocol. Knowledge of how deer impacts change through time will help guide deer management decisions at local and regional levels. Participants will document changes in forest plants on their own land, or land in their communities, and will learn:

- To identify important spring wildflower and tree species
- To recognize evidence of deer impacts based on the presence or absence of key wildflower, shrub, and tree indicator species

Benefits of Using AVID

Landowners, land managers, hunters, and others are increasingly interested in knowing how deer populations are changing through time and the impacts deer are having on woodland plants. However, reliably measuring the number of deer in a given area is difficult and time-consuming. The number of deer seen or harvested during the hunting season depends on many different factors, including weather and local food sources, and may not provide an accurate assessment of changes in deer abundance. In addition, no “one size fits all” optimum deer density exists for all areas. The “right” number of deer a given forest can support without substantial damage varies depending upon many factors including soil quality, soil moisture, the amount of other foods available for deer, and others. These factors may change between stands within a forest. Monitoring deer impacts by measuring the success or failure of indicator plants is a good way to know if the number of deer is in balance with the available habitat in a given woods, and if that balance is changing over time.

Data collected on lands in New York State can be used by New York State Department of Environmental Conservation staff to track the health and status of forest lands over time, and aid in deer management decision-making. For individual property owners or managers, the project will allow convenient storage and viewing of data collected on a given property over time. Landowners and managers from other states also are welcome to use the web site and phone apps. The long-term goal is to maintain healthy and diverse forests for future

generations. Each woodland owner can make his or her contributions to the sustainability of Northeastern forests and important wildlife habitat.

In addition to AVID, a number of other methods currently are being used for deer impact assessment (e.g. Blossey et al. 2019, Waller et al. 2017, Rawinski 2016). AVID is particularly useful to support citizen science efforts intended to document the extent of browsing across broad geographic areas. AVID documents a rapid vegetative response when other growth factors (e.g., sunlight) are sufficiently abundant. AVID is simple to accurately apply. The method requires minimal training, minimal supplies that are readily available, provides unambiguous data, and is designed to be statistically robust. AVID allows for assessment of population changes, such as drought-induced mortality, not possible by other methods. Because AVID uses existing and naturally occurring plants, it assesses deer impacts that are happening on-the-ground with existing vegetation and not biased by the introduction of a potentially novel species. However, because AVID uses existing naturally occurring plants, its use is limited in areas of very high deer impact, or for assessing the interaction of plant palatability, species diversity and deer browse impact (Blossey et al. 2019). Further, AVID does not implicitly document vegetation response as a function of browsing, though that option exists (Waller et al. 2017).

The Effect of Deer on Forest Health and Forests of the Future

White-tailed deer *(Odocoileus virginianus)* can significantly influence forests. Deer impact their habitat, the habitat resources available to other species, and the forest ecosystem overall. Low-intensity browsing can potentially have positive effects by thinning a dense understory and fostering species diversity. However, in many areas, deer browsing has become intensive. Deer browse selectively, and they impact some species more than others. Through selective and intensive browsing, deer affect the kinds and numbers of plants present in an area, impair the growth of new trees, and shape the overall look or structure of the forest, both present and future. The changes brought about by deer can affect the quality of the forest and reduce available food and habitat for other wildlife species. The abundance and number of different types of songbirds, for example, is lower in forests heavily browsed by deer.

As selective browsers, deer prefer to eat certain plant species more than other less desirable species. Many of the tree species deer prefer to consume are both valued for timber, and as food-producing trees for wildlife (e.g., oak (*Quercus spp*.), maple (*Acer spp*.)). Deer also eat many wildflower and understory plants such as trillium (*Trillium spp*.), Canada mayflower (*Maianthemum canadense*), and lady slippers (*Cypripedium spp*.), but tend to avoid eating less palatable species such as hay-scented fern (*Dennstaedtia punctilobula*) and essentially all invasive plant species (e.g., garlic mustard (*Alliaria petiolata*), barberry (*Berberis spp*.). By preferentially eating some species and leaving others behind, deer will reduce the native biodiversity of a forest. Selective browsing is a negative force on the species deer prefer, and a positive force on the less palatable species. When the variety of species in the forest changes, so may the way that a forest ecosystem functions, its resilience to natural disturbance, and the quality of products and services provided to society.

In addition to changing the types of plants, deer can also change the structure (i.e., the number and sizes of trees, and the presence or absence of some vegetation layers) of the forest. For

example, over-browsing of tree seedlings and shrubs can eliminate lower layers and create open, park-like stands with little or no ground vegetation or forest understory. Loss of forest understory affects wildlife such as small mammals, insects, and songbirds that rely on the forest understory to provide cover, nesting sites, and food. Some animal species may become less abundant in heavily browsed areas, while others may disappear completely.

The effects of deer browsing on the composition and structure of New York forests can have long-lasting effects (also called "legacy" effects) that persist for decades even after reducing deer impacts. In areas with a history of deer overabundance, regeneration failure – the failure of new, young trees and other desirable understory species to grow – is having a detrimental effect on forests and the potential to keep areas as forests in the future.

How Do I Know if My Woods are Affected by Deer?

The observations made in your woods may indicate the level of deer impacts to that forest. A number of plant and tree species are useful indicators for recognizing deer impacts. The level of impacts and your goals will help identify potential management strategies. You can use the simple diagnostic key below (Table 1) to establish a baseline condition for your woods. These pictures help illustrate signs of high and low deer impacts.

The following index can be used to assess woodland conditions at a single point in time. This key does not allow for comparison to other sites, the influence of general site conditions, or changes through time. AVID provides a more thorough assessment by measuring the condition of woody seedlings or indicator wildflower species. The systematic and repeated measurements through AVID allow you to monitor the growth and flowering frequency of key wildflowers, and changes in height of tree seedlings. Over time, AVID data will provide a more thorough understanding of deer impacts. If the condition of the woods is poor, management to improve the condition will need to provide some combination of reducing deer impacts and assuring desirable plant species have adequate sunlight. Specific management actions will depend on the extent of the problem, the objectives of the landowner, and the specific characteristics of the property and broader landscape.

Deer Impact Index for Assessing Initial Conditions of your Woodland (adapted from Marquis et al. 1992)

1) **No impact** – usually found only inside well-maintained deer exclosure fences.

2) **Low impact** − woody seedling regeneration of species preferred by deer is abundant and of varying heights, and seedlings are regularly able to grow beyond the reach of deer (5 feet or higher). Stump sprouts present. Herbaceous plants common. Spring wildflower indicator species of varying heights are present, and flowering is common. Your forest is generally healthy, and you will be able to regrow a new forest in the future.

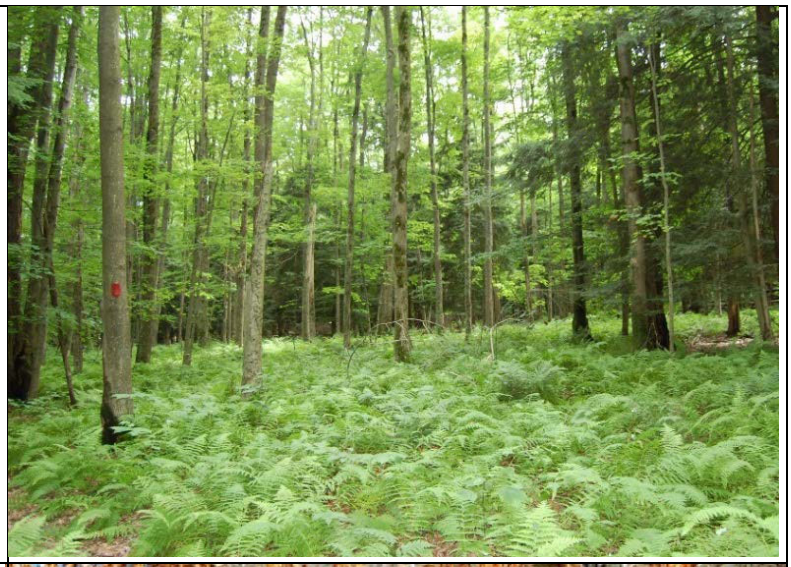
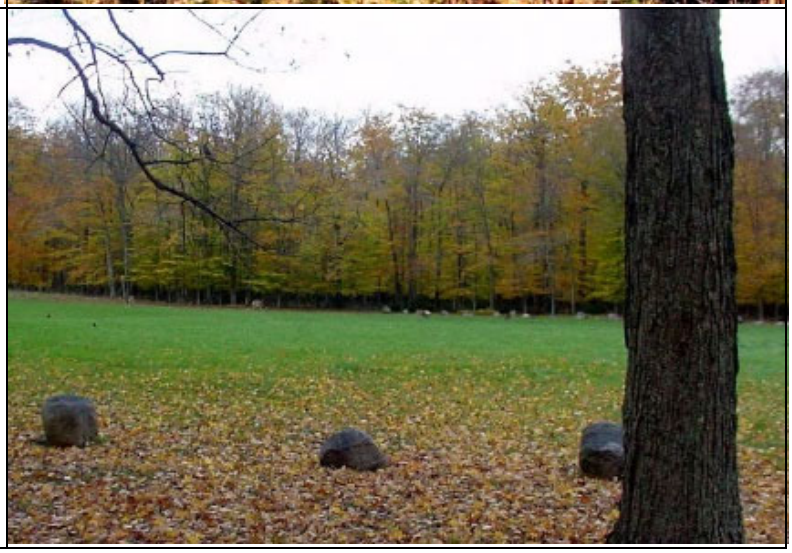
3) **Moderate impact** – woody seedling regeneration of species preferred by deer are present but with little height (e.g. most may be under 1 foot in height) variability. Stump sprouts browsed. Herbaceous plants rare. Wildflowers present but stunted and flowering is not common. Non- preferred browse and browse-resilient plant species are noticeably common and widespread. You have the potential to grow new trees and support plant diversity now, but only if deer browsing on seedlings and wildflowers is reduced, and the abundance of interfering vegetation is assessed and managed.

4) **High impact** − woody seedling regeneration of species preferred by deer is rare to absent. Non-preferred and browse-resilient vegetation limited in height by deer browsing. Seedlings are heavily browsed resulting in multiple-stem plants or deformed stems. Wildflower indicator species absent or severely stunted and flowering is absent. Ferns and invasive plants may be common. Forests in this condition may require a great deal of rehabilitation to reduce the abundance of undesirable plants, combined with a reduction of deer browsing, before new seedlings or wildflowers will be able to grow.

5) **Very high impact** − desirable woody seedling regeneration absent. Abundance of seedling species deer do not prefer is reduced by browsing, browse-resilient plants show signs of heavy, repeated browsing, and a browse line is readily evident. Wildflower indicator species absent. Ferns or invasive plants may dominate the forest floor, or the forest floor may be nearly bare. Forests in this condition may require a great deal of rehabilitation to reduce the abundance of undesirable plants, combined with a reduction of deer browsing, before new seedlings or wildflowers will be able to grow.

Table 1. When deer are having a substantial impact on the forest, recognizable signs can be detected by the trained eye.

Very high impact − A park-like understory with little vegetation growing in the shrub or understory layers. Browsing of any or all palatable plants that begin to grow can eliminate vegetation from the forest floor.	
Very high impact − An understory dominated by invasive shrubs such as barberry, multiflora rose, honeysuckle, or others. Invasive species can colonize and dominate when deer reduce or remove much of the native vegetation.	

High impact − An understory dominated by deer- resistant ferns. Ferns can dominate when other plants are removed through browsing. Once established, thick stands of fern shade the forest floor and can prevent seedlings from receiving sunlight necessary for growth.	
High impact − An understory dominated by native tree species less preferred by deer than other species in the forest. Examples include trees such as hop hornbeam, striped maple, and American beech. Deer browse other species, like sugar maple, ash and oaks, which allows the less preferred species to become established. American beech sprouts profusely when infected with beech bark disease and can block sunlight from reaching the forest floor. Once established, this condition can persist for decades.	
High impact − A "browse line", a visual line created by a lack of vegetation growing at a height of 5-6 feet, indicates deer have eaten everything growing within their reach.	

Moderate impact – Obvious signs of deer browsing to seedlings or understory plants can indicate deer impacts. Browsing on species not typically preferred by deer may indicate moderate deer impacts, as species that are more palatable will be eaten first.	
Low impact – Wildflower species highly preferred by deer are present in the forest, reach greater heights, and flower, or when preferred tree seedlings are able to grow beyond the reach of deer (5-6 feet).	 

Assessment Methods

Deer browsing affects many different components of our forests. Plants provide the basis to assess and document changes in deer population levels and associated impacts. AVID was designed as an index of deer impact that should respond quickly to changes in the deer population, be based on scientific evidence, and be easily and accurately applied by volunteers under different conditions. The methods supported by this protocol emphasize naturally occurring tree and shrub seedlings or specific spring wildflowers.

For the method (or methods) you select, plan to collect and record **all** of the relevant information described below. The data collected will be used to track vegetation changes over time and local environmental conditions that may influence the growth of the seedlings and wildflowers. Therefore, try to visit the plots and collect data on your established plots annually. If you miss a year, it is still useful to continue collecting and submitting data in future years. Re-measurement in subsequent years should happen within two weeks of the original date of measurement when possible.

Spring wildflowers, also called spring ephemerals because they occur for a short time, have been found to respond quickly to changes in deer pressure, and are effective indicators under a variety of forest conditions. As ephemerals, wildflowers will not be apparent for much of the year, and thus are seasonally restricted to spring. Woody seedlings are available year-round, but they tend not to respond as quickly as wildflowers, and seedling identification can be challenging during at times of the year when leaves are not present.

This protocol includes two methods:

- **Method #1** – tagging and measuring the height of 25-30 individual tree or shrub seedlings of each species of interest
- **Method #2** - tagging and measuring the height of 25-30 wildflowers each of one or more species

Having enough information to make deer management decisions at a local or regional level will require a sufficient amount of data from the same method. A concern with offering multiple assessment methods is that each is diluted, and insufficient data may be accumulated when volunteer efforts are spread across multiple methods. For this reason, volunteers are strongly encouraged to implement the Seedling Method (#1). If seasonal availability, identification skills, or your personal interest preclude the Seedling Method, use the Wildflower Method (#2). If time, energy and ecological conditions permit, collect data on multiple properties, or use both methods on one property.

Both methods require measurements on 25 to 30 stems of each of the focal species. The number of stems is based on what is needed for use in statistical analysis, and to allow for potential seedling mortality or lost tags that often happens over the monitoring period. If you decide to install some simple small-plot exclosure fences within the original area or compare two distinct areas (e.g., harvested forest versus unharvested forest), each needs 25 to 30 stems of each focal species.

There is similarity among the methods and their implementation is fairly simple. Both methods involve selecting a wooded area as your site (details are below). In these sites, circular plots with a 6-foot radius are established, and plants are tagged and measured (Table 2).

Table 2. Summary of attributes of assessment methods. See text for full details.

Attribute	Method 1- Woody Seedlings	Method 2- Spring Wildflower
What's measured (simplified)	Tag 25-30 seedlings each of the species and record the heights	Tag 25-30 wildflowers of one species or more and record height and whether plant is or has flowered
Sensitive to canopy or sub-canopy shading	May be unreliable in shaded conditions	Can work in shaded conditions
Seasonality	June-early October (before leaf-off), or fall and winter with adequate skill in seedling identification	Mid-May to late June
Standard equipment (details below)	• 6-ft-long rope or staff • Smart phone with app or tally sheet • Compass • Hammer (first year only) • Center and quadrant stakes or flags (first year) • Yard stick or tape measure to assess plant height	Same
Unique equipment	Tags to mark individual seedlings for height measurements Tree seedling identification guide	Tags to mark individual stems Wildflower identification guide (see Appendix)

Selecting a Property

The property where you take measurements will be a woodland or forest site. The property could be your own land, public forest land, properties owned by a local land trust, or other community-owned or private land. If you don't own the land, be sure to ask permission of the owner, and explain the long-term nature of the monitoring project. Some public or private agencies, organizations, or individuals may welcome your involvement.

At any property there will be a range of conditions among different areas. Think about the environmental differences you might expect in a steep-sided ravine with a dark hemlock canopy, versus a mature hardwood woodland with scattered wind-thrown trees, versus a recently harvested oak-pine forest. Light levels and soil conditions will be quite different. These areas of distinctly different conditions are called "stands." A forest stand is analogous to a farmer's field; and there are obvious differences between a cornfield, pumpkin field, or pasture.

At the property you select, **avoid areas** (stands) that have any of these characteristics (see site selection illustration guide below):

- Permanent standing water such as wetlands, although woodland around the wetland may be suitable
- More than 65% cover of exposed rock
- High densities of interfering plant species (ferns, grasses, invasive herbs, invasive shrubs, etc.)
- Slope greater than 70%
- Canopy > 50% closed, but some flexibility permitted (Wildflower method should be included if possible, under these conditions)
- Subcanopy > 50% closed, but some flexibility permitted (Wildflower method should be included if possible, under these conditions)

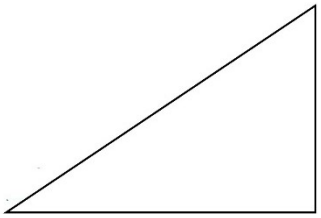
Sunlight is essential for plant growth. Although both methods may be implemented in forests with any amount of canopy closure (shading from overstory trees), a closed upper canopy or closed mid-story canopy prevents light from reaching the forest floor. Without adequate sunlight, flower development and seedling height growth are limited. Therefore, try to select a stand for your measurements where, on average, less than half the sky is shaded by overstory trees when looking up. Remember, your perspective on the amount of sunlight is your view skyward from ground level.

Stands with recent timber harvests, even where much of the tree canopy has been removed, are acceptable. However, stands where broadcast herbicides have been used to control competing vegetation, or that have been grazed, should be avoided for a period of two years to allow seedlings and wildflowers to re-emerge.

Key to Aid in Site Selection

Slope

Is slope > 70%? This is not a suitable site
Is slope ≤ 70%? This is a suitable site



This drawing depicts a slope of 70%. Any slope steeper than this would not be an appropriate site.

Rock cover

Is the site ≥65% covered by exposed rock? This is not a suitable site
Is the site <65% covered by exposed rock? This is a suitable site

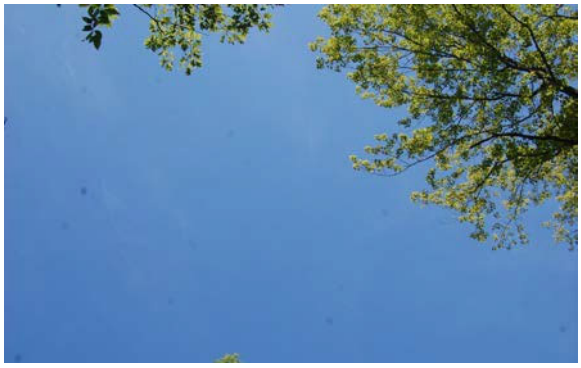
Canopy closure

Do the overstory trees in this stand block your view of more than 50% of the sky when looking up in most locations? If yes, both methods may be implemented at this site. However, shading from the tree canopy will limit seedling growth and lessen seedling height response to changes in deer browsing. Include the spring wildflower method at this site if possible.

Are there openings between the overstory trees that allow you to see more than half of the sky when looking up in most locations? If so, you can implement both methods at this site and expect good seedling growth rates.

The pictures below can help you decide how closed the canopy is at potential locations and can help you check the correct canopy percentage on your form (s).

0-10% canopy closure



10-20% canopy closure

20-30% canopy closure

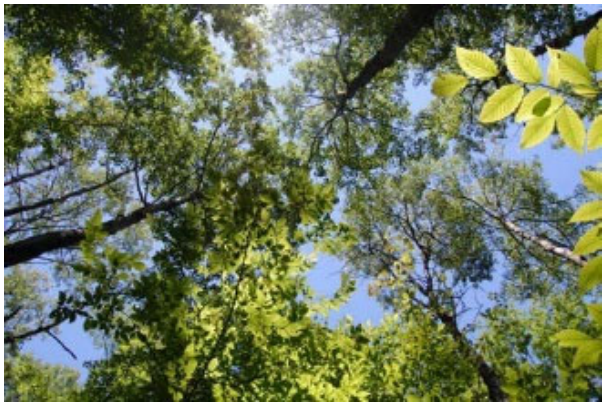
30-40% canopy closure

40-50% canopy closure

50-60% canopy closure

60-70% canopy closure

70-80% canopy closure



80-90% canopy closure

90-100% canopy closure

Understory canopy closure

Is there a dense subcanopy of trees or shrubs below the main canopy that blocks sunlight from over half of the sky? If yes, shading will limit tree seedling growth. Include the spring wildflower method at this site if possible.

Are there openings between the understory trees and shrubs that allow sunlight to reach more than half of the forest floor in most locations? If yes, you can implement both methods at this site.

Pictures showing dense cover of American beech (left) and barberry (right) in the subcanopy and shrub layers of the forest. In these stands, wildflowers are more likely than seedlings to respond to changes in browsing impacts.

Fern, grass, sedge and invasive herb cover

Do ferns, grasses, sedges, or invasive herbs cover significant amounts of ground within the stand? Wildflowers that occur within fern patches can be selected and measured. Only select woody seedlings if they are taller than the fern patch.

Equipment needed:

- ☐ Compass
- ☐ 2 yardsticks, or a stick or string cut to 6 feet in length
- ☐ Permanent marker
- ☐ Smart phone with app, or data sheets with pen or pencil and clipboard
- ☐ PVC (2-ft x 1-inch), fiberglass, heavy duty plastic (www.forestry-suppliers.com or https://www.berntsen.com/Surveying/Survey-Stakes), or wood stakes for marking plot center
- ☐ Hammer or mallet for pounding stakes into ground
- ☐ Brightly colored paint, brightly colored duct tape, or surveyors flagging for marking center and edge stakes
- ☐ Colored pin flags or additional stakes for marking the 4 cardinal directions along the edge of your plots
- ☐ GPS unit or phone with GPS capability
- ☐ Numbered seedling tags (can be provided by Cornell University Department of Natural Resources, email KLS20@cornell.edu

Plot Selection and Set-up

The objective of these methods is to measure whether seedlings and wildflowers are able to grow, and/or if their growth rate changes in response to reductions in deer browsing. If your property's woodland is small (<10 acres), you will establish a minimum of six plots for each method you plan to implement. To begin, locate the plots within the same "stand" in your woods; for additional stands or for plots protected by fencing, replicate the process. Because the vegetation in one stand will react differently to changes in deer numbers and browsing intensity than the vegetation in another stand, the data need to be collected by stand. If you have a larger property and are able to devote more time to the assessment, consider establishing sets of six or more plots in each of several stands. If more than one stand type is present on your property, you may choose to establish one complete set of six plots in two or more different stand types to capture the variability in deer impacts. For instance, if you have had a recent timber harvest in one area but not in another, you could set up monitoring plots in each of those areas. If you have woods of different ages or dominated by different tree species (oak trees versus sugar maple, etc.), you could establish a set of six plots in each stand.

For either of the two methods, it is necessary to have an adequate number of plants present to measure and monitor. Before choosing plot locations, spend 20 to 30 minutes walking the stand you plan to sample. Each plot is located subjectively to ensure there are adequate numbers of plants to measure. Because this type of sampling assesses deer impacts, the selection of plants does not need to be random. Rather, selection of plants needs to ensure that plants will reflect increasing or decreasing changes in deer browsing intensity. The goal is

to measure at least 25-30 plants total for each seedling or flower species you select. We recommend establishing six plots to disperse the measured seedlings and get a representative sample of deer impacts to seedlings in that stand. Each plot can have the same number of tagged seedlings or wildflowers (ex: 6 plots with 5 seedlings each = 30), or the plots can contain variable numbers of plants. A plot can contain multiple tagged species but plan for a dispersion of species to account for various patterns of deer movement within a stand. All plots should be located at least 50 feet from the forest edge where the trees meet an open field, shrubland, wetland, or other non-forest habitat type, and at least 25 feet from human disturbance (skid trail, old home site, hiking trail, road, etc.). If you are conducting the Spring Wildflower method, look for areas where the target species (Appendix A) are growing. Likewise, if you plan to implement the Woody Seedling method, look for areas with woody seedlings (trees or shrubs) between 6 inches and 3 feet tall.

Set Up Sampling Plots

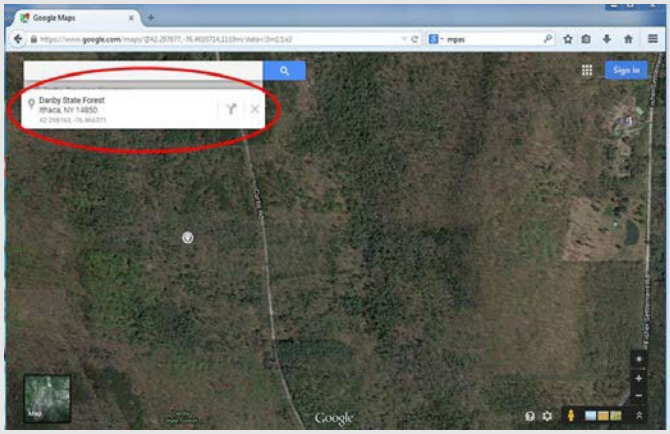
For either method, participants will establish plots with a six-foot radius. Working with a partner who can record data for you makes the sampling easier and faster. Establish as many plots as needed to include 25-30 or more plants of each species you select, but a minimum of 4 plots – ideally 6 plots for greater dispersion. Each plot center should be located at least 25 feet from the center of any another plot. Select a location and mark the plot center using a 2-foot long piece of pvc pipe that is 1 inch in diameter, or a short wooden stake, heavy duty plastic stake (www.forestry-suppliers.com or https://www.berntsen.com/Surveying/Survey-Stakes) or fiberglass rod (Figure 1). PVC is inexpensive and lightweight to carry. You can paint the top of the stake with tree-marking (or other) paint to make it more visible or wrap it in brightly colored duct tape. If possible, record the GPS location of each plot center in latitude and longitude (decimal degrees format) and write the plot numbers on your stakes using a metal tag, permanent marker or another long-lasting method.

Pacing to Measure Distance

Pacing is a reasonably easy and quick method of measuring distance in the field. One pace is defined as **two** footsteps walking at a natural pace. Twelve paces should cover 50 feet even for individuals with a very short stride. Therefore, if you don't have a long measuring tape or do not wish to carry one afield, you can walk 12 paces from any forest edge or disturbance. Six paces would represent an adequate distance between plot centers.

Using Google Maps to Find Latitude and Longitude – An Alternative to a GPS

If you do not own a GPS unit there is another easy way to find the coordinates for your site location. If you search the internet for Google Maps, you can zoom into the location where your site is located. Clicking the spot on the map will show the coordinates (latitude and longitude) in the box that appears underneath the search bar. You can then copy the latitude and longitude onto your data form. There are several ways to report latitude and longitude. Please record it as "decimal degrees". To set your Google Maps to decimal degrees go to Tools>Options>3D view and select "decimal degrees".



Permanent markers will fade and will need to be refreshed annually. It is also a good idea to draw a map of your plots on your data sheet and write the numbers on the map in case the numbering in the field fades or is lost. Marking an access trail with surveyors flagging or other material is helpful (and sometimes essential) for relocating plots.

Plots will have a 6-foot (2 yard) radius (Figure 2). You can use two yardsticks, or any stick cut to a 6-foot length. You can also use a 6-ft string tied to the center post or tied to a pill bottle that sits over the center post (Figure 3) and can rotate. The plot edge can be marked with small sticks or other objects around the edge to help you visualize the outer limits of the plot. **It is important to avoid trampling the vegetation within the plots you establish**. These plots will be resampled over time and plants can be damaged by trampling, affecting the validity of your results.

Figure 1. Mark your plot centers with pvc pipe, a wooden stake or rebar. Mark the stake using brightly colored paint, surveyors flagging or brightly colored duct tape to make it easy to relocate. Permanent markers can fade – refresh your plot numbers annually.

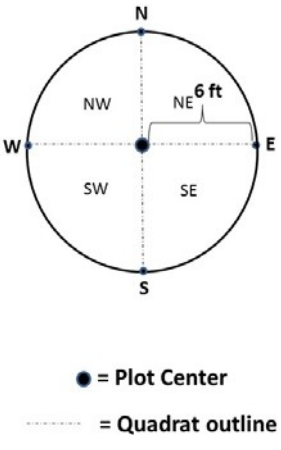


Figure 2. Schematic and picture of one plot showing 6-foot radius and four quadrants. Each quadrant is established by measuring six feet to the edge of the plot and marking the plot edge at each of the four cardinal directions.

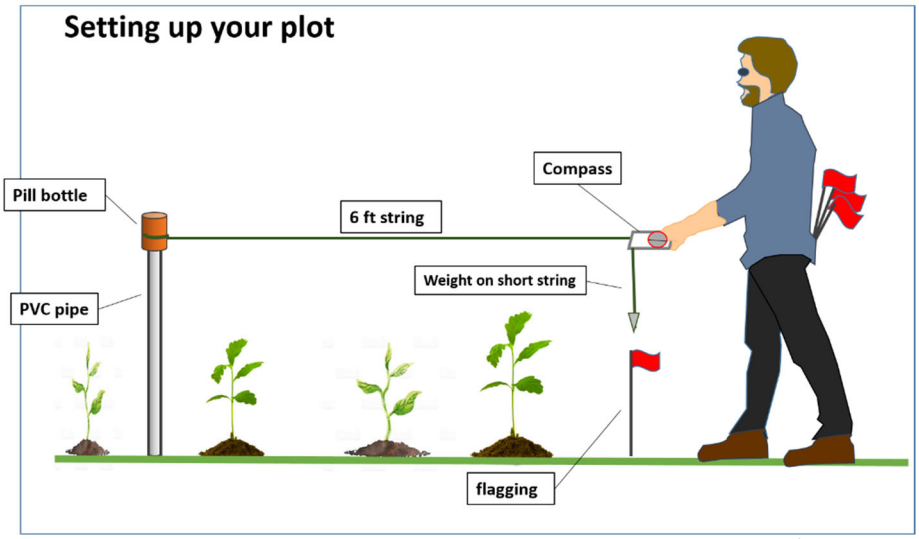


Figure 3. A pill bottle or something similar can be attached to a 6-foot string and slipped over a pvc plot stake. The bottle will turn as you walk around the circle, finding the cardinal directions and marking them with ease (graphic courtesy of Steve Kinne).

Set Up Sampling Quadrants

Dividing each plot into quarters, or quadrants, can be helpful for keeping track of, and relocating, individually marked flowers or seedlings. Four quadrants can be established by marking the plot edge at each of the four cardinal directions (north, south, east, and west) (Figures 3 and 4). A stake, brightly colored pin flag, PVC pipe, or painted and flagged kabob skewers, can be pressed into the ground to denote each of the cardinal directions. Use a ¾- or 1-inch PVC pipe cut to 24" lengths. Quadrant markers should be labelled N, S, E and W. This will create four quadrants for sampling – the northeast quadrant, northwest quadrant, southeast quadrant and southwest quadrant. Permanently marking the cardinal directions will make finding your plants and re-measuring easier in future visits. Two, 12-foot strings can (optional) be laid out from north to south and east to west to help you visualize the individual quadrants as you sample (Figure 4).

Figure 4. Schematic and picture of one plot showing 6-foot radius and four quadrants. Each quadrant is established by measuring two yards to the edge of the plot and marking the plot edge at each of the four cardinal directions.

Collecting Data

A smart phone application ("app") will be available through I-tunes or the Google Play Store to collect and submit your data. The app needs to be downloaded before going into the field and activated where a cell signal exists. The app will store the data and automatically upload the data to a central computer server when a signal is available. Real-time comparison to other data will be possible via the app. If you do not have a smart phone, or would prefer not to use the app, paper data sheets (Appendix A) are also available. If you use paper data sheets, please submit the data you collect to our online database at Aviddeer.com. The web site will also allow you to visualize your data and compare your results to others in your area.

Site Description

A site data sheet should be completed the first year you sample, and includes general information about site location, ownership, conditions, common species, and a basic map. Much of the information on the site data sheet is required to be able to enter your data into the web site. Unless conditions (ownership, most common species, average basal area, or average tree diameter) change, a new site data sheet does not need to be completed in future years of monitoring.

Plot Description

Use the data sheets (Appendix A), or phone app to collect information describing each plot. Each plot form can be used for four consecutive years unless the recorder(s), percent canopy/subcanopy/shrub cover, or exclusion from deer via fencing changes. In such cases, you should complete a new plot form to reflect these important differences or mark the changes on the original form with the appropriate date. The plot-specific information will allow for comparisons among plots and locations that vary in the growing conditions for plants. The plot description documents factors that influence the potential for plant growth. Because excessively rocky or wet soils are not sampled, only data on canopy cover, which impacts sunlight, needs to be recorded. The extent of cover is reported at each of three levels or layers, including:

- Canopy (the tallest layer, but usually $\geq$ 30 ft tall)
- Subcanopy (midstory) (the layer below the overstory, but usually 8 ft to 29 ft tall)
- Ground/shrub layer (the layer closest to the ground, but usually < 8 ft tall)

Details and pictures of canopy closure for each layer were provided previously. Some stands will have plants that occupy all three layers or levels, and in other cases one or more of the layers may be absent from the forest.

Some native and non-native species can be problematic. They may form subcanopy or ground layer cover that is inhospitable to wildflower and woody seedling establishment and growth. Some of these species establish dense monocultures, and in doing so, prevent light from reaching the forest floor. Other species form dense mats of roots that prevent plants from becoming established. These monocultures may persist indefinitely without action to remove them, and reduce the potential for other flowers, shrubs, and trees to grow. Examples include some native ferns, grasses and sedges, rhododendron (*Rhododendron spp*.), mountain laurel (*Kalmia latifolia*), blueberry (*Vaccinium spp*.), American beech, hop hornbeam, and others.

Many exotic invasive plants may also become established and persist in this way, including Japanese stiltgrass (*Microstegium vimineum*), barberry (*Berberis spp.*), honeysuckle (*Lonicera spp.*), mutiflora rose (*Rosa multiflora*), buckthorn (*Rhamnus cathartica*), tree-of-heaven (*Ailanthus altissima*), swallowwort (*Vincetoxicum spp.)*, oriental bittersweet *(Celastrus orbiculatus)* and others. To assess the degree to which interfering vegetation is preventing regeneration now and into the future, please complete the approximate percent cover provided on the datasheet (Appendix A) for each layer where competing vegetation exists. If you know the name(s) of the species present, please list them in the comments section. If you are uncertain of the species name, you can take a picture and upload it to our web site for identification.

Method 1. Woody Seedling Method

Spend 20 to 30 minutes walking the stand you plan to sample. This method focuses on identifying one to several common woody species in your stand and tracking seedling growth until seedlings grow beyond the reach of deer (5 feet tall). Look for areas with an abundance of woody seedlings, trees, or shrubs less than five feet tall, and ideally between 6 inches and 3 feet tall. In areas of very heavy deer impact there may not be seedlings 6 inches tall. In these heavily impacted areas, you can use shorter seedlings but plan to include some small exclosures (see next section) because annual re-measurement of unchanging stubby seedlings is useful but not as gratifying as documenting the effects of protection. Also, know that tags on short seedlings are easily buried by leaf litter and thus difficult to relocate.

When choosing the kind of tree or shrub to monitor, select species that allow you to measure at least 20 (but ideally 25-30) stems. If there are not enough seedlings in that height range, you may include individuals in the 3-4 foot height range as well. You should continue monitoring the individual seedlings you select until they reach 5 feet in height (the height at which deer will no longer affect their ability to grow into mature trees). If the number of seedlings of any one species drops below 20 before the 4-year monitoring period ends, you can add additional seedlings to tag and monitor. There are several reasons that seedlings may be added for sampling. For example, some may grow taller than the 5-foot limit, some may die, or tags may be lost.

Table 3. Some generally lower-preference and higher-preference tree and shrub species in New York State

High Preference Species	Low Preference Species
Red maple (*Acer rubrum*)	American beech (*Fagus grandifolia*)
Sugar maple (*Acer saccharum*)	Hop hornbeam (Ostraya virginiana)
White ash (*Fraxinus americana*)	Striped maple (*Acer pensylvanicum*)
Aspen (*Populus* spp.)	White pine (*Pinus strobus*)
Oak (*Quercus* spp.)	Red pine (*Pinus resinosa*)
Basswood (*Tilia americana*)	Spruce (*Picea* spp.)
Eastern hemlock (*Tsuga canadensis*)	American hornbeam (*Carpinus carolinensis*)
Birch (*Betula* spp.)	Black cherry (*Prunus serotina*)
Maple–leaf viburnum (Viburnum acerifolium)	
Witch-hobble (*Viburnum lantanoides*)	
Red elderberry (*Sambucus racemosa*)	

By tagging and monitoring one or more species with different browsing-preference levels (Table 3), you can learn a great deal about deer impacts in your woodland. If a variety of seedling species grow in your forest, and seedlings of species that deer prefer are able to grow past the reach of deer, then deer impacts are likely low. If only those species that deer do not prefer can grow, this may indicate that your forest is heavily affected by deer or has been historically heavily impacted. If you observe deer browsing on seedlings of preferred species, such as sugar maple, but not on American beech, which is less preferred, then deer impacts may be moderate. However, if deer are browsing on both preferred and non-preferred species (essentially any or all available woody seedlings), deer impacts likely are substantial.

Figure 5. Each seedling is identified with an individually numbered tag.

Select seedlings of your target species (i.e., the species you choose to monitor) that are as tall as or taller than the approximate average height of that species in the plot. Try to locate your six plots so that each includes five or more individuals of your target species. You may need to create more than six plots to include 25-30 tagged seedlings. If possible, select at least two species to monitor - one species that is highly preferred by deer and one species that is less preferred by deer (Table 3).

Seedlings need to be vigorous and healthy. Select five or more seedlings in the plot, attach an individually numbered tag to each (Figure 5), and record their heights. Record height as "natural height", **not extended height**. Measure straight up from the ground (at the base of the main stem) as if measured along a plumb-bob line from the ground to the highest point of woody growth and not the tip of the leaf. Seedlings should not be straightened for measurement. (Figure 6). For each tagged seedling, record the plot quadrant (ne, nw, se, sw), and the height to the nearest 0.5 inch.

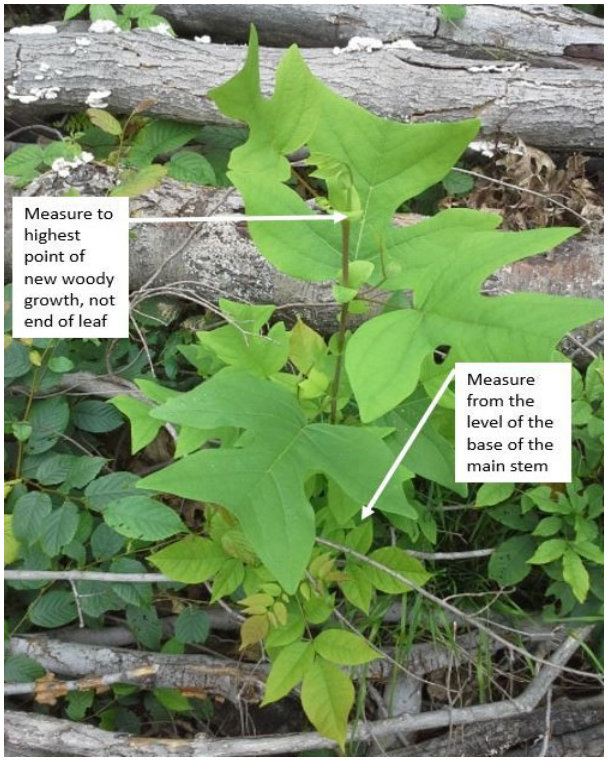


Figure 6. Proper measurement of a seedling.

If you choose to monitor more than one seedling species, you may use the same plots to capture seedlings of both when possible. Often that is challenging, though, and you will need to establish a few additional plots. Similarly, if you plan to implement both the Wildflower Method and the Woody Seedling Method, the same plots can be used for both of these if an adequate number of both seedlings and wildflowers are present. Otherwise, you will need to add additional plots as needed.

When re-measuring seedlings in subsequent years, you may occasionally be unable to locate a given tagged individual. If you cannot find the

tag, or you find the tag laying on the ground, record “NF” (not found) for that individual on the data sheet. Sometimes when you revisit in subsequent years you will be able to find the tag and record data for that seedling again. If the seedling is obviously dead, you may record it as “D”.

Method 2. Spring Wildflower Method

The spring wildflower protocol prioritizes measurements of Trillium, Indian cucumber (*Medeola virginiana*), or Jack in the pulpit (*Arisaema triphyllum*). These species are fairly common, and are useful because they decline in abundance, show reduced height, or show reduced flowering when browsed by deer. In the absence of these species, Solomon’s seal (*Polygonatum* spp.) and False Solomon’s seal (*Maianthemum racemosum*), as well as other indicator species may be monitored instead. The goal is to select areas that allow you to monitor at least 20 stems (ideally 25-30) of a species. Secondary species can be included if at least 20 stems are present.

Wildflowers exhibit patchy distribution in any forest and not all of these species will occur at every site. However, any or all of these species may be monitored when present. Picture guides to help you identify these flowers are provided (Appendix C). These guides are included in on the web site or can be printed and taken afield as references.

When selecting a wildflower species to monitor, search your stand for species with at least 20 (but ideally 30 or more) individual plants of that species that are four inches or taller. Place plots where the tallest plants of your chosen indicator species are growing. Deer tend to forage selectively on taller plants as they are more accessible. Therefore, the taller plants are more likely to be impacted by deer and will show the greatest response to changes in deer browsing intensity. Trillium and jack-in-the- pulpit begin as 1-leaved plants but do not flower until they have been a 3-leaved plant for several years. When monitoring these species, select 3-leaved individuals. Likewise, Indian cucumber does not flower until it has 2 whorls of leaves. When possible, select Indian cucumber plants with 2 whorls. However, if 2-whorled individuals are not present, 1-whorled plants can be selected.

Try to locate each plot to include from three to seven or more individual flowers of the species you plan to monitor (for a total of 25-30). If you wish to monitor more than one species it may be possible to capture enough individuals of more than one species within the same six plots, or you may need to establish additional plots.

Once you have chosen your target species and created your plots, mark each plant you will monitor using a sod stake and numbered tag. Place the stake next to the plant stem taking care not to disrupt the plant and its roots any more than necessary. Sod stakes (4 inches) can be purchased at stores carrying landscape supplies (e.g. Lowes, Home Depot) and can be used in combination with numbered plastic tags available from www.Forestry-Suppliers.com (“utility slip on tags” item # 79186) or other vendors, or through Cornell by emailing kls20@cornell.edu (Figure 7). Place the marker in the soil on the side of the plant opposite the center stake. Be careful not to insert the stake so close to the stem that the roots are severed. These markers will be helpful for relocating and tracking each plant.

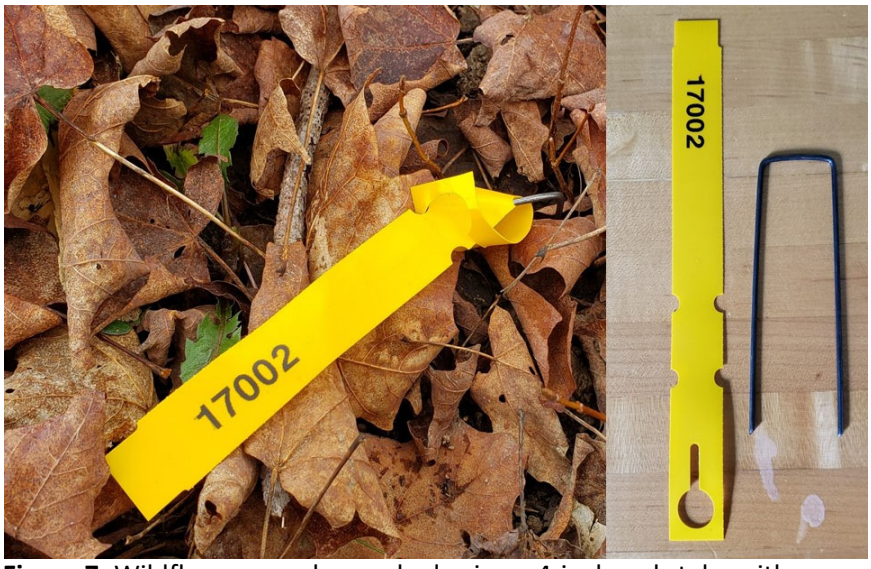


Figure 7. Wildflowers can be marked using a 4-inch sod stake with a numbered tag wrapped around it. The brightly colored tag will help you relocate the plant.

Measure and record the height of each plant from the litter surface to the base of the leaf whorl (Figure 8). Record the height as "natural height" (do not manually extend the plant to make it more upright), measuring straight up from the ground as if measured along a plumb-bob line from the ground to the point where the stem intersects the leaf whorl. For plants with multiple stems, choose the tallest stem to measure. Indian cucumber will often grow two sets of leaf whorls (Figure 8). If two sets of leaf whorls are present, measure to the base of the highest whorl. For each plant you are monitoring, record whether it is flowering or shows evidence that it has flowered or will flower this season (bud, flower stems still attached, opened seed pod, etc.).

Figure 8. Indian cucumber (pictured left) should be measured from the ground to the base of the second leaf whorl, if available, or the first whorl if only one is present. Trillium (pictured right) and jack-in-the-pulpit will only have one leaf whorl and should be measured from the ground to the base of the whorl.

When re-measuring wildflowers in subsequent years, you may occasionally be unable to locate a given tagged individual. If you cannot find the tag, record “NF” for that individual on the data sheet. Because these wildflowers are perennial, finding the tag but not the flower also should be recorded as a “NF” for height. Most of the time it will be difficult to determine if the plant has died or if the plant has not come up that year for other reasons. If, however, after several years of monitoring the plant has not reappeared then you may record it as “D”, indicating the plant is thought to be dead.

Mini Deer Exclosures – Establishing a Baseline for Your Woodland

Creating small deer exclosures in your woods can give an indication of what could possibly grow in your forest in the absence of deer browsing. By fencing a couple additional plots per stand, you will be able to see the potential wildflower, tree, and shrub species that could be present. You can also observe the height of the seedlings and flowers inside versus outside the exclosures, as well as the wildflower flowering rates.

Ideally, you should establish deer exclosures to complement measurements of species performance outside the exclosures, and to assess how a particular species will perform in the absence of deer browsing. By excluding deer from some areas in the same stand, you can make a direct comparison between what you might expect to see versus what you are seeing.

Small exclosures can be constructed from various fencing and pole materials and are easy to erect (Figure 9). Garden posts and welded-wire fencing, or even deer netting and bamboo poles with the wire affixed by zip ties, can provide protection. Small fenced areas should be 4 to 5 feet high.

A.  B. 

Figure 9. Deer exclosures can help establish a baseline for what vegetation you might expect to grow in your woodland if deer browsing was not a factor. Picture A shows a simple exclosure in a clover field. Picture B illustrates another simple design around a single AVID plot within the forest.

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Appendix A. Data Sheets

Data Sheet Instructions

Three separate data sheets are provided in this Appendix for participants who will not be using the phone app, or those wanting to see the structure of the data. We refer to these data sheets as “Site”, “Seedling” and “Wildflower.” The phone app includes all the information of these data sheets, but in a different format.

1. The “Site” data sheet should be completed once for each overall site or stand. After the initial sampling, you need only complete the site form again if the property owner, basal area, average tree diameter, or common tree or seedling species change.
2. A “Seedling” data sheet is provided for conducting the Woody Seedling method (Method #1).
3. The “Wildflower” data sheet is for conducting the Spring Wildflower method (Method #2).

The “Seeding” and “Wildflower” data sheets includes descriptive information for each plot. The plot data sheet also includes descriptive information for each plot which is completed during the first year. Following the first year, the same sheet or the version without plot information, can be used for re-measurement in future years. However, if the names of the recorders or percent canopy/subcanopy/shrub cover should change, or if measurements are to be replicated inside a deer exclosure, then a new data sheet with plot information form should be completed to document those changes.

Site Data Sheet
AVID: Assessing Vegetation Impacts from Deer

County (required)	Town (required)
Owner Name and Contact Information (required)	
Approximate basal area, sq. ft./acre (if known)	
Average overstory tree diameter (if known)	
Plant Community Description (required) List at least 1, and up to 4 most common overstory tree species in the stand: List at least 1, and up to 4 most common seedling or shrub species in the stand:	
Map of stand features, plot locations, etc. (optional)	

Woody Seedling Data Sheet (Method #1)

AVID: Assessing Vegetation Impacts from Deer

*All data fields are required except basal area

Plot #	Date	Recorder Names	
GPS at Plot (latitude/longitude recorded as "decimal degrees", datum WGS 84)		Vegetation Description	Use picture guides to estimate percent cover
		Ground and shrub cover (0-8 ft)	_____ %
Basal area (optional)		Subcanopy (8-29 ft)	_____ %
Is plot enclosed or protected from deer: Yes No If yes, for how many growing seasons? 0 1-2 ≥ 3		Canopy (≥ 30 ft)	_____ %
Comments:			

Seedling Height Data (If the plant is no longer alive and available to measure, enter "D" under height; If you were unable to relocate the tag, or found the tag on the ground, enter "NR" (not relocated) under height).

			Initial Measurement	Re-measurement date:	Re-measurement date:	Re-measurement date:
Species	Tag#	Quadrant	Height (inches)	Height (inches)	Height (inches)	Height (inches)

Seedling Height Data (If the plant is no longer alive and available to measure, enter "D" under height; If you were unable to relocate the tag, or found the tag on the ground, enter "NR" (not relocated) under height).

			Initial Measurement	Re-measurement date:	Re-measurement date:	Re-measurement date:
Species	Tag#	Quadrant	Height (inches)	Height (inches)	Height (inches)	Height (inches)

Spring Wildflower Data Sheet (Method #2)
AVID: Assessing Vegetation Impacts from Deer
*All data fields are required except basal area

Date	Recorder Names	
GPS at Plot (latitude/longitude recorded as "decimal degrees", datum WGS 84) Basal area (optional)	Vegetation Description	Use picture guides to estimate percent
	Ground and shrub cover (0-8 ft)	_____ %
	Subcanopy (8-29 ft)	_____ %
Is plot enclosed or protected from deer: Yes No If yes, for how many growing seasons? 0 1-2 ≥3	Canopy (≥ 30 ft)	_____ %
Comments:		

Wildflower data

If the plant is no longer alive and available to measure, enter "D" under height; If you were unable to relocate the tag, or found the tag on the ground, enter "NR" (not relocated) under height).

			Initial Measurement		Re-measurement date:		Re-measurement date:		Re-measurement date:	
Species	Tag #	Quadrant	Height (inches)	Flower Evidence (Y/N)	Height (inch)	Flower Evidence (Y/N)	Height (inch)	Flower Evidence (Y/N)	Height (inch)	Flower Evidence (Y/N)

Wildflower data If the plant is no longer alive and available to measure, enter "D" under height; If you were unable to relocate the tag, or found the tag on the ground, enter "NR" (not relocated) under height).

			Initial Measurement		Re-measurement date:		Re-measurement date:		Re-measurement date:	
Species	Tag #	Quadrant	Height (inches)	Flower Evidence (Y/N)	Height (inch)	Flower Evidence (Y/N)	Height (inch)	Flower Evidence (Y/N)	Height (inch)	Flower Evidence (Y/N)

Appendix B. Field Guide Summary Sheet for Volunteers

Field Guide Summary Sheet for Volunteers

16-inch plastic survey stake

Equipment needed:

- Compass
- 2 yardsticks, or a stick or string cut to 6 feet in length
- Permanent marker – permanent markings can fade so plot and quadrant markings should be refreshed annually. Alternatively use a pre-numbered metal or plastic tag to identify the plot center stake.
- Smart phone with app, or data sheets with pen or pencil
- PVC (2-ft x 1-inch), wood, fiberglass, or heavy-duty plastic survey stakes for marking plot center
- Hammer or mallet for pounding stakes into ground
- Brightly colored paint, brightly colored duct tape, or surveyors flagging for marking stakes
- Colored pin flags (available, in home improvement stores or from Forestry Suppliers) or additional stakes for marking the 4 cardinal directions along the edge of your plots
- GPS unit or phone with GPS capability
- Numbered seedling tags (can be provided by Cornell University Department of Natural Resources, email KLS20@cornell.edu)
- A partner! Working with a partner is not necessary but can speed up the process and add to the enjoyment

Steps to setting up plots:

Step 1: Select a forest stand

- You may have several different "stands" on the property you plan to monitor
- A stand is an area with distinctly different conditions – ex: hemlock stand; oak-pine forest; northern hardwood. Similar to a farmer's field.
- Select a stand where you will establish plots. Replicate these methods if you work in additional stands or with fenced exclosures.
- Complete site data forms

Step 2: Reconnaissance

- Take a look at seedlings growing in your selected stand(s). Are there seedlings present? What species are most abundant?
- Look at wildflowers. Are the target species present? If so, where?

Step 3: Decide whether to implement seedling or wildflower method

Step 4: Set up your monitoring plots

Within each stand you……

- Select the species you will monitor based on availability and deer preference for browsing
- Ideally establish 6 plots; for efficiency try to include at least 5 tagged seedlings of the same species within each plot. Establish additional plots if needed.
- Complete plot data sheets
- Mark and measure 25-30 seedlings or 25-30 total wildflowers of the same species (6 plots x 5 seedlings in each = 30)

Appendix C. Wildflower and Seedling Identification Guides

Seedling Identification Resources

Cope, J.A., & Winch, F.E. (1948) Know Your Trees. (latest revision 2014) Cornell University Cooperative Extension Department of Natural Resources. 80 p. ISBN: 1-57753-301-1 (download PDF at https://cpb-us-e1.wpmucdn.com/blogs.cornell.edu/dist/d/5957/files/2020/03/Know-Your-Trees-2014.pdf)

Kershner, B. (2008) National Wildlife Federation Field Guide to Trees of North America. *National Wildlife Federation Field Guide Series.* 528 p. New York: Sterling Pub. Co. ISBN: 978-1402738753

Ueda, K. & Loarie, S. (2011) iNaturalist. Website and App is a joint initiative of the California Academy of Sciences and the National Geographic Society. iNaturalist.org

Wildflower Identifications Resources

Newcomb, L. (2011) Newcomb's Wildflower Guide. 490 p. Boston: Little, Brown & Co. ISBN: 978-0316604420

Peterson, R.T. (1986) Peterson First guide to Wildflowers of Northeastern and North Central North America. Boston: Houghton Mifflin. 126 p. ISBN 0-395-40777-X.

Ueda, K. & Loarie, S. (2011) iNaturalist. Website and App is a joint initiative of the California Academy of Sciences and the National Geographic Society. iNaturalist.org

Indian cucumber-root
(Medea/a virginiana)

Habitat: moist woods

Height: approximately 3' tall

Leaves: 1 or 2 whorls of 5-8 leaves

Flower: small, appears above top whorl, may be 2-3 flowers per plant

Flower color: yellowish

Flower time: late May – early June

Fruit: a dark purpose or black berry

Distinguishing characteristics: whorls of usually 5-8 leaves, stem usually fuzzy and wiry close to ground

Flowers hang atop whorl

Whorl may have 5-8 leaves

Berries atop whorl

Flower arises from top whorl

Potential Look-alike

Star Flower *(Trientalis borealis)*

Similar whorl of leaves but no top whorl present.

Habitat: frequent in moist woods

Height: approximately 4-8 inches

Leaves: whorls of 5-10 leaves, leaves are narrow, unequal sized

Flower: 1-4 per plant, petals ½" across

Flower color: white

Flower time: May – June

Fruit: small, dry brown globular capsule

Distinguishing characteristics: distinctive flowers, features based on sevens: 7 leaves, 7 petals, and 7 sepals

Flowering plant

Flower close-up

Trillium *(Trillium spp.)*

Habitat: moist woods

Height: 1 - 1.5 ft, except for Snow Trillium (6 in.)

Leaves: 3 in a whorl

Flower: found at the center of the whorl of leaves

Flower color: white, maroon, pink, yellow, or green

Flower time: April - May

Fruit: a berry

Distinguishing characteristics: whorl of 3 leaves, flower is made of 3 petals

Large-flowered trillium *(Trillium grandiflorum)* white or maroon

Leaves form an equilateral triangle shape

1, 2, and 3 leaved white trillium

Fruit

Purple trillium *(Trillium erectum)* – maroon flower, leaves are stalk-less

* Note flowers/fruit at top of plant, whorl of 3 leaves

Painted trillium *(Trillium undulatum)* – white with pink center, leaves are on petioles that come out of the center

Jack-in-the-Pulpit *(Arisaema triphyllum)*

Habitat: common in moist woods, swamps, bogs

Height: approximately 3 feet

Leaves: 3 leaflets

Flower color: white, green, or maroon, streaked

Flower time: late April - June

Fruit: a cluster of red berries

Distinguishing characteristics: distinct flower shape

Entire plant showing leaves

Flower

Fruit

More prominent mid-vein

*Note leaves in 3 may resemble trillium, especially if no flowers are obvious. Jack-in-the-pulpit will have one prominent mid-vein. Trillium has less obvious mid-vein and rounder leaves.

Potential look-alike Trillium and Jack-in-the-Pulpit:

Mayapple *(Podophyllum peltatum)*

Also has whorled leaves, but has more leaflets. Usually branched into 2 leaves. Distinct flower.