Michigan Technical Note
USDA-Natural Resources Conservation Service

FORESTRY #29

Subject: CONDUCTING A FOREST INVENTORY

Date: September, 2011

BACKGROUND AND PURPOSE

Michigan has 19.3 million acres of forest land, approximately half of which is in private ownership. Management of this forest resource for timber, wildlife habitat, water and air quality, carbon sequestration, and other ecological services begins with a thorough and accurate understanding of the forests' and woodlots existing condition.

A timber inventory is a process to determine the stocking level, species composition, and other characteristics of a particular forested management unit, or stand. The inventory establishes a baseline necessary to assure that recommended management activities will provide their intended results.

Note that there is a glossary in Appendix A that covers some potentially unfamiliar terms.

CONDUCTING THE FOREST INVENTORY

A forest inventory can be conducted in a few different ways, which are selected based on the type of stand and the preference of the forester or person conducting the inventory. A stand can be inventoried using point sampling, plot sampling, or zig-zag transects. This document will focus on the point sampling technique, which can be used in virtually all stands.

In plantation-grown stands, where trees were planted with regular, even spacing, an optical assessment of the spacing or knowledge of the planting spacing in addition to a measure of average tree diameter can be used in lieu of point sampling. See the section on assessing plantations below for more information on this method.

Point Sampling

Point sampling is a technique to quickly determine basal area using an angle gauge or basal area prism. It calculates basal area by identifying trees to include in a tree count or tally, based on their apparent size relative to a fixed reference, the angle gauge. This technique can be used in virtually all types of forest stands.

Step 1. Preparing for the field inventory. Learn as much as possible about the forest in advance of the field inventory. It is strongly recommended to review the soils information at http://websoilsurvey.nrcs.usda.gov. Of particular interest there are the Forestland Productivity tables, which provide information about site productivity and common trees.

Additionally, presettlement vegetation maps and natural community abstracts from the Michigan Natural Features Inventory (MNFI) at http://web4.msue.msu.edu/mnfi/ can be very useful for interpreting a site.

Step 2. Determine the number of points needed. The acreage of the stand being inventoried will dictate the number of points needed to provide a useful sample size. For each stand, use the following number of plots:

Table 1: Number of Points required for Point Sampling

Area in acres:	Min. Number of points:
≤ 11	10
11 – 40	1 per acre
41 – 80	20 + .5(area)
81 – 200	40 + .25(area)
≥ 201	Refer to Table 1, Section 7 of Forestry Handbook (Wenger, ed., 1984)

Step 3. Determine location of inventory points. It is important that the points are randomly selected. The easiest way to do this is to determine a set distance to pace between points, stopping exactly at the end of that distance. This will help avoid the tendency to avoid areas that are too brushy, steep, wet, etc. to stand comfortably. Generally, if you plan on between 100 and 200 feet between points, you will be able to fit the necessary number of points in the stand. If you get through the stand and still need more points, though, it's ok to head back into the stand to get a few more. Again, just be sure that they are randomly selected locations.

Important! Place your points at least 100 feet from the edge of the stand to avoid skewing the data with open areas or trees from a neighboring stand.

If your inventorying a small stand (less than 10 acres), you may need to place your inventory points closer together to get 10 of them. When that happens, it is common that a tree may be included in more than one point. That is ok, since the data from all the points will be averaged for the stand.

Step 4. Collecting basal area data. At each point, you will need to, at a minimum, count trees that are "in" as determined by the angle gauge or prism. These are the trees that will be the basis of your inventory. All other trees may be ignored. These trees can be identified with a wedge prism or angle gauge.

Using a wedge prism: A wedge prism is a tool that 1. determines basal area and 2. identifies trees for further data collection. All trees surrounding the inventory point must be sighted through the prism, assessing them at breast height (4.5' from the ground). If the offset section of the tree (as viewed through the prism) overlaps the bole, it is an "IN" tree (Figure 1). If the tree does not overlap the original bole it is an "OUT" tree (Figure 2), and will not be included in the inventory. If the tree is offset exactly the width of the trunk, it is referred to as a borderline tree (Figure 3). Include every other borderline tree in the inventory.

Flexibility: Adjusting for stand differences

Often, as you are conducting your inventory, you will encounter a transition into distinctly different cover type or stand. It is best to inventory each stand separately, as they will likely have different characteristics, and may ultimately be managed differently. As such you should note on a map or aerial photograph where the transition occurs.

You may need to then adjust the number of points inventoried so that each stand meets the required number in table X above.

Alternatively, some people will record a GPS waypoint that corresponds with each inventory point. Then, if there are some trends that develop but aren't immediately apparent, e.g., the west end of a woodlot has significantly more of a particular species, you can extract those points in that area out and summarize them separately, delineating that area a separate stand.

Generally, very small areas within an existing stand that are too small to manage independently aren't considered separate stands. While it's ultimately up to the planner when to delineate a stand separately, typically one wouldn't do so for any inclusion smaller than 2 to 5 acres.

Important! Only include live trees in your inventory. If you were to include snags – standing dead trees – it would falsely inflate your total basal area. However, you likely will want to still make a note about their abundance, etc. See Step 6 below.

At each point, when viewing trees through a prism, keep the prism (not your eyes) directly centered over the point center. It is strongly advised to "sweep" around the point in one rotational direction only, counting each tree as it is encountered, regardless of how close or far it is. While this may result in more legwork for the person collecting tree data (see below), it will minimize the risk of skipping or double counting trees.

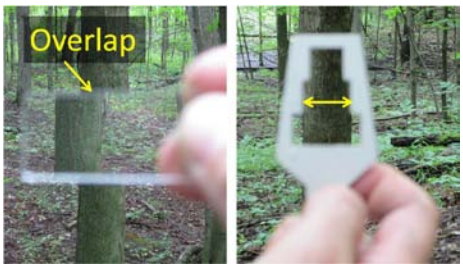

Figure 1. These trees are "IN" and would be included in the inventory. The tree on the left has overlap between the image through and outside the prism. The Tree on the right appears wider than the middle (10 BAF) portion of the angle gauge.

You will quickly notice that for a small tree to be "IN," it must be relatively close to the inventory point. Likewise, a very large tree can be quite far away and still be "IN."

Wedge prisms come in different basal are factors (BAF), commonly 5, 10, 20 and 40; the BAF of the prism is multiplied by the number of trees tallied in each plot to yield the basal area in the stand on a per acre basis. In most forests in Michigan, a 10-factor prism is used. As such, if there is an average of 13 "IN" trees per inventory point, there is an average basal area of 130 square feet per acre.

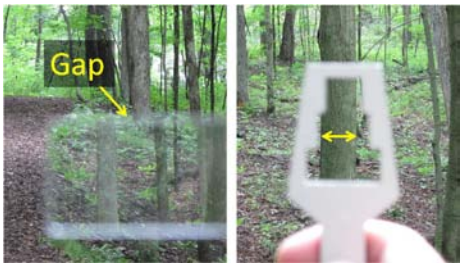

Figure 2. These trees are "OUT" and would NOT be included in the inventory. The tree on the left has gap between the image through and outside the prism. The Tree on the right appears narrower than the middle (10 BAF) portion of the angle gauge.

Using an angle gauge: An angle gauge works on the same principal as a wedge prism: it compares a tree with a fixed-width item that is used at a fixed distance from the user's eye. If a tree appears wider (at breast height) than the angle gauge, it is "IN." If it appears narrower, i.e., you can see beyond the trunk completely on both sides, it is "OUT." Trees that appear exactly the same width as the angle gauge are borderline trees. Consider every other borderline tree "IN."

Unlike the prism, with an angle gauge, your eye, not the tool, should remain fixed over the center of the plot.

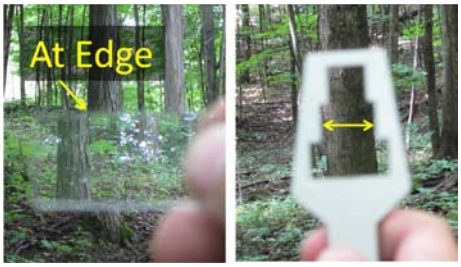

Figure 3. These trees are "Borderline" and every 2nd tree would be included in the inventory. With the tree on the left, the image through the prism just "touches" the image outside the prism. The Tree on the right appears as the same width as the middle (10 BAF) portion of the angle gauge.

Step 5. Collect other tree data. By simply counting "IN" trees and multiplying by the Basal Area Factor as detailed in the previous step, you can determine the stand's basal area. While this is a critical piece of information, it is only part of the complete picture of the stand's condition. At a minimum, some general observations about the species (trees, shrubs, and understory vegetation) and diameter distribution should be recorded with each point. Following a brief ocular estimate of the vegetation in the general vicinity of your point, you may record a statement such as "Sugar maples 14-22" DBH dominate the site, with a few scattered 8 – 12" black cherry and shagbark hickories. There are very few smaller trees. The understory is sparse, with little tree regeneration. A few ash seedlings were noted, along with a variety of native herbaceous plants."

By doing this at each point, you will be able to capture the overall character of both the diameter distribution, i.e., how many trees of various sizes are present, as well as the species composition.

If more detail is required, however, it is advised to collect that same information (species and DBH) for each of your "IN" trees. By doing this, you can generate very specific diameter and species distribution information. If two people are available to do the inventory, this can be very quick work – one person can operate the prism or angle gauge and record the data, while the other walks up to the "IN" trees and determines species and DBH. DBH can be determined with a Diameter tape, Biltmore stick or standard tape measure. A standard tape measure will yield stem circumference. Divide that value by pi (3.14) to determine DBH.

With this information, you can use the Forest Inventory Tool on eFOTG, Section II to generate specific tables and charts to display the stand-level information (see Figure 5 for an example).

For most conservation planning purposes, no other tree data (height, volume, timber grade, etc.) will need to be collected.

Figure 4. Using a Biltmore stick and Diameter Tape to determine DBH. This tree is approx. 17.4" DBH.

Step 6. Collect other stand data. Of course, a forest stand is composed of more than just trees. Ocular estimates of other vegetation, especially invasive species populations and rare plants, should be recorded. Also, details about downed and standing woody debris, topography, pest concerns, soil conditions, such as areas of erosion, water quality, wildlife habitat features (den trees, etc.), and cultural, historic or other special sites should be noted.

Step 7. Summarize the information. Once the field data has been collected, review the field notes to summarize the condition of the stand as a whole. If only basal area data and ocular estimates of other information was collected, you can simply average the number of "IN" trees at each point, and multiply by the basal area factor (usually 10) to get basal area.

If specific tree-level data (species and diameter) was collected, you can use the MI-NRCS Forest Inventory Tool to summarize the data. This tool will generate tables and charts like the one below.

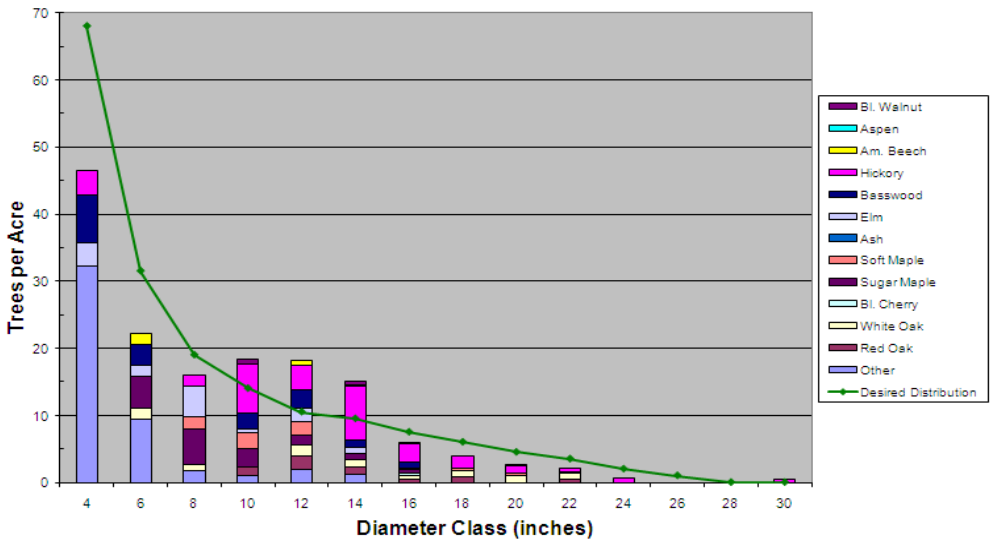

Figure 5. Example diameter distribution chart. By comparing the stand to the green line, one can see that this stand is overstocked with 10-14" DBH trees and understocked with smaller and larger trees.

Other information collected, e.g., invasive species, soil and water condition, etc., can be summarized in the conservation plan narrative, conservation notes, etc.

Most forest types in Michigan will have the best growth rates and site utilization between 60 and 90 sq. ft. per acre of basal area. [The exception is for conifer plantations; their ideal basal area that increases with tree size.] If the inventoried stand is more than 20% higher than the ideal basal area, it is a good candidate for Forest Stand Improvement. See the MI-NRCS Forest Stand Improvement (666) Conservation Practice Standard and Job Sheet for more information.

Inventorying Plantation-Grown Trees

If the stand to be inventoried is even-aged and planted in uniform rows, you may wish to forego the point sampling method above, and instead simply determine average tree diameter and average tree spacing. With this information, you can reference stocking guides, like those in the MI-NRCS Forest Stand Improvement (666) Job Sheet.

There isn't an exact standardized process for assessing these types of stands, but it is recommended to start with a row of trees and measure and record the DBH of 5 to 10 trees in a row. Then, move one or two rows over, and continue in the same direction for another 5 to 10 more trees. Do this several times throughout the stand, and in all areas, to account for differences in tree growth patterns. Note the number of tree gaps as well, since they will reduce your overall stocking. Simply average the DBH of all measured trees to determine a stand-wide average DBH. Likewise, measure the spacing between several adjacent trees, in both directions, and make a note of the average spacing between trees, e.g., 8' x 6', 10' x 10', etc.

By comparing the inventoried stand, with tables of ideal stocking levels, you can determine whether the stand is overstocked, understocked, or adequately stocked. If you are more than 20% over the ideal stocking, the stand is a good candidate for Forest Stand Improvement. See the MI-NRCS Forest Stand Improvement (666) Conservation Practice Standard and Job Sheet for more information, including tables of recommended stocking levels.

Making Management Recommendations

Once the inventory is complete, you will have adequate data to make management recommendations. If Forest Stand Improvement is appropriate*, refer to the MI-NRCS Forest Stand Improvement (666) Job Sheet. The "Specification" section of that document may be completed to provide the necessary implementation details to the landowner or their contractor.

*refer to the "Quality Criteria for SWAPA" document in eFOTG, Section III for a list of resource concerns, quality criteria and assessment tools.

REFERENCES

Wenger, Karl F., ed. 1984. Forestry Handbook. 2nd ed. Pub. No. SAF 84-01. John Wiley & Sons, New York, NY.

Kidd, R.P. and M.R. Koelling. 1991. Improving Hardwood Timber Stands. Michigan State University Extension Bulletin E-1578. East Lansing, MI.
http://forestry.msu.edu/msaf/ForestInfo/MSUElibrary/E1578_ImprHdwd.PDF

NRCS Field Office Technical Guide (eFOTG), http://www.nrcs.usda.gov/technical/efotg/

APPENDIX A. GLOSSARY

Basal Area (BA) of a tree – the cross sectional area of the stem of the tree at 4.5' from the ground. For example, a 12" diameter tree contains 113 square inches of basal area or 0.78 sq. ft. A 24" diameter tree contains 452 sq. inches, or 3.14 sq. ft.

Basal Area (BA) of a stand – arguably the most important stand-level measure, this is the sum of the individual basal area of all tree stems in a stand, usually expressed as a "per acre" value. It is a measure of stand density, or how "crowded" the trees are. Ideal BA typically ranges from 60 to 120 sq. ft. per acre, but varies by timber or cover type. Unlike other measures of stand density, e.g., trees per acre, BA information largely transcends trees size and age. For example, a young pole-sized stand at 160 sq. ft. per acre and a mature sawtimber stand at 160 sq. ft. per acre are essentially equally over-stocked.

Diameter at Breast Height (DBH) – By convention, foresters measure tree diameter at 4.5' from the ground, or "breast height." This can be done using a diameter tape that reads diameter directly, with a biltmore or woodland information stick, or with a standard tape measure. In the case of the latter, the circumference is measured, and needs to be divided by pi (3.14) to obtain diameter.

Even-aged Stand – a stand having no, or a relatively small, difference in age among trees. To perpetuate these stands, an even-aged management system is used, e.g., clearcut or shelterwood. Often, even-aged stands are those that contain light-demanding, or shade-intolerant species, e.g., aspen and jack pine, and require the complete removal of mature trees to allow adequate sunlight to reach the forest floor for regeneration.

Stand – a contiguous forest community with sufficient uniformity of species composition, age, spatial arrangement and condition to be distinguishable from adjacent communities. Typically, management will be applied consistently to a stand.

Uneven-aged Stand – a stand containing trees of multiple ages and sizes. Management of uneven-ages stands relies on uneven-aged management techniques such as single tree selection or group selection. Shade tolerant species or communities are commonly managed as uneven-aged stands because seedlings are able to regenerate and grow under a canopy of existing trees.

APPENDIX B. FOREST TYPES IN MICHIGAN

There are several different ways to classify forest types. Following are two commonly used in Michigan.

Michigan Natural Features Inventory Classification System

The Michigan Natural Features Inventory (MNFI) has developed "Natural Communities of Michigan: Classification and Description" which is an excellent reference covering all of the naturally occurring assemblages of plants, animals, and other organisms that repeatedly occur under similar environmental conditions across the landscape. The following are the forest communities listed and described in that guide:

Palustrine (wetland) Forests	Terrestrial Forests
Poor Conifer Swamp	Dry Northern Forest
Rich Conifer Swamp	Dry-mesic Northern Forest
Rich Tamarack Swamp	Mesic Northern Forest
Hardwood-Conifer Swamp	Dry Southern Forest
Northern Hardwood Swamp	Dry-mesic Southern Forest
Southern Hardwood Swamp	Mesic Southern Forest
Floodplain Forest	Boreal Forest
Wet-mesic Flatwoods	Wooded Dune and Swale Complex

Some other community types also contain trees in varying amounts, primarily those in the savanna group.

For a complete description of these types, visit the MNFI website at: http://web4.msue.msu.edu/mnfi/pub/index.cfm. Individual community abstracts can be obtained from the "Abstracts" link and the entire guide can be downloaded from the "Publications" link.

Michigan Department of Natural Resources Classification System

Many foresters in the Michigan Department of Natural Resources (MDNR) as well as those in the private sector use a classification system that is based primarily on the dominant timber species present, and an approximation of stocking level, and tree size. These stand characteristics are summarized with an alphanumeric code, which are often used on maps, in management plans, etc.

See the following page for a complete list of cover types. Note that some local variations of this system may be employed in some areas.

Figure 6. Using the MDNR classification system, this red pine stand, with a BA of 120 sq. ft., dominated by 9" DBH stems would be notated as "P6" or "Pr6."

Michigan Department of Natural Resources
Cover Type Classification System

A	Aspen, white birch, and balsam poplar
Ab	Balsam poplar predominates
Ag	Big tooth aspen predominates
At	Trembling aspen predominates
Aw	White birch predominates
C	White cedar
E	Lowland hardwoods: ash, elm and red maple
Ea	Ash predominates
Ee	Elm predominates
Er	Red maple predominates
F	Balsam fir, white spruce
Fb	Balsam fir predominates
Fs	White spruce predominates
G	Upland grass: grasses, blueberry, bracken fern & sweet fern
Gb	blueberry predominates
Gbr	Bracken fern predominates
Gs	Sweetfern predominates
H	Hemlock
Jw	Black walnut
L	Lowland brush: alder, dogwood, viburnum and willow
La	Alder predominates
Ld	Dogwood predominates
Lg	Lowland grasses, reeds, sedges and cattail
Lv	Viburnum predominates
Lw	Willow predominates
M	Northern hardwoods: sugar & red maple, elm, beech, yellow birch, basswood and cherry
Mb	Beech predominates
Mc	Cherry predominates
Me	Elm predominates
Mr	Red maple predominates
Ms	Sugar maple predominates
My	Yellow birch predominates
O	Mixed oak
Ob	Black oak predominates
Or	Red oak predominates
Ow	White oak predominates
P	Mixed pine
Pa	Austrian pine
Pj or **J**	Jack pine
Pr or **R**	Red pine
Ps	Scotch pine
Pw or **W**	White pine
Q	Swamp conifers: white cedar, hemlock, spruce, fir and tamarack (larch)
S	Spruce
Sb	Black spruce
Sn	Norway spruce
T	Tamarack
U	Upland brush: briar, dogwood, hazel, Juneberry, sumac, thornapple and viburnum
Ub	Briar predominates
Ud	Dogwood predominates
Uh	Hazel predominates
Uj	Juneberry predominates
Ul	Black locust predominates
Us	Sumac predominates
Ut	Thornapple predominates
Uv	Viburnum predominates
X	Christmas trees: Scotch pine, blue spruce, white spruce, Douglas fir, Fraser fir, etc.

Size & Stocking Levels

0	Nonstocked (less than 17%)
1	Seedling-sapling, lightly stocked (100-399 trees/ac.)
2	Seedling-sapling, moderately stocked (400-699 tree/ac. or a minimum of 40% stocking)
3	Seedling-sapling, well stocked (700+ trees/ac. or a minimum of 70% stocking)
4	Poletimber, lightly stocked (10-39 sq. ft./ac. BA of trees ≥ 5" DBH)
5	Poletimber, moderately stocked (40-69 sq. ft./ac. BA of trees ≥ 5" DBH)
6	Poletimber, well stocked (70+ sq. ft./ac. BA of trees ≥ 5" DBH)
7	Sawtimber, lightly stocked (10-39 sq. ft./ac. BA of trees ≥ 5" DBH)
8	Sawtimber, moderately stocked (40-69 sq. ft./ac. BA of trees ≥ 5" DBH)
9	Sawtimber, well stocked (70+ sq. ft./ac. BA of trees ≥ 5" DBH)

Diameter Ranges

Seedling-saplings	0 - 4.9 inches
Poletimber	5.0 - 10.9 inches
Sawtimber	11+ inches

APPENDIX C. POINT SAMPLE DATA COLLECTION SHEET

This sheet is for use in the field to collect stand data from a point sampling inventory.

Client Name:		Tract #:	
Inventory Date:		Stand/Mgmt. Unit #:	
Inventory by:		Acres in Unit:	

Summary of data below:

	÷		=		×		=	Sq. ft./ac.
Total number of trees (all plots)		Number of plots		Avg. # of trees/plot		Basal Area factor		Stand Basal Area

For additional analysis of data, use the Forest Inventory Tool in the "Forestry Information" folder, in Sec. II of eFOTG.

Plot #	Tree #	Species*	DBH (in.)	# of 16' logs or log length (optional)	Notes on understory vegetation, other site characteristics, natural resource concerns, etc. Makes notes for each plot.

*if abbreviations are used for species, make sure you note what they are, e.g., does "BW" stand for "black walnut" or "basswood?"

Use the correct number of plots to ensure accuracy:

Area in acres:	Minimum Number of points:
≤ 11	10
11 – 40	1 per acre
41 – 80	20 + .5(area)

Area in acres:	Minimum Number of points:
81 – 200	40 + .25(area)
≥ 201	Refer to Table 1, Section 7 of Forestry Handbook (Wenger, ed., 1984)

Point sample data collection sheet, cont'd. Reproduce this sheet as needed.

Plot #	Tree #	Species*	DBH (in.)	# of 16' logs or log length (optional)	Notes on understory vegetation, other site characteristics, natural resource concerns, etc. Makes notes for each plot.