BOTTOMLAND FORESTRY:

Forestry Fundamentals

Activity Idea Developed by Samuel Johnson, Cochrane/Fountain City School District, Wisconsin

OBJECTIVES

Students will:

- Develop plan for collecting height and dbh data of trees
- Develop, display and interpret models of tree height and dbh relationships

This activity was developed to meet the following Wisconsin Model Academic and Student Performance Standards for Mathematics

D.8.1 Identify and describe attributes in situations where they are not directly or easily measurable.
D.8.3 Determine measurement directly using lengths to the nearest inch.
D.8.4 Determine measurements indirectly using geometric formulas to derive lengths (change circumference into diameter).
D.12.2 Select tools with appropriate degree of precision to determine measures directly within specified degrees of accuracy.
D.12.3 Determine measurements indirectly using techniques of right triangle trigonometry.
E.12.1 Work with data in the context of real-world situations by
- formulating hypotheses that lead to collection and analysis of one and two variable data.
- designing a data collection plan that considers random sampling, the role of assumption, etc…
- conducting an investigation based on that plan.
- using technology to generate displays.

E.12.2 Organize and display data from statistical investigations using line of best fit.

METHODS

Students hypothesize, collect and interpret data measuring tree DBH and height.

Measuring the dbh of a tree with a Biltmore stick.

Specialized Terms:

Basal area – Cross section of tree stem at 4.5 feet off the ground

Board foot – A standardized unit used to describe the amount of lumber that could be cut from a tree. Amount of wood in a board measuring 1" X 12" X 12"

Clinometer – An instrument used to measure the height of a tree.

Grade Level: 8 – 12

Subjects: Math, Biology

Duration: 2 45 minute periods

Group Size: Individual or small group

Setting: Outdoors and classroom

Key Vocabulary: dbh, Biltmore stick, basal area, total height, clinometer

Materials:
- *Flexible measuring tape or string or Biltmore stick*
- *100 ft. tape measure or 100 ft. rope*
- *Yard stick, clinometer or Hypsometer*
- *Graphing calculator*
- *Tree Identification Book*

Management Issues

dbh (diameter at breast height) - The diameter of a tree is measured at a height of 4-1/2 feet above the ground, on
the uphill side of the stem. Diameter of a tree is usually measured in inches using a tree caliper, a diameter tape or a Biltmore stick.

Merchantable Height – The height of a tree from which usable wood for a particular purpose can be used. For lumber this is usually at the point on the trunk where the diameter is 8 inches. For pulp wood purposes, the merchantable height is where a tree trunk reaches a 4 inch diameter.

Total Height – The height of a tree from ground level to the top of the tree.

BACKGROUND

Management of the Mississippi River's natural resources takes expertise from a variety of different disciplines because of the diversity of habitats found within its floodplain. Forests are one habitat type present in the floodplain of the Mississippi River.

To make management decisions for any forest, a forester must know something about the trees in the forest. Once the tree species has been identified, the most commonly taken measurements are age, **height** and **dbh** (diameter at breast height) of the trees.

The height and dbh is used to calculate important information needed to make management decisions. For example, many forest management decisions are based on the **basal area** different tree species make up per unit (i.e. acre) of forested land. The basal area represents the cross-sectional area of a tree trunk at breast height. The summed basal area of the trees is usually presented for a unit of land, like an acre. This gives foresters an idea about the amount of timber in the forest and is also a measure of how close trees are growing together. (*In practice, foresters usually take a sample of trees from*

Forester from the U.S. Army Corps of Engineers determining the age of a tree by counting tree rings sampled using a tree increment borer (a hollow auger-like tool used to remove core samples from trees).

several small units (i.e. 1/10 acre plots) in the forest. These smaller areas are then used to calculate an estimate for the entire forest.)

Height and dbh is critical information used to calculate how much lumber could be cut from a tree and therefore, its value. The amount of lumber in a tree is commonly referred to in a unit called a **board foot,** measured from the **merchantable height** of a tree (Figure 1). A board foot is a piece of lumber 1 inch thick, 12 inches wide, and 12 inches long. Board foot is a function of dbh and height. The greater a tree's height and dbh, the more board feet there is in a tree. Most foresters use a table to determine the board feet of lumber in a tree (Table 1).

Many trees will reach their maximum height before they have reached there maximum dbh. In general, the older a tree gets, the greater it's dbh becomes even though it does not significantly increase in height. This means that for trees of the same height, the one with a larger dbh will provide more board feet of lumber.

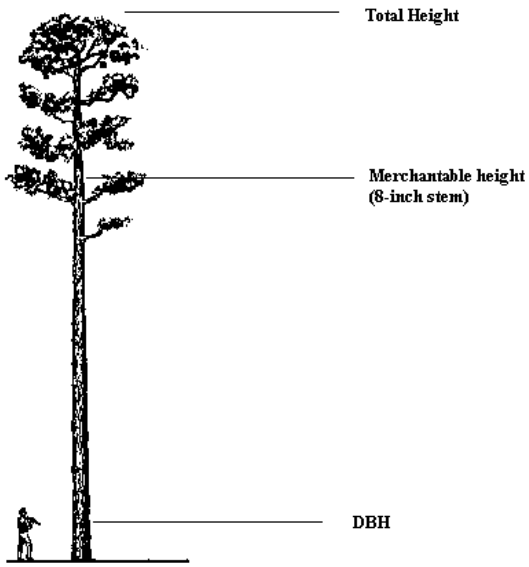


Figure 1. Three important tree measurements.

Source:
Mississippi State University Extension Service
(http://msucares.com/pubs/publications/p1686.htm)

PROCEDURE

1. ***Formulating the hypothesis:*** Begin the lesson by discussing with the students the relationship between trunk diameter and tree height.
2. ***Design a data collection plan for dbh:*** Discuss with the students that they will be collecting and interpreting data to show the relationship between tree diameter and height. Introduce the technique of measuring diameter breast height (dbh). Lead the discussion by pointing out the difficulty of measuring a linear distance on an object that is approximately circular in cross section. Show them a tape measure and ask them what this tool could measure (the circumference). Ask how knowing the circumference could help them determine the diameter. (divide the circumference by pi) Discuss what kind of units could be used (feet and inches) and what degree of accuracy is appropriate (inches).
3. ***Design a data collection plan for tree height:***
    a. Option 1: Show the students a clinometer. Demonstrate how it works and what it measures (angle of inclination). Discuss how that

A homemade Biltmore stick and hypsometer can be made by the students to measure the dbh and height of a tree. Instructions for constructing one are provided at the end of this activity.

measurement could be used with the tangent function to determine tree height. (tree height = tan (angle of inclination) x distance to tree).

b. Option 2: Since many trees grow at right angles to the ground, you can estimate the height of a tree using the properties of a right triangle (Figure 2). Lead a discussion with the students on ways they could measure the height of a tree using items available in the classroom. One method would be to use string and a yard stick in the following manner:

Step 1. Have the student measure the distance from their cheek bone to a yard stick held in their hand at arms length (variable A) and record it. *Step 2.* Have the student stand 50 feet from the tree.

Step 3. Hold a yard stick marked in 1/10th foot increments at arms length and head level, align the bottom of the yard stick to the bottom of the tree. Without moving your head, read the point on the yard stick that aligns with the top of the tree (variable S) and record to nearest tenth of a foot.

Step 4. Have the student develop a formula for converting these measurements into the height of the tree. For example:

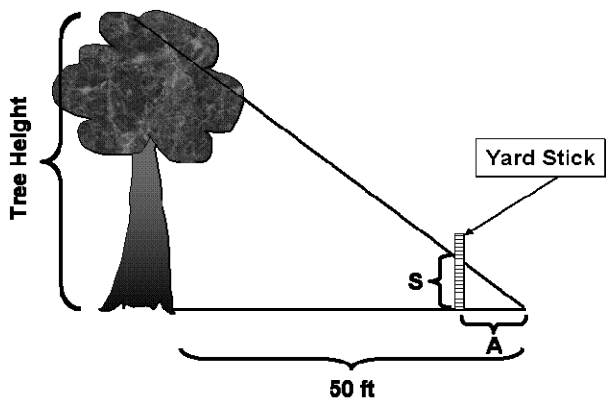


Figure 2. Using a yard stick to estimate tree height.

Tree Height = (S/A) X (50)

4. ***Collecting the data:*** Prior to beginning, mark at least five trees of the same species with varying sizes. These will be the trees the students use to gather data. Hand out data collection sheets (2 examples are provided at end of activity) or use data collection sheets developed by the students. Have the students work in teams of three or four. Each team should divide up responsibilities for measuring circumference and angles of inclination. The sharing of data collecting will save time, encourage cooperation and reduce the need for equipment. The students will initially need reassurance that they are using the equipment correctly. Once reassured they should proceed and have their data collected in approximately 20 minutes.
5. ***Organizing and displaying the data:*** Have the students enter the data into graphing calculators. The data can then be quickly displayed as points on a graph. Have the students show a line of best fit for the data points. Use the linear regression function on the calculator to determine

the equation of the line. Point out that what they have done is to create a mathematical model that describes the relationship between trunk diameter and tree height.

6. ***Using the data:*** Have students rank trees based on how much wood they think could be cut from each tree. After they have ranked the trees, hand out a copy of Table 1 and have the students look up the number of board feet in each tree based on it's dbh and height.

CONCLUSION

Discuss the limitations of the model. Trees will not have trunk diameters and heights that are zero or less. Neither will they have infinitely large diameters and heights. Most species in Minnesota, Iowa and Wisconsin will not exceed three foot diameters and one hundred foot heights. Mathematicians call this domain and range.

Discuss the assumptions that are made:

1. Tree trunks are only approximately circular so that diameters are approximations.
2. The data are linear.

Point out to the students the need for good math skills in creating reliable models. Ask students how data like this could be used.

Discuss how foresters calculate board feet of lumber. Lead the discussion toward wildlife management and how various degrees of forest maturity indicate habitat for different communities of species. Knowing tree size can help foresters make habitat improvement decisions.

ASSESSMENT

DURING

1. Are all the data collected accurately?
2. Did each member of the team contribute to collection of data?
3. Are the data accurately converted on a graphing calculator to a mathematical model showing the relationship between dbh and height?

POST

1. What is the relationship between a tree's dbh and height? (In general, the larger the dbh the greater the height. Remember that this is not infinite, eventually the height will remain constant while the dbh continues to increase).
2. What limitations does this model have? *(The growth of trees is dependent on many factors (soil, how close other trees are, species, etc.). The model also may be limited based on sample size. A model developed based on a few measurements may not be as accurate as one made based on the measurements of several trees. The model developed assumes a linear relationship when most dbh and height relationships are curvilinear since trees will often reach a maximum height before they reach their maximum dbh.)*
3. Why do foresters need to understand the relationship between dbh and height? *(For this exercise, the main purpose is to determine the amount*

of wood that could be obtained from a tree. However, foresters also use dbh and height as two factors in making management decisions and used in calculating site index, or measuring the productivity of a site.)

Table 1. An example of a table used to calculate board feet of lumber.

Standing Tree Board Foot Volumes - International 1/4-Inch Rule

Dbh (inches)	Number of 16-Foot Logs							
	1/2	1	1-1/2	2	2-1/2	3	3-1/2	4
	Board Feet							
12	30	60	80	100	120			
14	40	80	110	140	160	180		
16	60	100	150	180	210	250	280	310
18	70	140	190	240	280	320	360	400
20	90	170	240	300	350	400	450	500
22	110	210	290	360	430	490	560	610
24	130	250	350	430	510	590	660	740
26	160	300	410	510	600	700	790	880
28	190	350	480	600	700	810	920	1,020
30	220	410	550	690	810	930	1,060	1,180
32	260	470	640	790	940	1,080	1,220	1,360
34	290	530	730	900	1,060	1,220	1,380	1,540
36	330	600	820	1,010	1,200	1,380	1,560	1,740
38	370	670	910	1,130	1,340	1,540	1,740	1,940
40	420	740	1,010	1,250	1,480	1,700	1,920	2,160
42	460	820	1,100	1,360	1,610	1,870	2,120	2,360

From: Ashley, Burl S. 1980. *Reference handbook for foresters*. USDA NA-FR-15. 35 pp.

Example datasheet for use with clinometer.

Tree	Circumference (ft and inches)	Diameter (inches)	Distance from Tree in (ft)	Inclination from Clinometer	Total Height (ft)	Merch. Height of tree (ft)	Rank	Board Feet
1								
2								
3								
4								
5								

Example datasheet for use with yard stick.

Tree	Circumference (ft. and inches)	Diameter (0.1 in)	Dist. from Tree (feet)	Dist. from students eye to yard stick (inches)	Total Height		Merchantable Height		Rank	Board Feet
					yard stick to nearest (0.1 ft)	Total Height (ft)	yard stick to nearest (0.1 ft)	Merch. Height (ft)		
1										
2										
3										
4										
5										

Measuring Trees

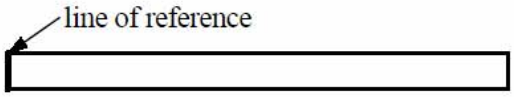
Foresters measure trees to assist them with forestry decisions. To determine the approximate timber yield of a tree or stand of trees, a forester must know how to estimate the volume of useable wood that a tree has produced. To determine the volume, the diameter of the tree must be measured at breast height (4 1/2 feet above the ground) on the up hill side. This diameter measurement is called "d.b.h." Then the height must be measured. By using a prepared volume table, the forester can then determine the estimated volume of the tree.

Measuring Tree Diameter

One tool that is commonly used by foresters to estimate diameter at breast height (d.b.h.) is called a Biltmore stick. To use a Biltmore stick, hold it horizontally against the tree at breast height and at arms length (25 inches from your eye is an industry standard for purchased Biltmore sticks). Line up the zero end with the outside of the tree. Then, without moving your head, glance at the other side of the tree and read the graduation where your line of sight and the edge of the tree cross the stick. Because trees are commonly oblong, a measurement should be taken from at least two different sides of the tree and the estimated diameter averaged.

Making your own Biltmore stick:

1. Find a sturdy piece of lath, approximately 36" to 40" in length.
2. Identify a line of reference or a zero line at the far left end of the stick.



3. Hold the stick horizontally, near the mid-point, fully extend your arm at a height of 4 1/2 feet above the ground and have someone measure the distance from your eye to the stick.

Distance from eye to stick with arm extended => E = _____ inches

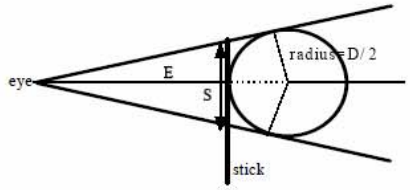
4. For each inch in diameter (you may want to start at 4 inches dbh), calculate the distance on the stick from the line of reference, using the following equation:

S = distance on stick from line of reference(inches)

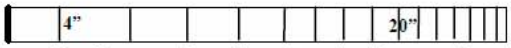
E = distance from eye to stick with arm extended (inches)

D = diameter of tree at d.b.h.

$$S = \sqrt{\frac{ED^2}{E+D}}$$



5. Mark the distances for each diameter on your stick, identifying at each mark which diameter it was calculated for.



Note: The larger the diameter is the smaller the distance between the lines on your stick will become.

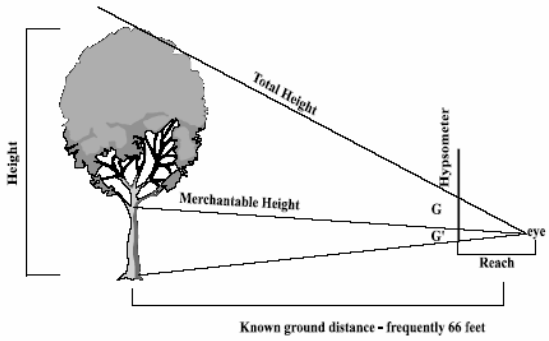
Measuring Tree Height

It is necessary to know height as well as diameter (d.b.h.) when determining the volume of a tree.

1. Total height is usually measured from a 1 foot stump to the top of the tree. This height is often used in calculating firewood volumes. Although, it is useful in many other situations just to know the total height of a tree.
2. Merchantable height is usually measured from a 1 foot stump to the point at which the tree is no longer usable for the desired product. This measurement is more commonly used when estimating yield for sawtimber and veneer type products.

A tool that is commonly used to determine tree height is a Hypsometer. Often, commercially produced Biltmore sticks have a side that is dedicated to a Hypsometer. Hypsometers are based on the concept of similar triangles. To use a Hypsometer, stand 66 feet from the base of the tree. Hold the hypsometer vertically, at arms length (25 inches from your eye). Line up the bottom of the hypsometer with the bottom of the tree.

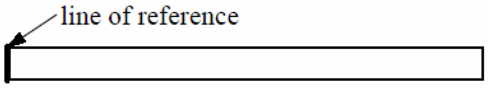
Without moving your head, sight to the top (or merchantable top) of the tree. Read the number on the hypsometer where your line of site and the top of the tree cross. This number equals the height of the tree in feet. When the tree is more than 66 feet high, stand 2 x 66'=132' from the base of the tree and remeasure. This time multiply your reading by 2.



Making Your Own Hypsometer

1. Use the back of your Biltmore stick or find a sturdy piece of lath, approximately 36" to 40" in length.

2. Identify a line of reference or a zero line at the far left end of the stick.



3. Hold the stick vertically, near the mid-point, fully extend your arm at eye level and have someone measure the distance from your eye to the stick.

*Distance from eye to stick with arm extended => **Reach =** _____ **inches***

4. For each foot of height (you may want to do this in increments of 8 feet, as this represents a 1/2 log at industry standards), calculate the distance on the stick from the line of reference, using the following equation:

G = distance on stick from line of reference (inches)

$$G = \frac{\text{ReachxHeight}}{66\text{feet}}$$

Mark these on your stick, identifying at each mark which diameter it was calculated for. Note: The distance between the lines on your stick will be roughly the same.

Determining Estimated Volume

Once you have measured the diameter and merchantable height, you can determine the estimated board-foot volume. One board foot is equivalent to a piece of lumber 1 inch thick, 12 inches wide, and 12 inches long.

Foresters typically use a prepared volume table to determine the estimated volume for a given tree. A volume table gives an estimate of the number of board feet of lumber that can be sawed from different sized trees.

Amount of Sawtimber in Trees

(Scribner Rule – Tree Scale)

Merch. Log Length	*8*	*12'*	*16'*	*20'*
Dbh				
12"	*28*	*37*	*48*	*57*
13"	*34*	*46*	*59*	*70*
14"	*40*	*55*	*70*	*83*
15"	*47*	*64*	*81*	*95*
16"	*54*	*73*	*93*	*111*
17"	*63*	*86*	*109*	*128*
18"	*72*	*97*	*122*	*145*
19"	*81*	*110*	*140*	*164*
20"	*90*	*123*	*156*	*184*
21"	*100*	*138*	*176*	*208*
22"	*111*	*152*	*194*	*228*
23"	*125*	*169*	*214*	*254*
24"	*137*	*186*	*236*	*277*

Let's take an example. You have measured a tree with the Biltmore stick and have found it to be 22 inches d.b.h. You have then measured the merchantable height using the Hypsometer and found it to be 16 feet. Now, find the diameter (22) in the left-hand column of the table and move across to the column headed by the Merchantable log length (16). The table shows that this tree contains 194 board feet of usable sawtimber volume.

BOTTOMLAND FORESTRY:
A Question of Quality

OBJECTIVES

Students will:

- Interpret data from four different bottomland forest sites.
- Describe differences between habitat quality of 4 bottomland forest sites
- Hypothesize reasons for differences in habitat quality of bottomland forest sites.

METHODS

Students analyze and interpret actual data from a Mississippi River bottomland forest.

Specialized Terms:

Bottomland Forest -- a term used to describe forest communities found in the floodplains of rivers or edges of other wetlands.

Crown Class -- a subjective procedure to assign a relative importance of a tree with regards to its position in the overstory, or canopy, of a forest.

> Dominant = the tree's crown receives light from 3-4 directions
> Codominant = the tree's crown receives light from 1-2 directions
> Intermediate = the tree's crown only receives light from the top
> Suppressed = the tree's crown is entirely shaded and underneath the stand canopy

Dbh -- the diameter of a tree at breast height (4.5 feet above the ground).

Health – the condition a tree appears to be in. (Vigorous = full crown, healthy, green leaves and no visible signs of disease; Stressed = small crown relative to size, some crown dieback, some or many leaves may appear brown or yellow in entirety or along edges, signs of disease or damage to trunk and/or limbs; Snag = a standing dead tree)

Overstory – The trees that make up the canopy, or upper layer, of a forest.

Grade Level: 7 – 12

Subjects: Math, Biology

Duration: 45 minutes

Group Size: Individual or small group

Setting: Classroom

Key Vocabulary: Bottomland forest, crown class, dbh, health, overstory, sapling, seedling

Materials:

- *Graphing Calculator*
- *Handouts*

Pre-activity: Bottomland Forests: Forest Fundamentals

Data for this activity was provided by the U.S. Army Corps of Engineers, Natural Resources Project Office, La Crescent, Minnesota.

than 5 inches dbh

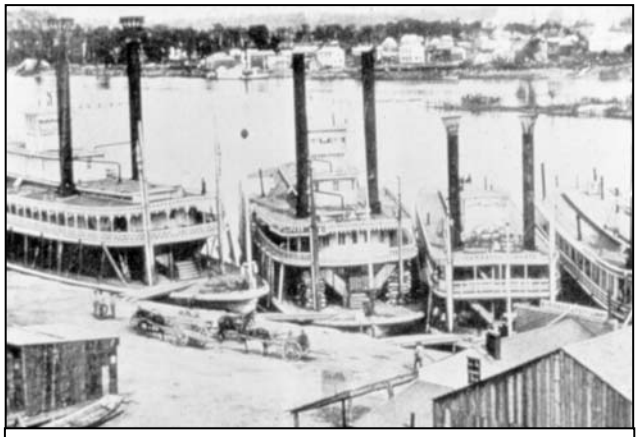
Seedling – term applied to trees that are < 1 inch dbh.

BACKGROUND

The floodplain of the Mississippi River is comprised of a diverse mix of habitat types. The first types of habitat that often come to mind are those dependent on water and often wet (lakes, ponds, wetlands, sloughs, channels and the main part of the river itself). But the floodplain of the Mississippi River also contains a mix of habitat that isn't always wet. One component of floodplain habitat that isn't wet all of the time is the bottomland forest.

Many of the forests in the Mississippi River floodplain are referred to as bottomland forests. The tree species found in a bottomland forest are adapted to grow in areas with "wet" soil conditions and may be flooded part of the year. The floods in the river valley do not cover the tops of the trees, but the floodwaters do cover the land where the trees are growing. The trees of a bottomland forest have adapted to survive in conditions where their roots are underwater for a period of time.

Bottomland forests provide a home for a diverse array of wildlife. These forests also play important roles in trapping sediment and nutrients washed from the watershed and adjacent uplands, preventing erosion of islands and provide shelter during floods for a variety of fish species. Unfortunately, human actions in the Mississippi River floodplain have caused a loss in the amount of bottomland forest and have affected the quality and health of many of the forests that remain today.



Steamboats relied heavily on the forest resources of the bottomlands and bluffs to fuel their boilers.

Changes to the forest began in earnest during the heyday of steamboat travel. It has been estimated that during the peak of steamboat travel on the Mississippi River from St. Louis, Missouri, to St. Paul, Minnesota, over 420,000 acres of bottomland and upland forest were cut in April through November each year (personnel communication with Hank Whipple, Wisconsin Historical Society). This level of impact lasted about 15 years. The next big impact to the bottomland forests of the Mississippi River came when the locks and dams were constructed to create a 9-foot deep commercial navigation channel.

The direct impact of construction of the locks and dams came from the cutting of trees on islands and land that would become flooded by the impoundments, or reservoirs, created. The changes along Mississippi River bordering Wisconsin, Iowa and Minnesota resulted in a loss of almost 50% of the bottomland forests. For example, Pool 8 lost 84% of it's bottomland forest habitat from 1890 to 1989 due to construction of locks and dams, urbanization and agriculture (Figure 1). Much of the bottomland forest that wasn't cut was impacted by the higher water levels created by the locks and dams. The higher water levels caused some of the islands to become too wet to support the growth of a diverse and healthy bottomland forest, and some areas became too wet to support the growth of trees at all.

Clearing the bottomland forest from areas that would be flooded by the construction of the locks and dams.

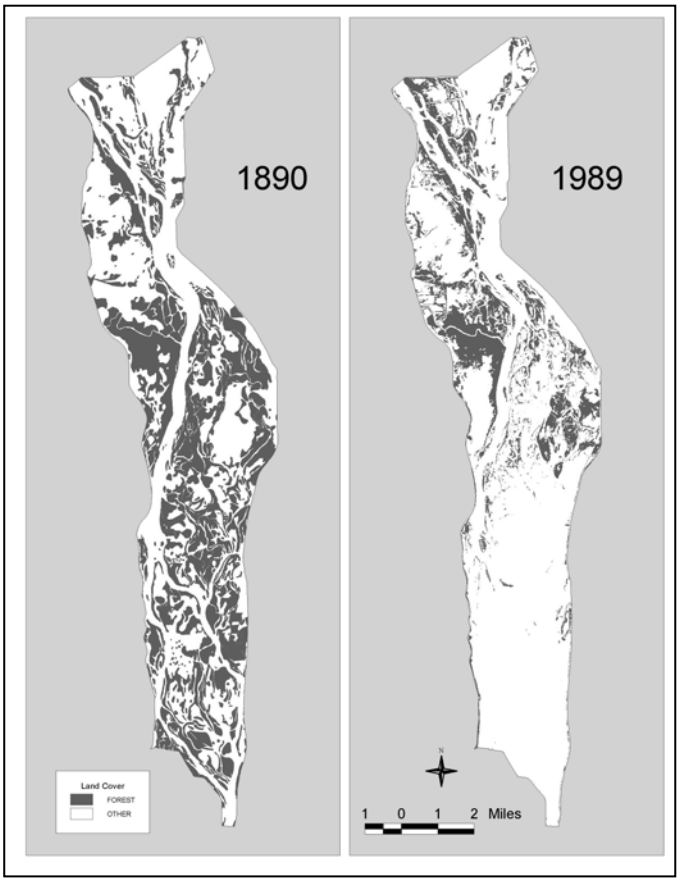


Figure 1. Loss of bottomland forest in Pool 8 of the Upper Mississippi River between 1890 and 1989.

An experienced forester can quickly assess the health and condition of a bottomland forest based on a hike through the trees. However, the forester needs basic information about the forest to develop management recommendations or accurately describe the health of a forest and share the information with others. Some of the information about the forest comes from where the forest is located. For example, a forester will determine the type of soil the trees are growing in, the topography of the land, aspect to the sun (i.e. north or south facing slope), soil moisture and presence of other plants, including seedlings. Location within a pool is also very important since most of the bottomland forest resources are found in

the upstream sections of a pool.

To make management decisions, the forester must also know something about the trees in the forest. Once the tree species have been identified, the most commonly taken measurements are age, height and dbh (diameter at breast height) of the trees.

All of this data, when looked at collectively, can reveal clues about the potential fate of a bottomland forest site. A site with a high potential of staying a diverse and healthy bottomland forest will usually have a diversity of desirable tree and other plant species, signs of tree reproduction (saplings and seedlings) and may have a few dead trees, or snags. The key sign of reproduction in a bottomland forest is the presence of saplings and not necessarily the seedlings. Seedlings are dependent on flood elevations for their survival and therefore their survival in a given year can be highly variable. Seedlings that are submerged by floodwater will most likely “drown” and die. But a few favorable years of minor to no flooding, and the seedlings will become saplings – capable of surviving periodic floods. These sites may only need a small amount of management by the forester to maintain its diversity and health.

Signs that the future of a Mississippi River bottomland forest is in jeopardy include: no sign of reproduction, very few different species of trees, numerous snags (dead trees) or stressed trees and a high percentage of reed canary grass as ground cover and/or other exotic species or invasive species like black locust. Reed canary grass is an exotic species that has been extensively used in the past as ground cover to reduce erosion. However, reed canary grass forms a very thick mat of vegetation that makes it very difficult for other plants to grow. In the case of trees, this mat of vegetation impacts the germination of seeds and growth of seedlings. Bottomland forests that are of poor quality need a high level of management, and in many cases a lot of money, to be restored back into a healthy and diverse part of the River ecosystem. The type of management action will depend on the physical characteristics of the site: elevation of land above average water levels, soil conditions, position in pool and/or floodplain and types of exotic species present. In some locations, managers have “raised” the elevation of the land to provide better growing conditions for trees, planted the trees, and kept invading species in check.

Planting a new bottomland forest (left) and a sapling protected by a tree tube to limit competition from other plants and damage by animals.

The most dramatic impacts to the bottomland forests of the Upper Mississippi River occurred due to a series human action over 75 years ago. However, those events

set the stage for a forest that is essentially even aged with very little reproduction occurring due to changes in ground water levels and exotic species, like reed canary grass and black locust. Today, humans are trying to have a positive impact on the bottomland resources. The Corps of Engineers and U.S. Fish and Wildlife Service have been obtaining data on the forests to gain the information necessary to make sound management decisions. **The management decisions for many of the bottomland forests in the Mississippi River floodplain will focus on improving and maintaining them as habitat for a wide variety of wildlife species.** This approach is different than some other forests where timber production and harvest in the shortest amount of time is often one of the management goals, along with habitat.

MATERIALS

- Copies of the following (1 per student or group):
    - Bottomland Overstory Inventory
    - Subplot Data
    - Microplot Data
    - Photos
    - Map of Pool 8 in 1890 and 1989

PROCEDURES

1. Begin the activity by asking students to list factors that contribute to a healthy and desirable place for people to live. They should consider not only the proximity to a mall or skateboard park, but also consider factors like neighborhood, food, water, housing, climate, etc.

2. Next, ask the students to list factors contributing to a healthy forest that provides good habitat for wildlife. Have them think about different types of forests they are familiar with (i.e. pine forest, parks, oak forest, etc). Where were the forests located? Did they differ in any ways (location, topography, species of trees, appearance)? What types of animals lived there? Have them hypothesize why there is a difference among forests based on their experiences.

3. Introduce them to the term bottomland forest and describe what it is.

   "Many of the forests in the Mississippi River floodplain are referred to as bottomland forests. The tree species found in a bottomland forest are adapted to grow in areas with "wet" soil conditions and may be flooded part of the year. The floods in the river valley do not cover the tops of the trees, but the floodwaters do cover the land where the trees are growing. The trees of a bottomland forest have adapted to survive in conditions where their roots are underwater for a period of time."

4. Explain to them that they will now play the role of a Corps of Engineers' forester responsible for management of the Mississippi River bottomland forest. They will be trying to assess the habitat quality and health of different bottomland forests based on forest plot data. (It would be very expensive to identify and measure all of the trees in a forest. Therefore, foresters often take samples of the forest. In this activity, students will be provided actual data collected by Corps of Engineer foresters. Each plot is typical of the plots found in each of the forests sampled.)

5. Hand out the Bottomland Forest Overstory Inventory and map of Pool 8 showing where the plots were taken and changes in forest cover from 1890 to 1989. The Bottomland Forest Overstory Inventory contains information on trees > 5 inches dbh that were found at the sample plot. Introduce the following terms to them: dbh, health, crown class, total height and merchantable height (also see the acitivity "Bottomland Forests: Forestry fundamentals).

   Discuss with them the table. How is the data summarized/presented? What information is provided? The rows on the table that are shaded grey have the pool, date, water and land elevation and coordinates of where the plot was located. Point out that the summary table includes information that would allow someone to go out and find exactly were the data came from. The elevation is also included to provide information on how high the site is above the water elevation of the river on the day the sample was taken. Water levels may change from day to day, but the ground elevation remains constant from year to year.

6. Have them review the data. What differences do they see among the sites? What tree species are common? Which plot has the largest trees in dbh and/or height? What do the snags represent *(Snags are an important component of a forest. The snags provide habitat for cavity nesting animals and food for several species of birds that feed on insects living in the dead tree (i.e. woodpeckers). Therefore, having some snags present is good from a wildlife habitat standpoint, but lots of snags shows that something has happened that is affecting the quality of the bottomland forest.).*

   Have them rank the sites from the best to least quality. They should explain what they considered in their ranking.

7. (Optional: Using the overstory data provided, have them develop a "model" by graphing a relationship between height and dbh for each tree species for each plot following procedures 5 and 6 (found on page MI 26) for the activity "Bottomland Forests: Forestry Fundamentals.")

8. Hand out subplot data. Explain the subplot data represents an even smaller sample of the forest community used to look at the tree species present below the overstory, or canopy, of the forest. Many of the trees are saplings that may someday replace the larger trees if the overstory trees die, fall down or are harvested.

   Have them review and interpret the subplot data. Following are some questions that can be used to initiate discussion: Why is knowing what saplings are present important? What species are present to replace the overstory trees? Are they the same as the overstory trees at the plot? What may become of a forest that has no saplings? What might be some reasons that sapling are or are not present?

   Based on this information, they can re-rank the quality of the plots if they want to.

9. Hand out the microplot data. This is an even smaller sample of the area of a forest within a plot. The microplots are used to look at the seedlings and other plants present at the sample plot.

   Have them review and interpret the microplot data. Following are some questions that can be used to initiate discussion: Why is knowing what seedlings are present important? What species are present to replace the sapling and overstory trees? Are they the same as the sapling and overstory trees at the plot? What may become of a forest that has no seedlings? What might be some reasons that saplings are or are not present? Are there any differences in the non-tree species found?

   Remember, not finding any seedlings may mean that reproduction isn't occurring, or that a flood that year may have already killed them.

   Based on this information, they can re-rank the quality of the plots if they want to.

10. Look at the photos. Have the students examine the photos and compare the plot, subplot and microplot data for each photo. Can they see any visual differences in the condition of the bottomland forests? What are the differences? How does the data collected match the photo (i.e. few vs. many trees, ground cover, etc.)?

    Based on this information, they can re-rank the quality of the plots if they want to.

11. Using all of the information, have them develop of list of potential human and natural factors that may be affecting the quality of each of the forests. What might be some actions a forester or landowner could take to

manage each of the forests? Keep in mind the potential for each site. For example, if exotic or invasive species can be eliminated or controlled then a site could be restored to a good quality forest.

12. Share with them the ranking the Corps of Engineers forester would place on each of the sites. The quality of the sites would be rank as follows (from best quality to least quality): 1, 3, 4, 2. However, ranking of the sites is a bit subjective and differs based on the criteria used to assess the habitat quality and health of the site. Therefore the key is that students provide justification for their ranking.

ASSESSMENT

During:

- Did the students look at more than one factor when ranking the quality of the plots?
- Did the students adjust, if necessary, their rankings when given more information?
- Did the students actively participate in the discussions?

Post:

- What is a bottomland forest?
- What data does a forester collect in order to assess a bottomland forest's health?
- Contrast a healthy bottomland forest and a forest in jeopardy.

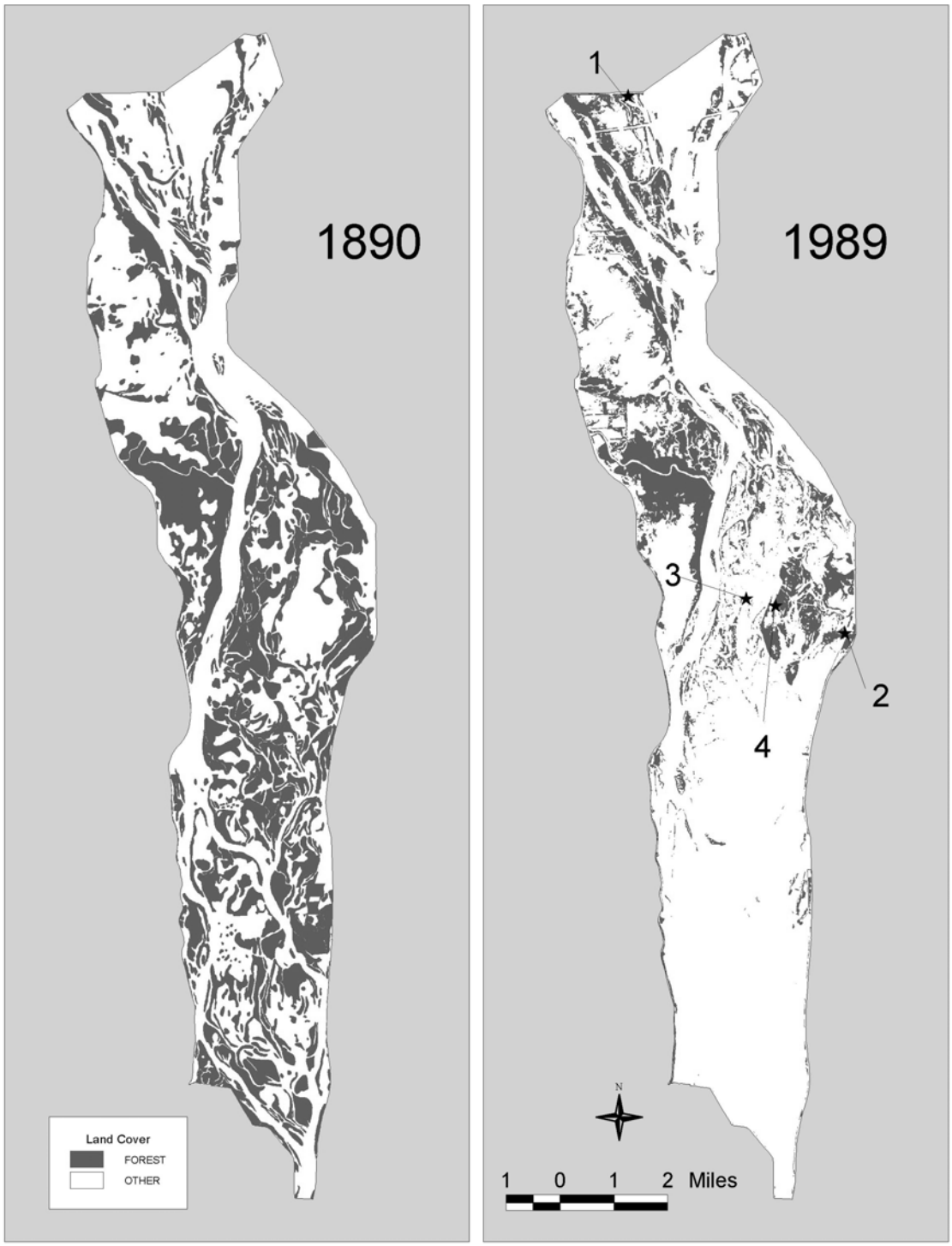


Figure 1. Comparison of forest coverage between 1890 and 1989 for Pool 8 of the Mississippi River located near La Crosse, Wisconsin. The combined effects of agriculture, urbanization and construction of the locks and dams caused an 84% loss in the acreage of bottomland forest in 100 years. Numbers indicate locations of plots used in this activity.

BOTTOMLAND FOREST OVERSTORY INVENTORY

Plot Number: 1 **Date** 07/14/2004 **Pool:** 8 **Geomorphology**: Natural Ridge
UTM Coord N 4858427 **UTM Coord E** 638491 **NAD27 Zone 15**
Pool Elevation 632.76 **Ground Elevation** 635.22 **Basal Area** 150

Tree	Common Name	dbh (inches)	Total Height (feet)	Merchantable Height (logs)	Age (yrs)	Health	Crown Class
1	Silver Maple	5.8	80	0.0		Vigorous	Intermediate
2	Silver Maple	5.9	42	0.0		Vigorous	Suppressed
3	Silver Maple	13.0	81	0.5		Vigorous	Co-dominant
4	Silver Maple	6.4	45	0.0		Vigorous	Intermediate
5	Silver Maple	13.7	74	1.5		Vigorous	Co-dominant
6	River Birch	9.2	8	0.0		Snag	Snag
7	Silver Maple	13.0	80	1.5		Vigorous	Co-dominant
8	Silver Maple	7.8	55	0.0		Vigorous	Co-dominant
9	Silver Maple	13.8	72	1.0		Vigorous	Co-dominant
10	Silver Maple	13.6	78	1.5		Vigorous	Co-dominant
11	Silver Maple	8.1	70	0.0		Vigorous	Intermediate
12	Silver Maple	8.1	65	0.0		Vigorous	Intermediate
13	Silver Maple	12.6	78	0.0		Vigorous	Co-dominant
14	Silver Maple	7.4	62	0.0		Vigorous	Intermediate
15	American Elm	50.0	34	0.0		Vigorous	Suppressed
16	River Birch	11.9	70	1.0		Vigorous	Co-dominant
17	Silver Maple	5.0	34	0.0		Vigorous	Intermediate
18	River Birch	11.8	74	0.5		Vigorous	Co-dominant
19	River Birch	11.7	63	0.0		Snag	Snag
20	Silver Maple	10.9	65	0.5		Vigorous	Co-dominant
21	River Birch	12.0	60	1.5		Vigorous	Co-dominant
22	River Birch	6.8	50	0.0		Vigorous	Co-dominant
23	River Birch	9.8	42	0.0		Snag	Snag
24	River Birch	8.0	56	0.0		Vigorous	Co-dominant
25	River Birch	10.8	68	1.0	52	Vigorous	Co-dominant
26	Silver Maple	7.4	55	0.0		Vigorous	Intermediate
27	Silver Maple	7.0	50	0.0		Vigorous	Intermediate
28	River Birch	13.2	68	1.0		Vigorous	Co-dominant
29	Green Ash	7.0	55	0.0	54	Vigorous	Co-dominant
30	River Birch	10.3	15	0.0		Snag	Snag
31	Silver Maple	7.3	55	0.0		Vigorous	Co-dominant
32	Silver Maple	7.2	48	0.0		Vigorous	Co-dominant
33	River Birch	9.3	20	0.0		Snag	Snag
34	River Birch	11.4	20	0.0		Snag	Snag
35	Silver Maple	5.9	52	0.0		Vigorous	Co-dominant
36	River Birch	10.2	22	0.0		Snag	Snag
37	Silver Maple	15.4	75	0.5		Vigorous	Dominant

Plot Number: 2 **Date** 08/06/2004 **Pool:** 8 **Geomorphology**: Terrace, Streambank
UTM Coord N 4842384 **UTM Coord E** 644631 **NAD27 Zone 15**
Pool Elevation 633.27 **Ground Elevation** 645.76 **Basal Area** 140

Tree	Common Name	dbh (inches)	Total Height (feet)	Merchantable Height (logs)	Age (yrs)	Health	Crown Class
1	Boxelder	5.8	10	0.0		Snag	Snag
2	Boxelder	7.0	11	0.0		Snag	Snag
3	Boxelder	6.1	10	0.0		Snag	Snag
4	Boxelder	10.4	30	0.0		Stressed	Suppressed
5	Boxelder	9.7	27	0.0		Snag	Snag
6	Boxelder	11.0	68	8.0		Vigorous	Co-dominant
7	Boxelder	10.0	46	0.0	29	Vigorous	Intermediate
8	Boxelder	5.7	7	0.0		Snag	Snag
9	Boxelder	10.6	41	0.0		Vigorous	Intermediate
10	Boxelder	7.4	42	0.0		Stressed	Intermediate
11	Boxelder	10.7	43	0.0		Vigorous	Intermediate
12	Boxelder	14.0	59	8.0	43	Vigorous	Co-dominant

Bottomland Forest Overstory Inventory **Page 1 of 2**

Plot Number: 3 **Date** 08/18/2004 **Pool:** 8 **Geomorphology**: Island terrace
UTM Coord N 4843426 **UTM Coord E** 641679 **NAD27 Zone 15**
Pool Elevation 633.00 **Ground Elevation** 639.20 **Basal Area** 100

Tree	Common Name	dbh (inches)	Total Height (feet)	Merchantable Height (logs)	Age (yrs)	Health	Crown Class
1	Silver Maple	5.6	24	0.0		Stressed	Intermediate
2	Silver Maple	6.0	24	0.0		Stressed	Intermediate
3	Silver Maple	43.7	29	0.0		Snag	Intermediate
4	Silver Maple	12.6	5	0.0		Snag	Snag
5	Silver Maple	26.7	60	0.0		Snag	Co-dominant
6	Silver Maple	13.6	35	0.0		Snag	Intermediate
7	Silver Maple	18.5	26	0.0		Snag	Intermediate
8	Silver Maple	6.5	16	0.0		Snag	Intermediate
9	Silver Maple	28.3	35	0.0		Snag	Intermediate
10	Silver Maple	17.7	10	0.0		Snag	Intermediate
11	Silver Maple	49.0	86	1.5		Vigorous	Dominant
12	Swamp White Oak	8.3	10	0.0		Stressed	Intermediate
13	Swamp White Oak	12.9	47	1.0	49	Vigorous	Co-dominant
14	Swamp White Oak	13.0	54	1.5	46	Vigorous	Co-dominant
15	Swamp White Oak	15.4	50	1.0		Vigorous	Co-dominant
16	Swamp White Oak	5.3	30	0.0		Snag	Suppressed
17	Swamp White Oak	12.8	48	0.0		Vigorous	Co-dominant

Plot Number: 4 **Date** 08/04/2004 **Pool:** 8 **Geomorphology**: Terrace
UTM Coord N 4843214 **UTM Coord E** 642557 **NAD27 Zone 15**
Pool Elevation 631.00 **Ground Elevation** 639.20 **Basal Area** 110

Tree	Common Name	dbh (inches)	Total Height (feet)	Merchantable Height (logs)	Age (yrs)	Health	Crown Class
1	Boxelder	5.9	31	0.0		Stressed	Intermediate
2	UNKNOWN	6.4	38	0.0		Snag	Snag
3	Silver Maple	14.9	78	1.0		Vigorous	Dominant
4	Black Walnut	10.9	72	1.5	30	Vigorous	Co-dominant
5	UNKNOWN	5.5	39	0.0		Snag	Snag
6	Black Locust	7.9	65	0.0		Snag	Snag
7	Black Locust	5.4	51	0.0		Vigorous	Co-dominant
8	Black Locust	5.4	51	0.0		Stressed	Intermediate
9	Black Locust	7.9	66	0.0		Vigorous	Co-dominant
10	Black Locust	6.1	61	0.0		Vigorous	Co-dominant
11	Black Locust	6.4	41	0.0		Snag	Snag
12	Black Locust	6.0	57	0.0		Stressed	Intermediate
13	Black Locust	5.6	22	0.0		Vigorous	No Data
14	Black Locust	7.1	66	0.0		Stressed	Co-dominant
15	Silver Maple	11.7	51	1.0		Vigorous	Intermediate
16	Black Locust	9.1	67	0.0	53	Vigorous	Co-dominant
17	Black Locust	8.6	46	0.0		Stressed	Intermediate
18	Black Locust	9.1	69	0.5		Vigorous	Co-dominant
19	Black Walnut	6.3	55	0.0		Vigorous	Intermediate
20	Black Locust	5.0	55	0.0		Vigorous	Intermediate
21	Black Locust	8.3	72	0.5		Vigorous	Co-dominant
22	Black Locust	9.1	71	0.5		Vigorous	Co-dominant
23	Black Locust	9.6	35	0.0		Snag	Snag
24	Black Locust	12.6	73	0.0		Stressed	Co-dominant
25	Black Locust	6.3	58	0.0		Snag	Snag
26	Black Locust	14.0	72	0.0		Stressed	Co-dominant
27	Black Locust	11.1	63	0.0		Stressed	Co-dominant
28	Black Locust	5.7	26	0.0		Snag	Snag
29	Silver Maple	14.2	77	1.0		Vigorous	Dominant
30	Green Ash	16.4	50	2.0	32	Vigorous	Intermediate
31	Silver Maple	7.1	55	0.0		Vigorous	Intermediate
32	River Birch	7.3	52	0.0		Stressed	Intermediate
33	River Birch	7.8	56	0.0		Vigorous	Co-dominant
34	Black Locust	8.5	32	0.0		Stressed	Suppressed
35	Black Locust	6.1	59	0.0		Vigorous	Co-dominant

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Subplot Data

Subplot: Saplings (trees) > or = 1 inch up to less than 5 inches dbh
Subplots 11.8 ft. radius 15 ft. from plot center.
Subplot locations are at following directions: Subplot 1 - 0°, 2 – 120°, 3 - 240°

Plot	Subplot	Common Name	dbh (inches)	Total Height (feet)	Health
1	1	Silver Maple	3.4	28	Vigorous
	1	Silver Maple	3.4	30	Vigorous
	2	Silver Maple	2.6	18	Vigorous
	2	Silver Maple	4.2	25	Vigorous
	2	Silver Maple	4.7	36	Vigorous
	2	Silver Maple	4.3	35	Vigorous
	2	Silver Maple	3.6	30	Vigorous
	2	Silver Maple	4.6	33	Vigorous
	2	Silver Maple	1.4	10	Vigorous
	2	Silver Maple	2.3	22	Snag
	3	None Found	0	0	No trees
2	1	None Found	0	0	No trees
	2	None Found	0	0	No trees
	3	None Found	0	0	No trees
3	1	None Found	0	0	No trees
	2	None Found	0	0	No trees
	3	None Found	0	0	No trees
4	1	Black Locust	4.7	38	Snag
	2	Black Locust	3.9	46	Vigorous
	2	Boxelder	3	25	Vigorous
	2	Green Ash	1.4	13	Vigorous
	2	UNKNOWN	1.5	25	Snag
	2	UNKNOWN	1.8	25	Snag
	2	UNKNOWN	1.9	26	Snag
	2	UNKNOWN	1.2	20	Snag
	2	UNKNOWN	2.4	27	Snag
	2	UNKNOWN	1.7	13	Snag
	2	Black Locust	2.5	35	Stressed
	3	Black Cherry	2.4	12	Vigorous
	3	UNKNOWN	4	40	Snag
	3	UNKNOWN	2.3	33	Snag
	3	UNKNOWN	3	35	Snag
	3	UNKNOWN	2.4	30	Snag
	3	Swamp White Oak	1.5	13	Stressed

Microplot Data

Microplot Data: < 1 inch dbh, 6.8 ft plot radius (if < 1 foot tall, use % cover+).
Microplots are at following locations from Plot center: Microplot A - 0°, B – 120°, C - 240°

Plot Number	Common Name	Height (feet)	Percent Cover of Microplot A	Percent Cover of Microplot B	Percent Cover of Microplot C
1					
Seedlings					
	Silver Maple	<1	0-10%	0-10%	0-10%
	Common Hackberry	<1	0-10%		
	Green Ash	1-2			0-10%
	Green Ash	2-4			0-10%
	White Mulberry	1-2			0-10%
	Silver Maple	4-6			0-10%
Non tree species					
	Poison Ivy		10-20%		0-10%
	Virginia Creeper		0-10%		0-10%
	Greenbrier				0-10%
	Sedge				0-10%
	Violet				0-10%
	Wood Sorel				0-10%
	Fern sp.				0-10%
2					
Seedlings					
	Green Ash	<1	0-10%	0-10%	0-10%
	Bitternut Hickory	<1	0-10%		
	Red Oak	<1		0-10%	
	Northern Red Oak	<1		0-10%	
Non tree species					
	Canadian Clearweed		0-10%	0-10%	0-10%
	Foxtail		20-30%	0-10%	0-10%
	Creeping Charlie		60-70%	70-80%	70-80%
	Interrupted Fern		0-10%	0-10%	0-10%
	Woodnettle		0-10%	0-10%	
	Virginia Creeper		0-10%	0-10%	0-10%
	Reed Canarygrass		0-10%	0-10%	
	Violet		0-10%		
	Nettle			0-10%	
	Poison Ivy			0-10%	0-10%
	Lesser Burrdock			0-10%	
3					
Seedlings					
	Silver Maple		0-10%		0-10%
Non tree species					
	Black Raspberry		0-10%		
	False Nettle		0-10%	0-10%	0-10%
	Reed Canarygrass		90-100%	90-100%	90-100%
4					
Seedlings					
	Green Ash		0-10%		
	Black Locust		0-10%		0-10%
	Red Oak	>6		0-10%	
	Northern Red Oak	>6		0-10%	
Non tree species					
	Foxtail		50-60%	20-30%	60-70%
	White Grass		0-10%	10-20%	20-30%
	Smartweed		0-10%	20-30%	0-10%
	Grass		10-20%	0-10%	0-10%
	Canadian Clearweed		0-10%		
	Ragweed			0-10%	
	False Nettle			0-10%	0-10%

Plot #1 photo from plot center.

Plot #2 photo from plot center.

Plot #3 photo from plot center.

Plot #4 photo from plot center.

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