Massachusetts Envirothon

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EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS

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Contents

LEARNING OBJECTIVES

Team members will be able to:

- Understand, communicate, and recount forestry facts (state tree, forest products, forest measurements [acres, cords, MBF, percent forested]).
- Apply methods of measurement including tree height, DBH, board foot volume.
- Identify trees from the required tree list, during all four seasons using bark, cones, nuts, buds, leaves, leaf scars, lenticels, scent, branching pattern, piths etc.
- Describe the history of Massachusetts forests.
- Explain forest ecology, including layers of a forest, succession, shade tolerances, fire, etc.
- Describe urban forest ecology.
- Describe forest silviculture and forest management options.
- Describe forest health methods and identify insect and disease specimens.
- Explain the environmental laws and rules and regulations of Massachusetts.

Test Format

Questions will reflect topics from the above outline. A resource kit will be provided containing a Peterson tree identification guide and tools for tree measurement. Students will be asked to identify up to 24 tree samples utilizing winter twigs, cones, acorns, bark, scent, piths, and individual leaves. They will also be asked to identify standing trees at the site. Students will be asked to identify and label various parts of a tree and explain their functions. There will be questions on insects and diseases, Massachusetts forest history, forest composition, percentage forested, species composition, major insects and diseases, volume figures on the various wood products and species associated with these facts. There will be hands-on questions with actual on-site measurements of flagged trees. There will also be a few questions on the various silvicultural and management options that would be most appropriate for this site. Expect generic questions on the types of management, silvicultural applications, and various state (Massachusetts) and federal laws, and rules and regulations that apply. There may be questions from other resources that are not found in this manual, but that can be found on the MassEnvirothon Website.

Key Massachusetts Forest Facts

The following Massachusetts facts are from the 2020 Massachusetts Forest Action Plan: https://www.mass.gov/info-details/massachusetts-forest-action-plan

While Massachusetts is the third most densely populated state in the country, it is also the 11th most forested state by percent forestland (Oswalt et al. 2019). The 3.2 million acres of forest in the Commonwealth makes up 63% of the state's area. These forestlands comprise state forests and reservations, town forests and conservation lands, small family forests, non-profit owned conservation land, commercially owned working forests, and even wooded backyards; each contributes to the multitude of essential benefits that forests provide to the Commonwealth and its residents.

More than 2.1 million acres of the forestland in Massachusetts is owned by private landowners. These lands are owned and managed for a variety of reasons ranging from aesthetic to economic. The Commonwealth is responsible for over 525,000 acres of forestland, the majority of which is managed by the Department of Conservation and Recreation or the Division of Fisheries and Wildlife. These lands are managed for the conservation of diversity in wildlife and plants, the protection of drinking water, recreation, ecosystem services, and a variety of wood products.

Municipalities protect 262,000 acres of land for similar public purposes including water supply protection, habitat, and public recreation. Nonprofit land trusts own 129,000 acres. Another nearly 196,000 acres in private ownership are protected from development by conservation restrictions.

Massachusetts has many forest habitats arising from variations in topography, bedrock soils, and climate, further shaped by land use history and the effects of natural disturbances like hurricanes, tornados, and ice storms. Human-use has played a particularly important role in how our forests look today. Massachusetts is in a transition zone between central and northern forest types. Coastal areas are covered with pitch pine and scrub oak forest, while inland forests are predominantly central and transition hardwoods. The higher elevations in the west are northern hardwoods and spruce fir forests. Transition hardwoods, dominated by oak species, cover the largest amount of area (O'Keefe and Foster 1998).

The forests and trees of Massachusetts collectively provide cascading benefits, including clean air and water, recreation, wildlife habitat, climate resiliency, and numerous forest products. While many of these ecosystem services cannot be replaced, the economic benefits of our forests must also be considered. Thousands of people are employed or engaged in activities to ensure that the people of Massachusetts have continued access to these diverse services.

Forest Facts	
Total Land Area (acres)	5,175,349
Forested Area (acres)	3,242,113
Timberland Area (acres)	2,874,000
Old Growth Forest (acres)	1,119
Highest Point	Mount Greylock - 3,491 feet
State Tree	American elm
Most Common Forest Trees	Red maple, eastern white pine, eastern hemlock, red oak
Forestland Owned by Private Landowners (acres)	2,193,496 (67.7% of Massachusetts forestland)
Average Number of Cutting Plans Filed Each Year	513
Growth to Harvest Removal Ratio on Timberland (in 2017)	6.8:1
Trees planted by the Urban and Community Forestry Program 2009-2019	46,035
Annual Gross Output of Massachusetts' Forest Products Industry	$3 Billion
People Employed in Forest Products Industry	17,000
Active Licensed Timber Harvesters	168
Land Lost to Development	13.5 acres a day
First Land Trust Stablished	1891, The Trustees of Reservations
Continuous Forest Inventory Plots	Since 1960, 102,000 trees monitored
Carbon stored on DCR-Division of State Parks and Recreation Forests in Soil and Standing Live and Dead Trees (million tons)	21.5

Other State Facts

STATE TREE
American Elm

FOREST PRODUCTS

Maple syrup	Wood pallets
Veneer	Paneling
Landscape ties	Lumber
Wood chips	Stock
Firewood	Flooring
Furniture	Specialty products

MEASUREMENTS

1 Cord	128 cubic feet ((4' x 4' x 8') or 1,536 Board Feet
1 Board Foot	1-inch thick by 1-foot by 1-foot
MBF	1 Thousand Board Feet or Roughly 2 cords
1 Acre	43,560 square feet or 208.7 feet squared (*Roughly the size of a football field)
1 mile	5280 feet, 1 square mile = 640 acres
1 gallon of maple syrup	40 gallons of maple sap boiled down

Trees to Know

Students should be able to identify the following common species by learning the characteristics of leaves, bark, buds, and twigs.

White pine
Red pine
Pitch pine
Eastern hemlock
Balsam fir
White spruce
Red oak
White oak
Black oak
Scarlet oak
Pignut hickory
Shagbark hickory
Red maple

Sugar maple
Norway maple
White ash
Black cherry
White birch
Gray birch
Yellow birch
Black birch
Eastern cottonwood
Quaking aspen
Bigtooth aspen
American elm
American sycamore

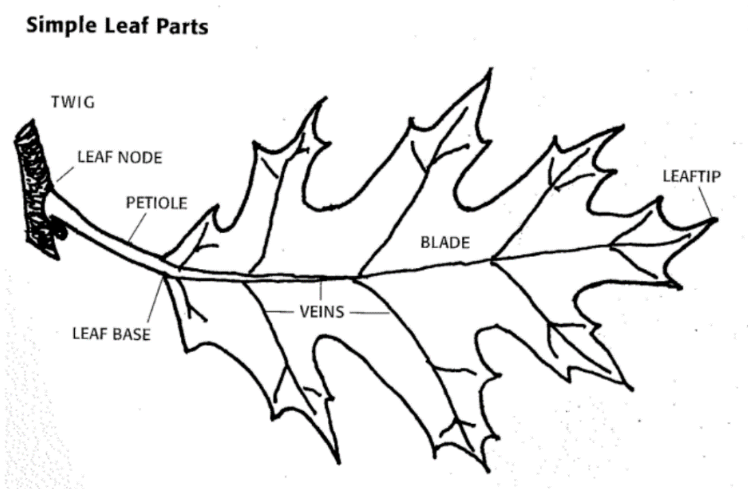
Sassafras
American beech
Flowering dogwood
Black walnut
Butternut
Black willow
Horse chestnut
Tupelo/Black gum
American basswood
American holly

It is suggested you obtain a good tree identification guide to supplement the following information

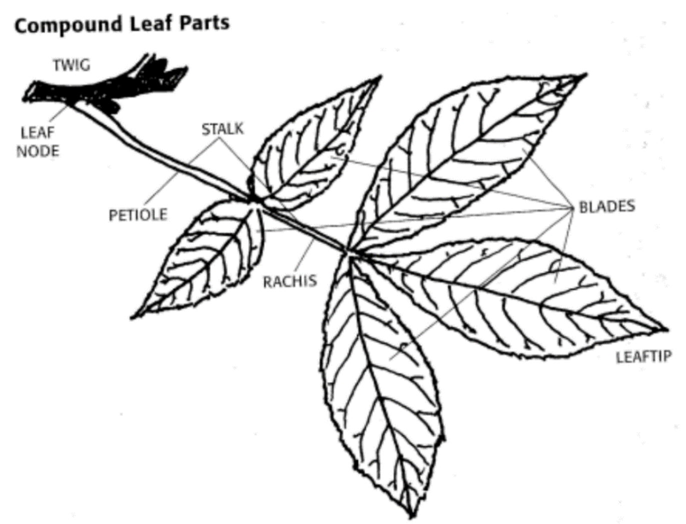
GENERAL IDENTIFYING FEATURES OF TREES AND SHRUBS

Correct identification of a tree should be based on a combination of features and not just one or two. In the warmer weather, leaves are commonly used to identify what type of tree you are looking at but often (especially in winter) other features will be needed to make a correct identification. Features that are common identification tools are:

Bark	Twigs	Leaves
Buds	Bundle scars	Fragrance
Overall shape	Location	Fruit/flowers



It is highly recommended that students become familiar with the different patterns, features, and terminology to properly identify trees. Practicing using a dichotomous key/field guide is the best way to learn how to identify an unknown tree. When choosing a key/field guide there are two things to remember. The first is to make sure it is specific to the location where you plan to use it. Don't use one designed for Florida when you are looking at trees in Massachusetts. The second thing is to use one you are comfortable using, each key/field guide uses the same basic premise but can have little nuances that will make it easier or harder for you to use.



Patterns

PATTERNS OF BUDS

Alternate

Opposite

Whorled

LEAF ARRANGEMENT

Alternate

Opposite

Whorled

LEAF PATTERN

Simple

Palmately Compound

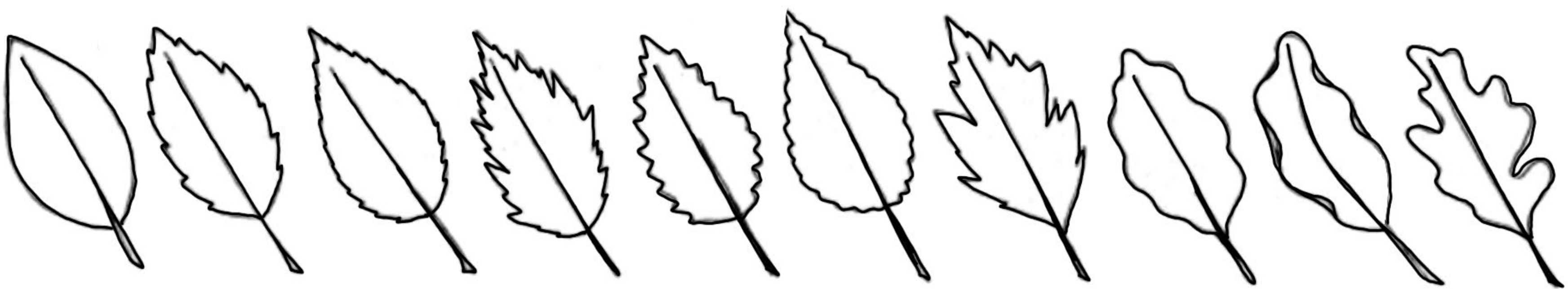
Pinnately Compound

Bi-Pinnately Compound

Leaves

BASES

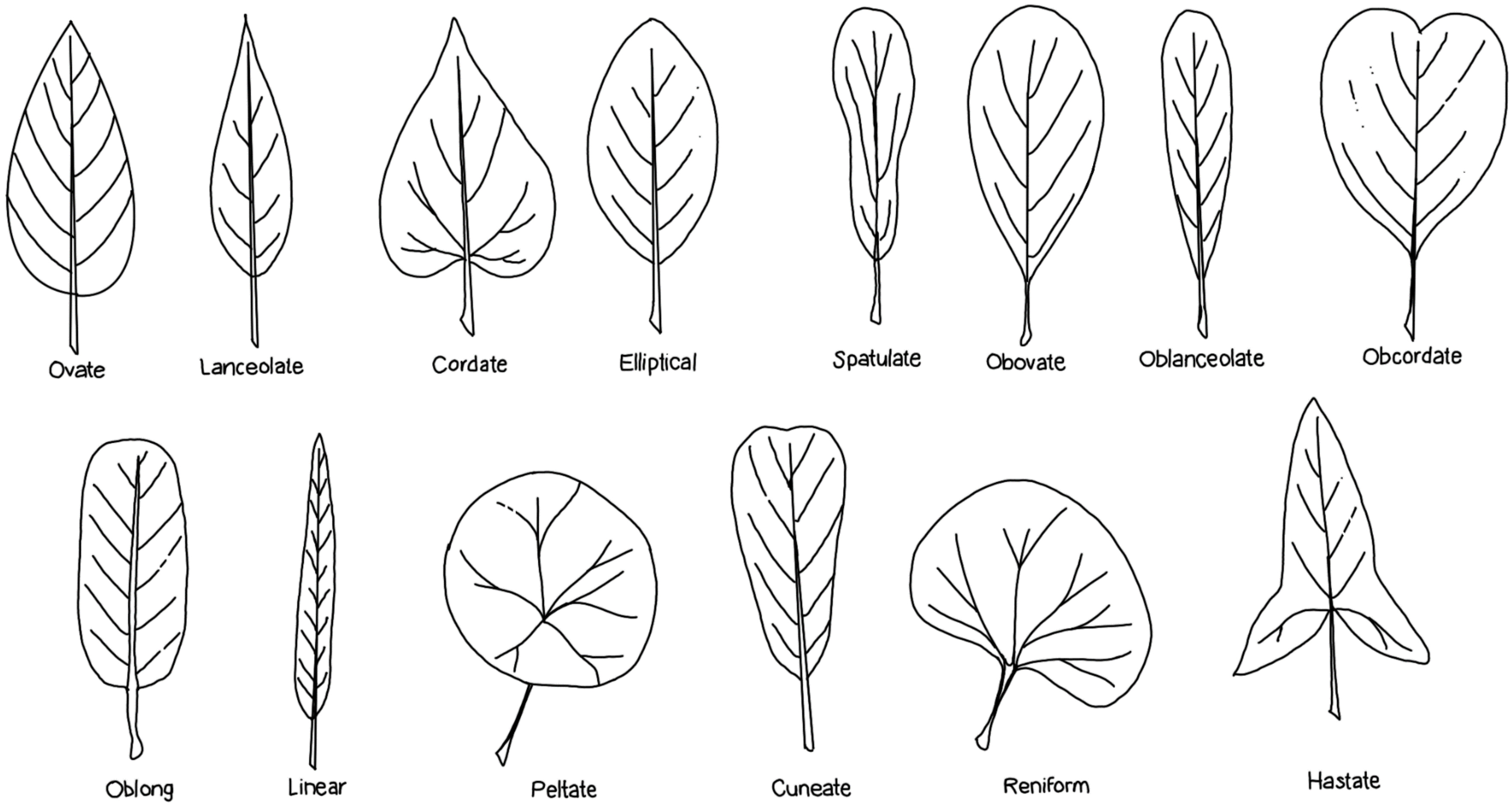
MARGINS



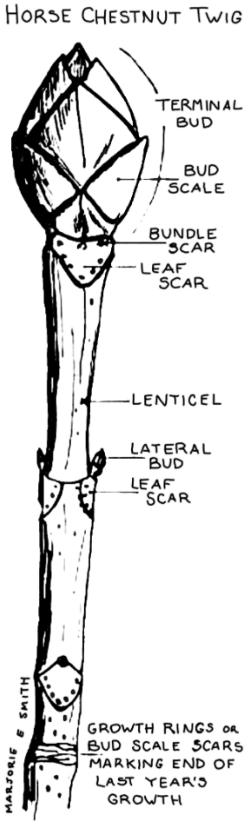
APICES

Leaf Shapes

The tremendous quantity of terminology related to leaf shapes can be confusing. Association of the following pictures with the terms will help to alleviate the burden of strict terminology. This also applies to leaf bases, margins, and apices.



HOW TO BE A TWIG DETECTIVE



Have you explored the miracle of buds? Observing ice quickly find them, large and small, on bushes and trees in a variety of sizes, shapes, and colors. To identify buds it is important to notice their arrangement on the twig. Are they in pairs or **opposite** each other? A few trees have their buds so arranged- maple, ash, horse chestnut, and dogwood are native eastern ones. Most buds are **alternate**, appearing first on one side of the twig then the other; elm, oak, birch, etc. Below the bud look for a **leaf scar**, left when the leaf fell off in autumn. It differs for each kind of tree. In the leaf scar are tiny dots or **bundle scars** which are the ends of veins that transported food and water between leaf and twig. The tiny dots may form a pattern, and even resemble a face in walnut and butternut.

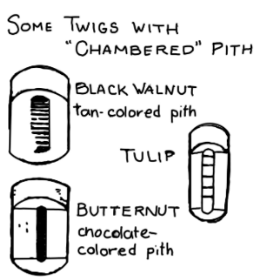
Buds are usually protected by several scaled. Willow is an exception and has a single, cap-like scale that covers the bud. This is easily seen in the pussy willow. Can you find the **terminal bud** of a twig when it has one? It is the largest bud at the very end, as in the maple. Buds along the sides of the twig are called **lateral buds**. Usually the larger buds contain flowers, or leaves and flowers, while the small ones are leaf buds. Open a large bud and look for these things.

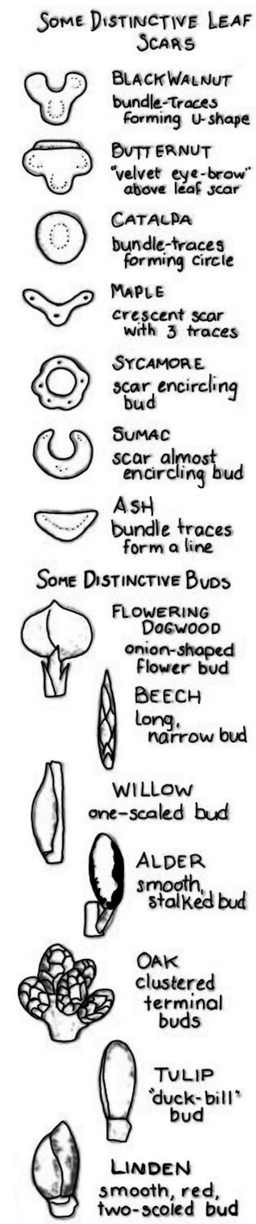
When the terminal bud is formed, that ends growth for the season. Some trees do not have terminal buds. In these cases, the twig keeps growing until food supply falls off. The twig then dies back to the last lateral bud, which becomes pseudo-(false) terminal bud with a small round scar (different from the leaf scars) at its base where the branch died back and fell off. These buds are usually set at an angle (examples: linden, elm, and sycamore).

Do you have little raised dots here and there along your twig? They are **lenticels** that allow oxygen into the branch (see "Word of the Month"). The dark lines on white birch bark are the lenticels.

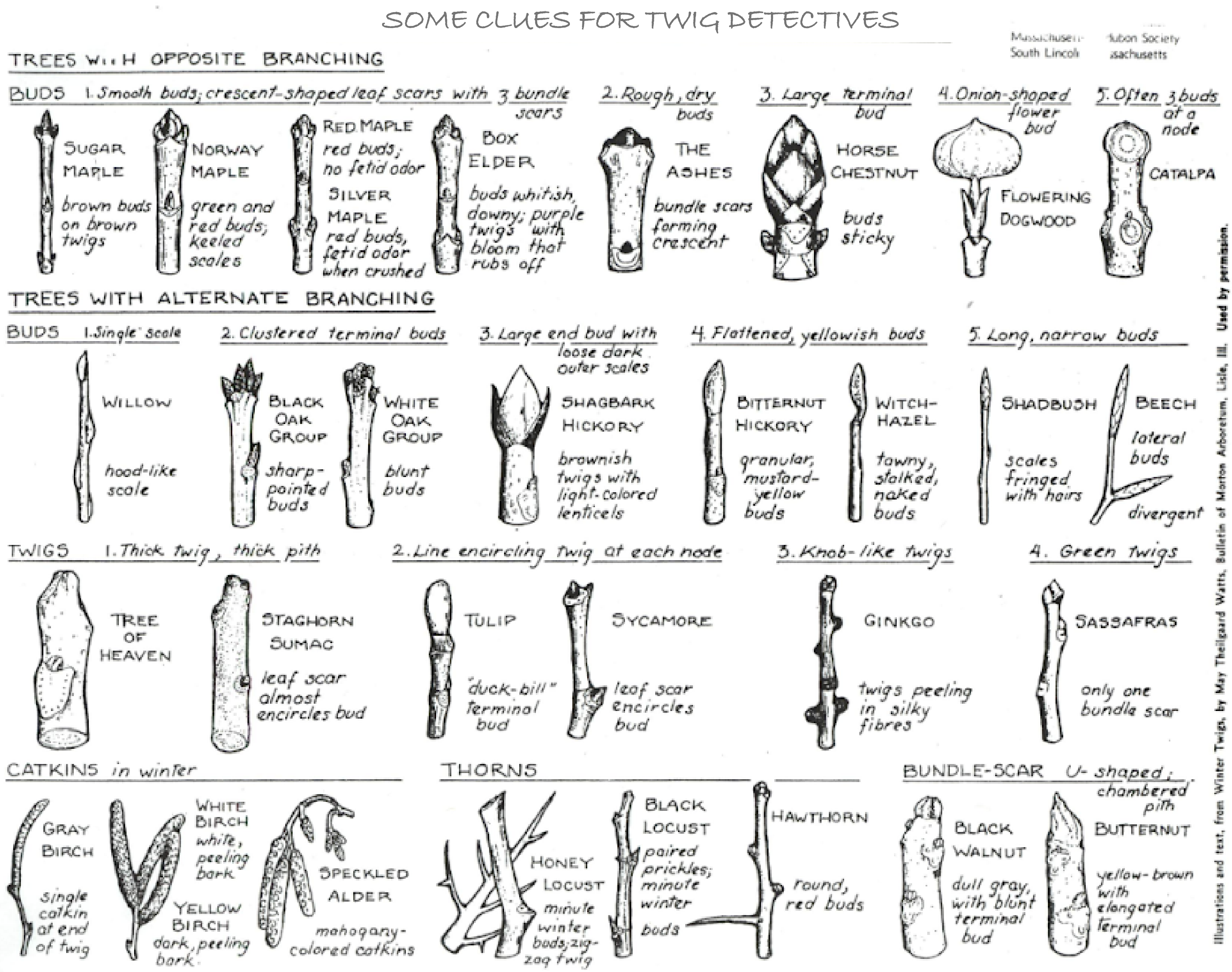
A few inches from the tip of your twig you may discover several lines or rings close together. These **growth rings** were left when the bud scales of last year's terminal bud fell off. They show last year's growth or how much the twig grew in one year. Now look for the next ring further down. That marked the end of the twig two years ago. Starting at the tip of the twig, count the growth rings to get the age of the twig. Be a twig detective.

Marjorie E. Smith



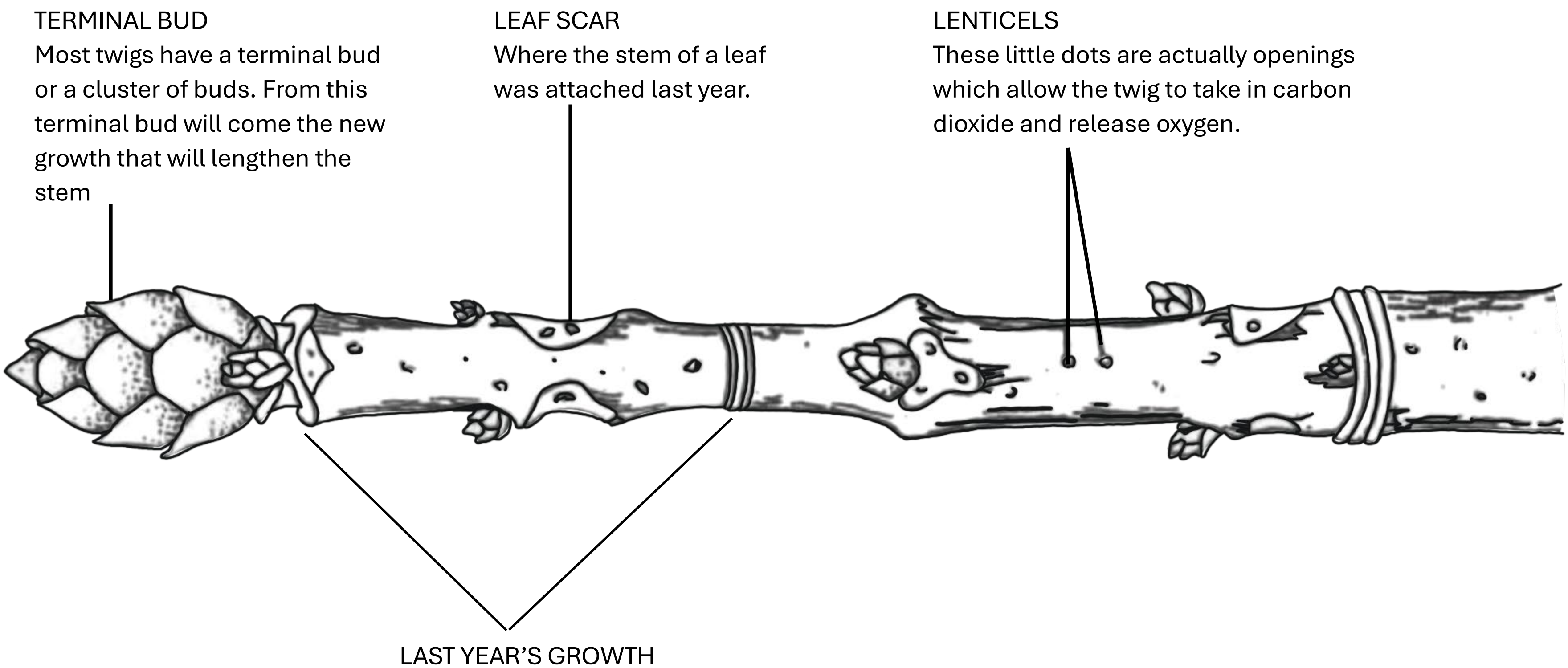


Small drawings by May T. Watts. Accompanying text adapted from her "WINTER TWIGS," a MORTON ARBORETUM BULLETIN


SOME CLUES FOR TWIG DETECTIVES
TREES WITH OPPOSITE BRANCHING
BUDS 1. Smooth buds; crescent-shaped leaf scars with 3 bundle scars
SUGAR MAPLE brown buds on brown twigs
NORWAY MAPLE green and red buds; keeled scales
RED MAPLE red buds; no fetid odor
SILVER MAPLE red buds, fetid odor when crushed
BOX ELDER buds whitish, downy; purple twigs with bloom that rubs off
2. Rough, dry buds
THE ASHES bundle scars forming crescent
3. Large terminal bud
HORSE CHESTNUT buds sticky
4. Onion-shaped flower bud
FLOWERING DOGWOOD
5. Often 3 buds at a node
CATALPA
TREES WITH ALTERNATE BRANCHING
BUDS 1. Single scale
WILLOW hood-like scale
2. Clustered terminal buds
BLACK OAK GROUP sharp-pointed buds
WHITE OAK GROUP blunt buds
3. Large end bud with loose dark outer scales
SHAGBARK HICKORY brownish twigs with light-colored lenticels
4. Flattened, yellowish buds
BITTERNUT HICKORY granular, mustard-yellow buds
WITCH-HAZEL tawny, stalked, naked buds
5. Long, narrow buds
SHADBUSH scales fringed with hairs
BEECH lateral buds divergent
TWIGS 1. Thick twig, thick pith
TREE OF HEAVEN
STAGHORN SUMAC leaf scar almost encircles bud
2. Line encircling twig at each node
TULIP "duck-bill" terminal bud
SYCAMORE leaf scar encircles bud
3. Knob-like twigs
GINKGO twigs peeling in silky fibres
4. Green twigs
SASSAFRAS only one bundle scar
CATKINS in winter
GRAY BIRCH single catkin at end of twig
WHITE BIRCH white, peeling bark
YELLOW BIRCH dark, peeling bark
SPECKLED ALDER mahogany-colored catkins
THORNS
HONEY LOCUST minute winter buds; zig-zag twig
BLACK LOCUST paired prickles; minute winter buds
HAWTHORN round, red buds
BUNDLE-SCAR U-shaped; chambered pith
BLACK WALNUT dull gray, with blunt terminal bud
BUTTERNUT yellow-brown with elongated terminal bud
Illustrations and text, from Winter Twigs, by May Theilgaard Watts, Bulletin of Morton Arboretum, Lisle, Ill. Used by permission.

Twig Illustration

Horse Chestnut in Spring



Parts of a Tree Cookie

Tree cookies are cross sections of tree trunks used to illustrate how trees grow (Figure 1).

- **Growth Ring** – one year of growth containing spring wood and summer wood.
    - The lighter portion is called the "early wood" or "spring wood" (because it grows in the spring)
    - The darker portion is called "late wood" or "summer wood" (which grows in the summer).
- **Heartwood** – Develops as a tree gets older. It is old sapwood that no longer carries sap. Heartwood gives the trunk support and stiffness. In some tree species, heartwood is a darker color than sapwood since its water-carrying tubes get clogged up.
- **Sapwood or Xylem** – Carries the sap (water plus nitrogen and mineral nutrients) back up from the roots to the leaves. Sapwood gives a tree its strength.
- **Cambium** – The growing part of the trunk. It annually produces new bark and new wood. a layer of cells, just one cell thick, inside the inner bark. The cambium produces both the xylem and phloem cells. This is where diameter growth occurs and where rings and inner bark are formed.
- **Medullary Ray** – Cells conducting materials across the tree. They run at right angles to the xylem and phloem which run vertically.
- **Pith** – the center of the tree trunk.
- **Inner Bark or Phloem** – Carries sugar made in the leaves/needles down to the branches, trunks, and roots where it is converted into the food. Lives for only a short time then dies and turns to cork to become part of the protective outer bark.
- **Outer Bark** – Protects the tree from injuries, insects, disease. Helps keep out moisture in the rain and prevents the loss of moisture when the air is dry. Insulates against cold and heat. Continually renewed from within.

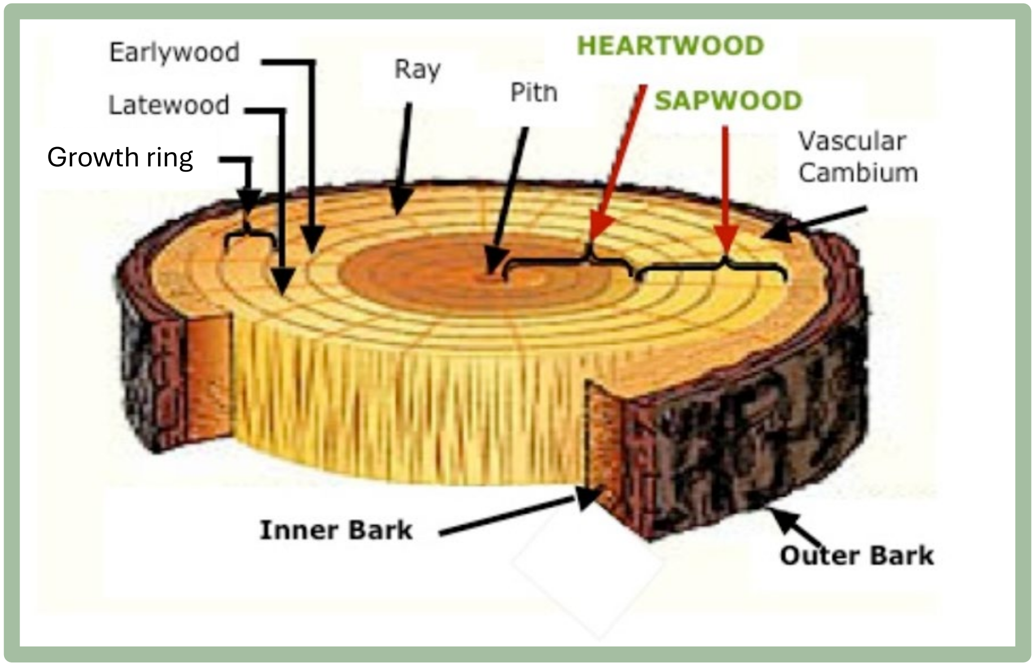


FIGURE 1 GRAPHIC FROM HTTPS://CWPERRY.ROCKYVIEW.AB.CA/MEMBERS/STWILSON/ASSIGNMENTS/SCIENCE/TREES-FORESTS/PARTS-OF-A-TREE-COOKIE/IMAGE_VIEW_FULLSCREEN.

Twig Identification

When trees lose their leaves, many people feel they also lose their identity, but a bare tree has its own stark beauty when its branching pattern and individual twigs become visible. Careful examination of its winter twigs reveals many distinguishing features about each kind of tree. The wide variety of shapes, colors, textures, and patterns are exciting to see and to learn about.

Twigs give a miniature account of the trees past, present, and future. At the tip of the twig or close to it, there should be a bud. Buds, formed the previous summer, are miniature branchlets containing next spring's leaves and flowers. These are protected by bud scales. The arrangement of which is characteristic for each tree species. Bud scales are modified leaves serving to protect the delicate growing point within the bud from drying out or being injured. Willows characteristically have only one bud scale, which unzips and comes off like a hood in spring. Maples have several overlapping scales, while oaks have many scales arranged in five rows (Figure 2).

Buds at the tip of the branch are called terminal buds. They mark the end of one season growth and contain the embryonic stages of the next season's growth. Last year's bud scales are also evident. Look for a narrow band of markings around the twig: the distance between the new terminal bud and last year's bud scale rings shows how much the twig grew in one year.

Oaks have a cluster of terminal buds. Aspens have a single terminal bud. Some trees like staghorn sumac, bigtooth aspen, and elms have pseudo, or false, terminal buds. These are the final lateral or side buds formed on the twigs during the growing season and are thus not centered at the end but pointed slightly to one side.

Buds on the side of the twig are called lateral buds and may contain flowers or leaves. When two sites of lateral buds occur on one twig, the larger usually contains flowers and the smaller leaves. The

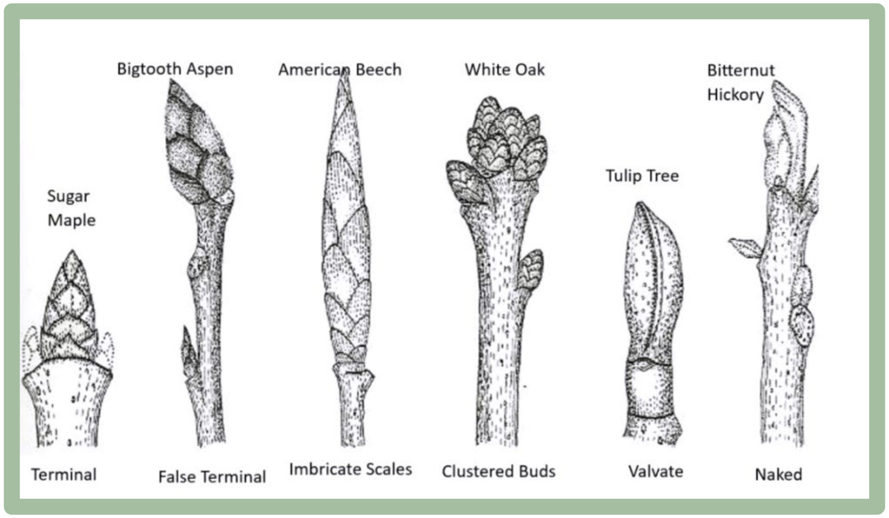


FIGURE 2 TERMINAL BUD TYPES

location of these buds in an opposite, alternate, or whorled pattern is useful in identifying specific trees. Opposite buds for example, will open to become twigs, growing opposite each other. These patterns are reflected in the branching pattern of the entire tree.

Only a few trees have opposite branching: an easy way to remember them is the acronym MADCAP HORSE. The letters stand for families:

M - **M**aple
A - **A**sh

D - **D**ogwood

CAP - **Cap**rifoliaceae (family including honeysuckle, elderberries, viburnums)

HORSE- **Horse** Chestnut.

Before leaves are shed each autumn, a corky layer develops across the leaf stem where it joins the twig. This is called the abscission layer; it gradually cuts off the supply of water and food. When the leaf drops off, only a scar is left behind on the twig. The shape of the leaf scar reflects the shape of the end of' the leaf petiole or stem. In most trees, it is an oval, a crescent, or a triangle, but in a few trees, such as sycamore and staghorn sumac, it is almost circular, enclosing a lateral bud. The veins that serve to conduct food and water between the leaf and the twig also leave scars (within the leaf scars). Referred to as bundle scars (Figure 3), they vary in numbers and patterns specific to different types of trees. In examining twigs carefully, one can find very interesting leaf scars (e.g., the butternut scar resembles a monkey face, with the bundle scars forming the monkey's eyes and mouth).

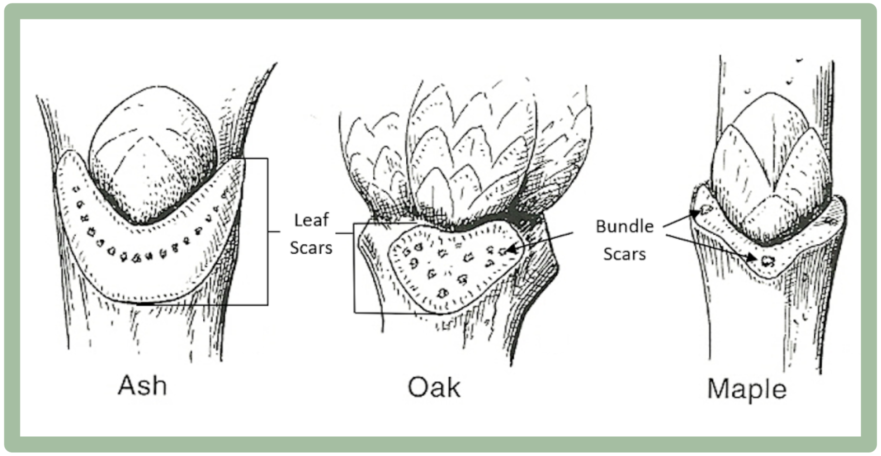


FIGURE 3 - EXAMPLES OF LEAF AND BUNDLE SCARS.

Lenticels are the corky vents through which gases are exchanged between the tree tissues and the outside air. The size, color, and density of these marks vary: on white birches, lenticels appear as dark horizontal lines, on cherry trees the horizontal lenticels are light colored and smaller than those of the birches, and on maple and alder twigs they are light colored dots. Color is another characteristic of different twigs. Some are red (dogwoods and striped maple), others golden yellow (weeping willows), and some vary from soft grays/browns to deep purples and bronze greens.

Twigs have one distinguishing feature that can only be seen by cutting through the twig itself. The very center is called the pith. The pith is composed of soft, spongy parenchyma cells which store and transport nutrients (Figure 4). It varies in color, shape, and structure. Years ago, the large central pith used to be pushed out of the twigs of some trees, such as elderberry and staghorn sumac, to make spouts for sugaring or whistles.

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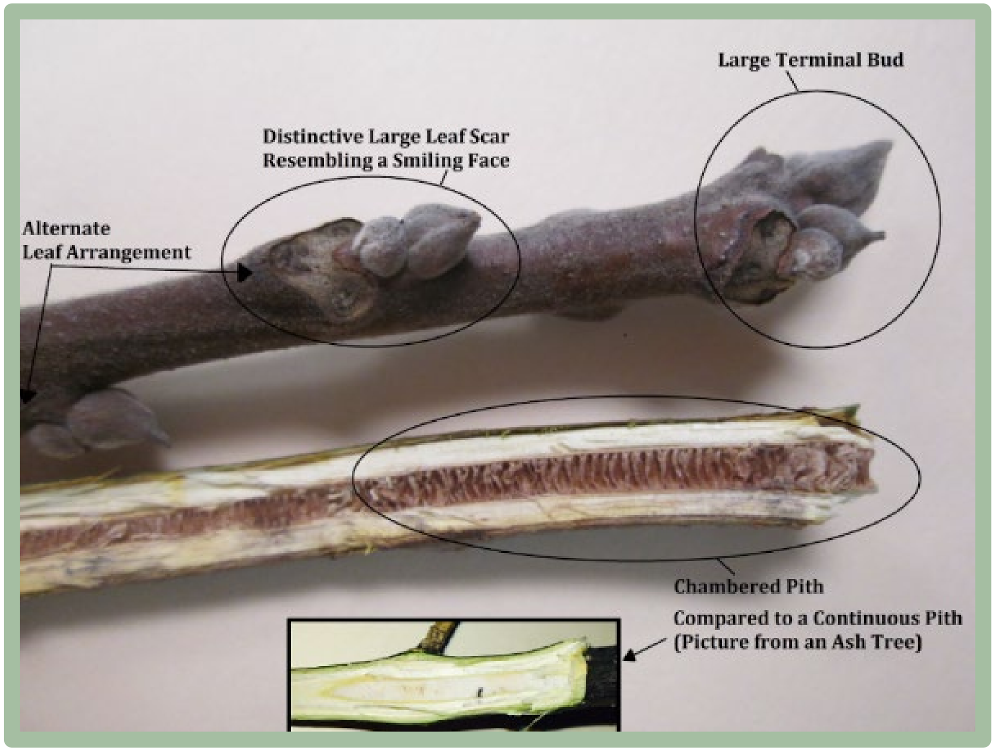


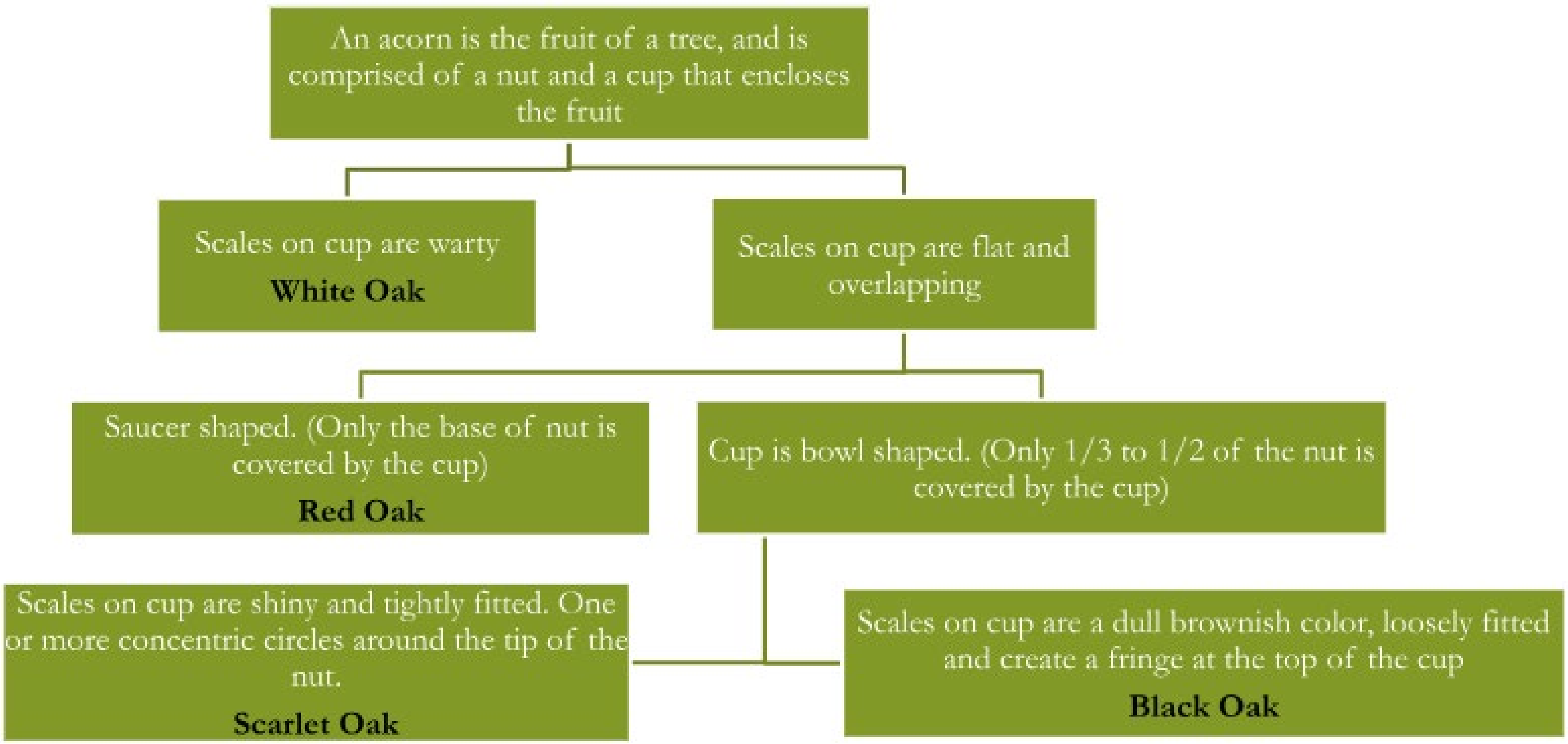
FIGURE 4 PHOTO FROM HTTPS://NYSPARKSNATURETIMES.FILES.WORDPRESS.COM/2015/01/BLACK-WALNUT-LS-E1420741653476.JPG

Sometimes the odor of a bruised twig is a nose worthy feature. Both black birch and yellow birch smell and taste like wintergreen. Cherry twigs have a strong bitter almond-like odor and taste.

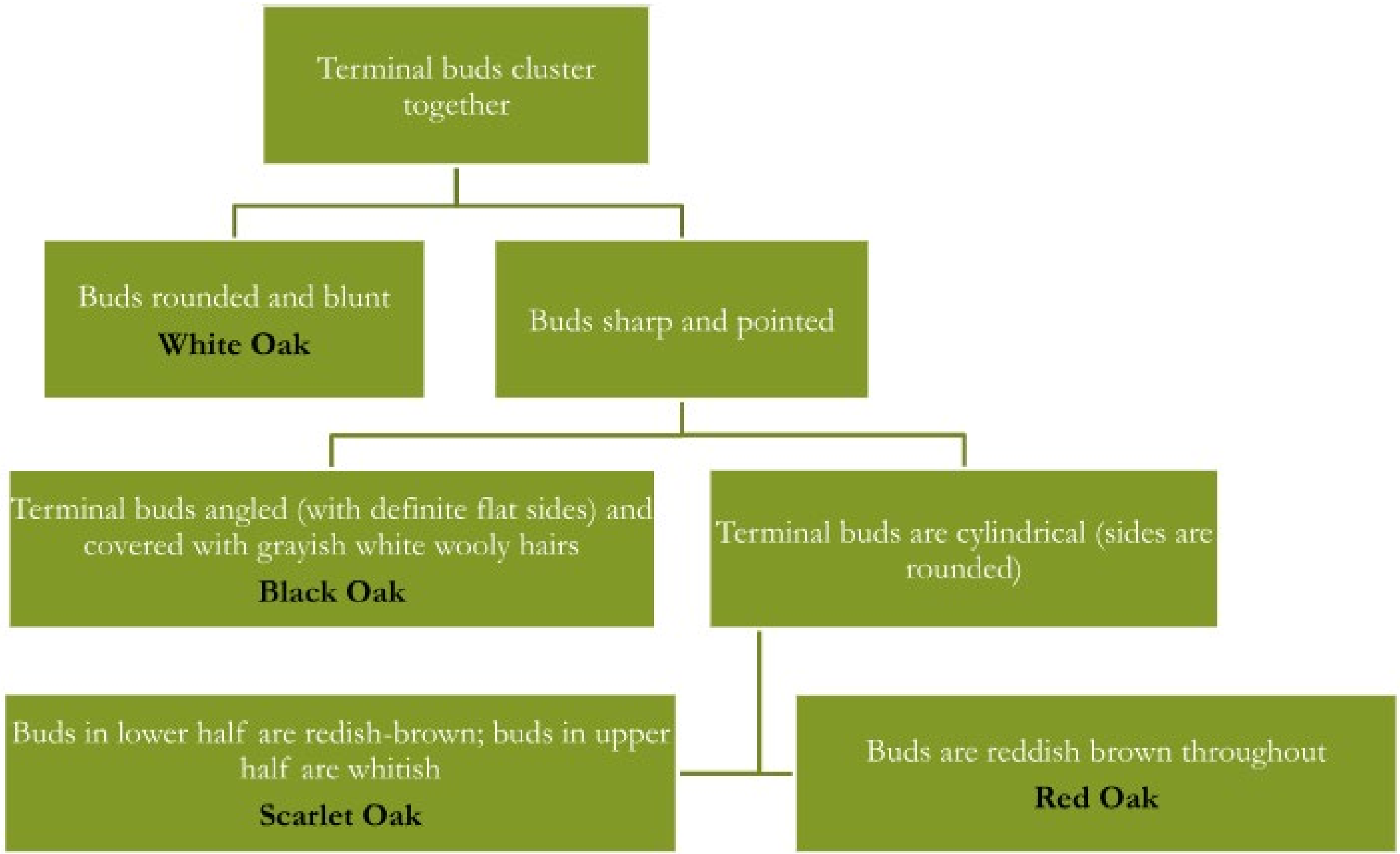
Winter trees may appear as lifeless skeletons against a somber landscape, but careful examination of their twigs reveals the prophecy of spring and the history of seasons gone by.

Key to Oaks

Key to Oaks Using Acorns



Key to Oaks Using Buds



To understand the forest, we must know the history of the forest; the forces that have shaped it and the interactions between humans, the forest, and nature.

The Massachusetts forest provides us with clean air and water, wildlife, food, wood products, and a variety of recreational opportunities. To obtain these benefits, we must understand what factors influence the forest, as well as the impacts of human activities.

Silviculture is the art and science of managing the vegetation in the forest to produce a desired effect and benefit. This can include any or all of the following: producing wood products, clean water, wildlife, recreation, control of pests, carbon sequestration, clean air, and aesthetics.

A Massachusetts Forest History

Before European settlers arrived in Massachusetts, natural disturbances played the dominant role in shaping the age and composition of forests, American Chestnut estimated at 25% of tree species. Hurricanes and other windstorms, outbreaks of disease and insects, and periodic fires caused dramatic and subtle changes to woodlands. Beaver activity is another large source of disturbance as well as ice scouring along rivers. First Nation or Indigenous tribes focused on the whole ecosystem but burned the forest to stimulate growth favored by game species, cleared land around major lakes and rivers for settlements, and harvested wood for cooking fuel. Because the indigenous population was small, the forests of Massachusetts were not greatly influenced by these practices. After European colonization, the impact from human activities on the development of forests surpassed the effects from natural disturbance.

The First Forest

European settlers found forests dominated by red oak, white pine, and hemlock. Wildlife species like elk, caribou, moose, mountain lion, and timber wolves roamed the woodlands. Species that prefer shrub and young dense forested conditions like deer, quail, skunk, grouse, and hare, were largely confined to settlement areas or younger forests that had been affected by natural disturbance.

Potash is the common name given to a group of minerals and chemicals that contain potassium, used as a fertilizer.

For the next 200 years, forests were cut to establish farms and to harvest wood for houses, barns, forts, furniture, fuel, charcoal, and **potash** (common name given to a group of minerals and chemicals that contain potassium, used as a fertilizer). By the early 1800s, only 20% of the land in Massachusetts was forested and the elk, caribou, and mountain lion had disappeared. Hunting and trapping caused a steep decline in wild turkey and beaver populations. One particularly ubiquitous legacy of this period is stone walls. Most were constructed between 1810 and 1840 as stone fences (wooden fence rails had become scarce) to enclose sheep within pastures, or to exclude them from croplands and hayfields. Clues to their purpose are found in their construction. Walls that surrounded pasture areas were comprised mostly of large stones, while walls abutting former cropland accumulated many small stones as farmers cleared rocks turned up by their plows.

During the 1800s, reports of fertile farmland to the west, the opening of the Erie Canal, the California Gold Rush, and the offer of free land to Civil War veterans were situations too tempting for the Massachusetts farmer to refuse. Many abandoned their farms and moved west.

The Second Forest

Trees with seeds capable of establishment in grassy pastures, like white pine and grey birch, began to form a forest in Massachusetts. By the early 1900s, the earliest farmland to be abandoned had grown into pine stands ready for harvest.

The opening of the Panama Canal and improved railroads expanded the marketplace from New England to the rest of the nation and the world. Containers were needed to ship commercial goods, and the white pine forests of Massachusetts provided wood for the manufacture of shipping crates. The heaviest commercial exploitation of the Commonwealth's forests to date followed, in 1908, at the peak of the "**boxboard boom**", when the sawmills of Massachusetts produced almost 400 million board feet of lumber. Today, production is about one quarter of that figure.

After the pine was harvested, the young oaks and maples already established grew quickly to form the next forest. This was a great boon to deer, and in 1910, a century-long ban on deer hunting was lifted. Populations of black bear, wild turkey, and beaver were still in decline.

The Third Forest

Exploitation of forests nationally and within the Commonwealth during the turn of the 20th century stimulated the conservation movement. In Massachusetts, The Trustees of Reservations and the Massachusetts Forestry Association were formed to address public concern over the fate of forest resources. These groups raised public and private funds to acquire large parcels of land including the Mt. Greylock, Middlesex Fells, and Blue Hill Reservations. In 1904, the legislature created the office of the State Forester, and by 1910 staff was in place to work on **the spongy moth** (formerly known as gypsy moths) epidemic, create a scientific system for forest management, and raise tree seedlings in plant nurseries. A State Forest Commission was established and in 1915, the first state forest, the Otter River State Forest in Winchendon and Templeton, was purchased.

Insects, diseases, and natural disasters changed the composition of the forest at this time. A fungus imported from England introduced the **chestnut blight** and within 15 years, the tree that was estimated to compose about 25% of the forest was virtually eliminated from the eastern United States. American chestnut had been one of the primary components of the Massachusetts forest, providing durable lumber and food for wildlife. **Dutch Elm disease** was also established in the early 1900s, and has slowly killed most American Elms, the state tree of Massachusetts. The population of spongy moths reached epidemic proportions at this time, defoliating thousands of acres of white and red oak. The Great Hurricane of 1938 roared through Massachusetts and blew down 880 million board feet of timber, five and a half times the current annual harvest.

The wood products industry languished during the Depression. Mobilization for the war effort brought renewed activity for forest industries, but generally, this was a period of low exploitation. Hardwood stands that were established after the white pine was cut were not mature enough for harvest, and the abundance of natural gas and oil made cordwood less popular.

Boxboard boom refers to a time of period when the sawmills of Massachusetts produced almost 400 million board feet of lumber. Today, production is about one quarter of that figure.

Spongy moth, previously known as gypsy moths, is a foliage-feeding insect and forest pest that targets deciduous trees.

Chestnut blight is a fungal disease of chestnut trees (Castanea spp.) that hat grows underneath the bark, resulting in cankers that slowly develop and surround the infected trunk, stem or branch.

Dutch Elm Disease is a lethal fungal disease of elm trees transmitted when bark beetle vectors feed on twigs or small branches. As the beetles feed, they introduce the pathogen spores attached to their body into the sapwood.

After the war, many people left urban areas to move to the country. As farming became less profitable, farmers sold cropland and forests for housing development.

This trend continues today as development pressures on forestland intensify. The following chart from the 2020 Massachusetts Forest Action Plan exemplifies this trend (Figure 5).

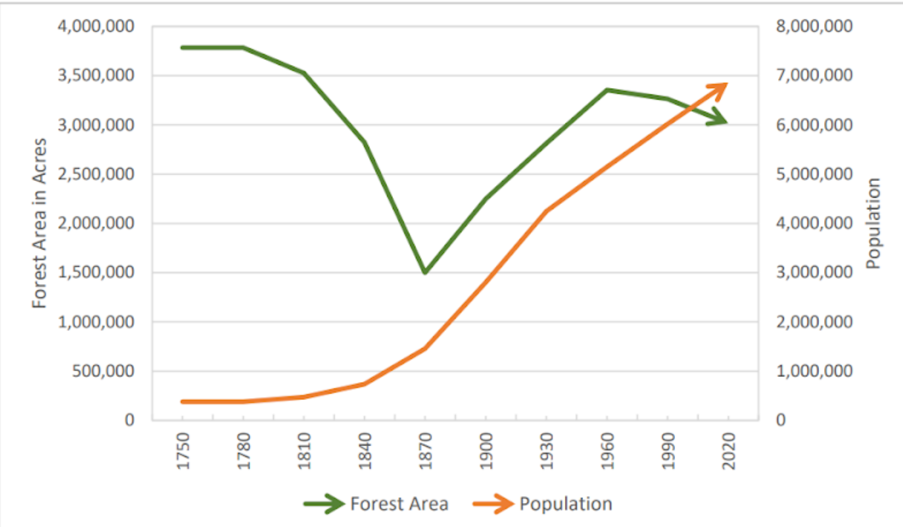


Figure 1.2. The trend of Massachusetts forest area (acres, left axis) and population (right axis) over time (data: Foster and Gould 2009, FIA EVALIDator 2017, US Census).

FIGURE 5 - THE TREND OF MASSACHUSETTS FOREST AREA (ACRES, LEFT AXIS) AND POPULATION (RIGHT AXIS) OVER TIME.

Forest Stewardship in Massachusetts Forests

Massachusetts is a small state, but it contains a tremendous variety of ecosystems, plant and animal species, management challenges, and opportunities.

Biological diversity is, in part, a measure of the variety of plants and animals, the communities they form, and the ecological processes (such as water and nutrient cycling) that sustain them. With the recognition that each species has value, individually and as part of its natural community, maintaining biodiversity has become an important resource management goal.

While the biggest threat to biodiversity in Massachusetts is the loss of habitat to development, another threat is the introduction and spread of invasive, non-native plants. Non-native, invasive species like European buckthorn, Asiatic bittersweet, garlic mustard, and Japanese barberry spread quickly, crowding out or smothering native species and upsetting and dramatically altering ecosystem structure and function. Once established, invasive species are difficult to control and even harder to eradicate. Therefore, vigilance and early intervention are paramount.

Another factor influencing biodiversity in Massachusetts relates to the amount and distribution of forest growth stages. Wildlife biologists have recommended that, for optimal wildlife habitat on a landscape scale, 5-15% of the forest should be in the seedling stage (less than 1" in diameter). Yet we currently have no more than 2-3% **early successional stage** seedling forest across the state. There is also a shortage of forest with large diameter trees (greater than 20").

Rare species include those that are **threatened**, those of **special concern**, and **endangered**. Some species are rare, threatened, or endangered globally, while others are common globally, but rare in

Early successional stage is the only period when tree canopies do not dominate the forest site, and so this stage can be characterized by high productivity of plant species (including herbs and shrubs), complex food webs, large nutrient fluxes, and high structural and spatial complexity.

A threatened species is abundant in parts of its range but declining in total numbers.

A species of special concern is any species that has suffered a decline that could threaten the species if left unchecked.

An **endangered species** is at immediate risk of extinction and probably cannot survive without direct human intervention.

Massachusetts.

Of the many native plant and animal species living in Massachusetts, 432 are state listed and protected under the Massachusetts Endangered Species Act (MESA, MGL c. 131a) and its implementing regulations (321 CMR 10.00). Some of these species are also listed and protected under the U.S. Endangered Species Act (16 U.S.C. c 35 s. 1531). The Commonwealth's forests provide habitat for multiple state-listed species including plants, reptiles, amphibians, birds, insects, fish, and mollusks. Maintaining forested land in forest use is vital to preserving viable populations of state listed species such as the wood and Eastern box turtles, blue-spotted, Jefferson and marbled Salamanders, and rare plants including climbing fern. However, forest managers need to recognize that harvesting can potentially result in direct mortality to individual species as well as a decline in the integrity of the woodland ecosystem these species rely on.

Priority and Estimated Habitat maps are used for determining whether an area is mapped as rare species habitat and required review by Natural Heritage & Endangered Species Program (NHESP) for compliance with the Massachusetts Endangered Species Act (MESA). These maps can be viewed at https://rb.gy/i5vs7r . It is the responsibility of the landowner or project proponent to determine if their project falls within **Priority Habitat** or **Estimated Habitat**. In collaboration with the Department of Conservation and Recreation (DCR), the University of Massachusetts Extension Service, and Massachusetts Division of Fisheries and Wildlife (MassWildlife) forestry staff, NHESP developed specific guidelines for working in habitats of state-listed rare species, which provide the opportunity to ensure that management activities will not have a negative impact on a listed species, and in some cases forestry activities can be tailored to promote or enhance these species. The guidelines, called Forestry Conservation Management Practices (CMPs), provide guidance for proactively developing and executing a **Forest Cutting Plans (FCP)** that will mitigate risks, and potentially improve, those state-listed rare species and their habitats. CMPs are available via this link https://rb.gy/9qrah2 . In addition, NHESP developed rare species fact sheets. These are available at https://rb.gy/4vh6bk .

Forest management proposed within these habitats requires review by the NHESP. If forest management is proposed as part of a Forest Cutting Plan, the DCR Service Forester will submit the plan to NHESP for review. The plan is reviewed to determine what actions taken during the project are most appropriate to preserve the listed species and/or their habitat.

If the project site is only in Priority Habitat, there is a 10-day deadline to issue a determination letter to the DCR. If the project is within both Priority Habitat and Estimated Habitat, the deadline is 15 business days. NHESP sends the review letter to the DCR Service Forester indicating whether any modifications to the FCP are necessary to avoid harm to state-listed rare species or their habitats. The DCR Service Forester then modifies the FCP to incorporate the modifications before final approval. The DCR Service Forester will also meet on-site with a representative from the NHESP if there are questions or concerns related to the recommendations.

Please note that activities secondary to, but associated with, forest management such as invasive species management, post-management restoration, or installation of access gates may be submitted as part of the FCP. However, certain activities such as the

Areas delineated as **Priority Habitats** are protected and can include wetlands, uplands, and marine habitats.

Estimated Habitats are subsets of Priority Habitats of Rare Species. They are based on occurrences of rare wetland wildlife observed within the last 25 years and documented in the NHESP database.

A **Forest Cutting Plan** includes information such as: landowner name and address, property location, Best Management Practices used for stream and wetland crossings, harvesting in wetlands, type of cutting being proposed for the property, and the volume of products to be harvested. At least two maps need to be included as a part of the Forest Cutting Plan.

installation of permanent wetland crossings and permanent upgrades to or permanent additions of forest roads, skid roads, and landings may require review under a MESA Project Checklist (https://rb.gy/6unznh).

For foresters and forest landowners who are interested in receiving additional guidance on how to incorporate rare species into their forest management planning process, the Natural Heritage and Endangered Species Program recommends requesting a pre-file consultation by contacting the NHESP FCP Review Biologist at 508-389-6354. For additional information, please go visit: https://www.mass.gov/info-details/forestry-and-rare-species-review.

To protect wetlands and riparian areas and to prevent soil erosion during timber harvesting activities, Massachusetts requires the use of Best Management Practices (BMPs), which can be viewed and downloaded at https://www.mass.gov/doc/massachusetts-forestry-best-management-practices-manual-0/download). Maintaining or reestablishing the protective vegetative layer and protecting critical areas are the two rules that underlie these common-sense measures. Department of Conservation and Recreation details both the legally required and voluntary specifications for log landings, skid trails, water bars, buffer strips, filter strips, harvest timing, and much more.

The two Massachusetts laws that regulate timber harvesting in and around wetlands and riparian areas are:

The Massachusetts Wetlands Protection Act (CH 131, https://malegislature.gov/Laws/GeneralLaws/PartI/TitleXIX/Chapter131)

The Forest Cutting Practices Act (CH 132, https://malegislature.gov/Laws/GeneralLaws/PartI/TitleXIX/Chapter132%20)

Among other things, CH 132 requires the filing of a cutting plan and on-site inspection of a harvest operation by a DCR Service Forester to ensure that required BMPs are being followed when a commercial harvest exceeds 25,000 board feet or 50 cords (or combination thereof).

Soil and Water Quality

Forests provide a very effective natural buffer that holds soil in place and protects the purity of our water. The trees, understory vegetation, and the organic material on the forest floor reduce the impact of falling rain and help to ensure that soil will not be carried into our streams and waterways.

Rocks as small as tiny clay particles and larger that are moved by the water are called **sediment**. Fast-moving water can pick up, suspend, and move larger particles more easily than slow-moving waters. This is why rivers are more muddy-looking during storms.

To maintain a supply of clean water, forests must be kept as healthy as possible. Forests with a diverse mixture of vigorous trees of different ages and species can better cope with periodic and unpredictable stress such as insect attacks or windstorms.

Timber harvesting must be conducted with the utmost care to ensure that erosion is minimized, and that **sediment** does not enter streams or wetlands. Sediment causes turbidity, which degrades water quality and can harm fish and other aquatic life. If Best Management Practices (BMPs) are implemented correctly, forest management activities can be conducted without harming water quality.

Forest Health

Like individual organisms, forests vary in their overall health. The health of a forest is affected by many factors including weather, soil, insects, diseases, air quality, and human activity. Forest owners do not usually focus on the health of a single tree but are concerned about catastrophic events such as insect or disease outbreaks that affect so many individual trees that the whole forest community is impacted.

Like our own health, it is easier to prevent forest health problems than to cure them. This preventative approach usually involves two steps. First, it is desirable to maintain or encourage a wide diversity of tree species and age classes within the forest. This diversity makes a forest less susceptible to a single devastating health threat. Second, by thinning out weaker and less desirable trees, well-spaced healthy individual trees are assured enough water and light to thrive. These two steps will result in a forest of vigorously growing trees that are more resistant to environmental stress.

Fire

Most forests in Massachusetts are relatively resistant to catastrophic fire. Historically, First Nations or Indigenous peoples commonly burned certain forests to improve hunting grounds. In modern times, fires most often result from careless human actions. The risk of an unintentional and damaging fire in your woods could increase from logging activity if the **slash** is not treated correctly.

Adherence to the Massachusetts slash law minimizes this risk. Under the law, slash is to be removed from buffer areas near roads, boundaries, and critical areas and lopped close to the ground to speed decay and arranges fuels closer to the ground making any fires that may occur in the area less dangerous and easier to control. Well-maintained woods roads are always desirable to provide access should a fire occur.

Depending on the type of fire and the goals of the landowner, fire can also be a management tool to favor certain species of plants and animals. The use of **prescribed burning** is largely restricted to the coast and islands, where it is used to maintain unique natural communities such as sandplain grassland and pitch pine/scrub oak barrens. However, state land managers are also attempting to bring fire back to many of the fire-adapted communities found elsewhere around the state. Fire management is discussed in greater detail in the Fire and Forest chapter.

Wildlife Management

Enhancing the wildlife potential of forested property is a common and an important goal for many woodland owners. Sometimes actions can be taken to benefit a particular species of interest (e.g., put up Wood Duck nest boxes). In most cases, recommended management practices can benefit many species, and fall into one of three broad strategies; these are managing for diversity, protecting existing habitat, and enhancing existing habitat. Woodland is important because it contributes to the surrounding landscape and has the potential to increase diversity and protect or enhance wildlife habitat. Wildlife management is discussed in greater detail in the wildlife section of this manual.

Wood Products

If managed wisely, forests can produce a periodic flow of wood products on a sustained basis. Stewardship encompasses finding ways to meet your current needs while protecting the forest's ecological integrity. In this way, you can harvest timber and generate income without compromising the opportunities of future generations.

Massachusetts forests grow many highly valued species (e.g., white pine, red oak, sugar maple, white ash, and black cherry) whose lumber is sold throughout the world. Other lower valued species (e.g., Eastern hemlock, birch, beech, red maple) are marketed locally or regionally and become products like pallets, pulpwood, firewood, and lumber. These products and their associated value-added industries significantly contribute to the Massachusetts economy.

By growing and selling wood products in a responsible way it is helping our society's need for these goods. You are also reducing the demand for wood that is produced in areas of the county or world that do not have our strict environmental regulations. Harvesting from sustainably managed woodlands – rather than from unmanaged or poorly managed forest – benefits the everyone. The sale of wood provides income that can be reinvested in the property, which can increase its value. Producing wood products helps offset the costs of owning

The term **slash** is used to refer to woody debris such as treetops and branches generated as a result of logging activities or natural forest disturbances such as wind and storms.

Prescribed fires, also known as **prescribed burns**, refer to the controlled application of fire by a team of fire experts under specified weather conditions to restore health to ecosystems that depend on fire.

woodland and helps private landowners keep their forestland undeveloped.

Cultural Resources

Cultural resources are the places containing evidence of people who once lived in the area. Whether a First Nations or Indigenous people's village from 1,700 years ago, or the remains of a farmstead from the 1800's, these features all tell important and interesting stories about the landscape and should be protected from damage or loss.

Recreation and Aesthetic Considerations

Recreational opportunities and aesthetic quality are the most important values for many forest landowners. Removing interfering vegetation can open a vista or highlight a beautiful tree, for example. When a landowner's goals include timber, thoughtful forest management can be used to accomplish silvicultural objectives, while also reaching recreational and/or aesthetic objectives. For example, logging trails might be designed to provide a network of cross-country ski trails that lead through a variety of habitats and reveal points of interest.

KNOWLEDGE CHECK

A Massachusetts Forest History

- What were the main differences between the first, the second and the third forest?
- Why was the State Forest Commission was established?
- What were some of the diseases occurring in the Third Forest in Massachusetts?

Forest Stewardship in Massachusetts Forests

- What are some of the current threats to Massachusetts forests' biodiversity?
- What does NHESP stand for and what is its purpose?
- What are the two Massachusetts laws that regulate timber harvesting in and around wetlands and riparian areas?

Soil and Water Quality

- How do forests impact soil and water quality?

Forest Health

- What are the two steps in the preventative approach to forest health?

Fire

- What is slash and what is its role in forest fires?

Wildlife Management

- What exactly does the term wildlife management mean in respect to forests?

Wood Products

- What are the benefits of consuming local wood products?

Cultural Resources

- What are cultural resources?

Recreation and Aesthetic Considerations

- Imagine you own 50 acres of woods. What are some of the activities you'd like to do there?

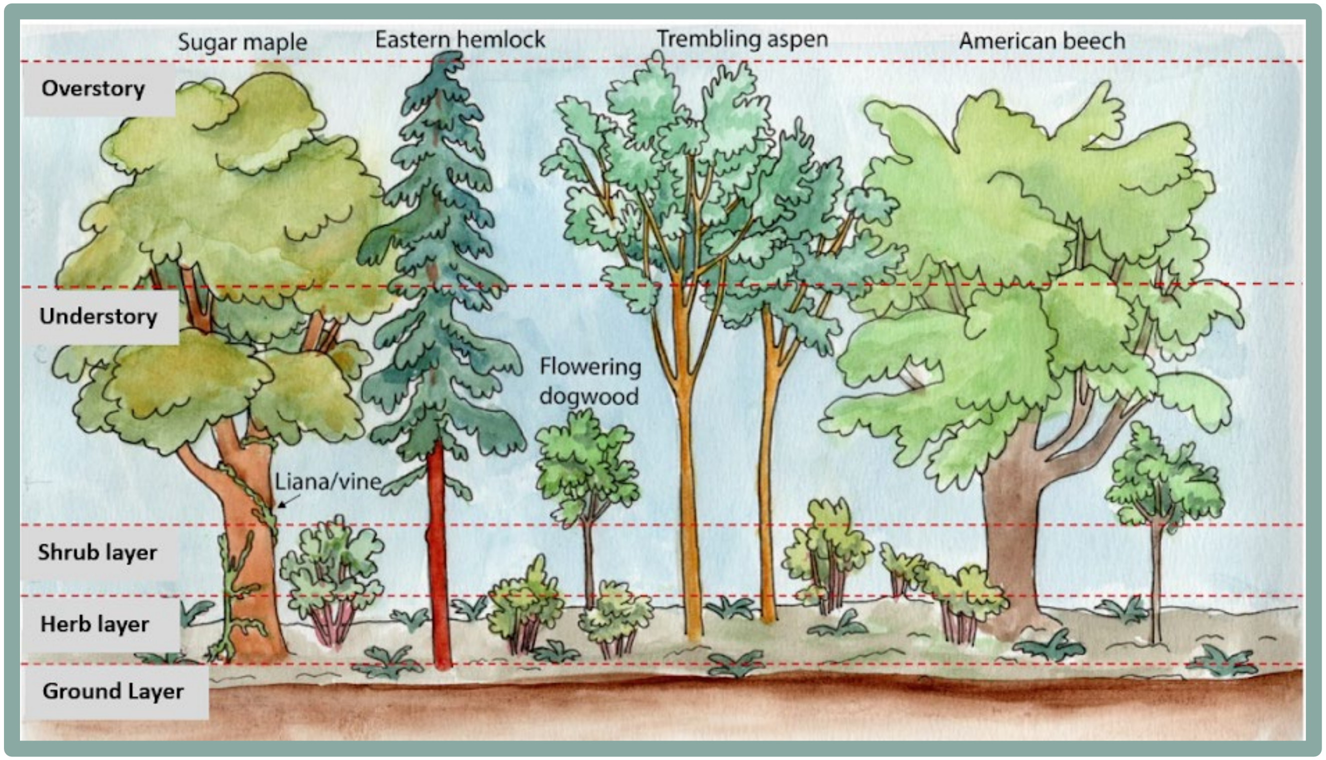


FIGURE 6 ARTWORK BY SARA HEWITT-WOOD

Forest Ecology

Forest Layers

Trees, plants, and vegetation form several vertical layers in a forest; from the top down, these layers are the overstory, the midstory, the understory, shrub layer, herbaceous layer, and the ground layer (Figure 6).

The overstory or topmost level, is made up of the following crown classes: large dominant and co-dominant tree species which receive sunlight on 2-4 sides of the tree's crowns. These species usually grow best when they are in full sun.

The midstory, or the intermediate layer, is made up of trees that receive sunlight only on the top.

The understory, or the suppressed layer, is made up of trees that are shaded by the overstory and the midstory. This level may be made up of smaller tree species and shade-tolerant (i.e., can grow well under low-light conditions) species such as dogwood or hornbeam.

The shrub layer is made up of woody shrubs such as gooseberry and highbush cranberry.

The herbaceous layer is the most diverse and contains mostly non-woody species. Grasses, sedges, and wildflowers all grow in the herbaceous layer. Vines, such as Virginia creeper and poison ivy, climb from this layer, as far as to the overstory to reach the sunlight.

The ground layer, or forest floor, is composed of the soil builders and stabilizers: the fungi, mosses, liverworts, and lichens.

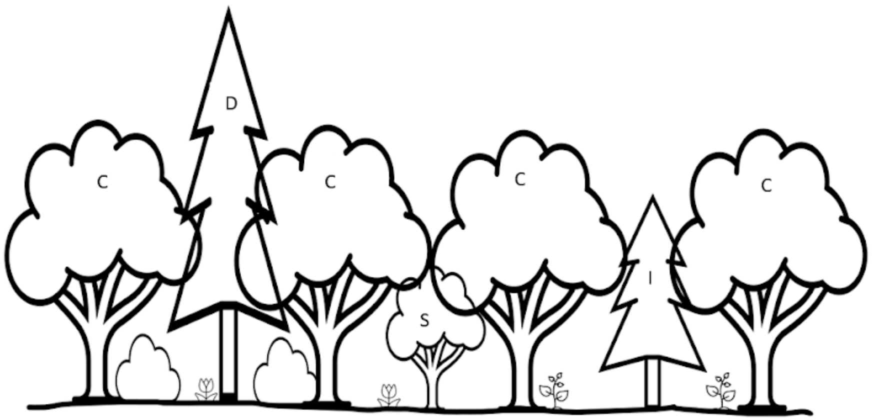


FIGURE 7 CROWN CLASSES OF THE FOREST CANOPY. D= DOMINANT, C= CO-DOMINANT, I=INTERMEDIATE, S= SUPPRESSED.

The vertical layers of a forest, or the stratification of a forest, can be identified as a group, as seen in Figure 6. Whereas, in Figure 7, each individual tree can be assigned a position, as well.

Forest Succession

Succession in a plant community can be defined as a process of changes in the species composition of the community over time. Succession usually begins after some type of disturbance occurs and creates open ground. This disturbance could be caused by natural events such as fire, flood, storm, or glacier. Human cause specific types of disturbances, with important goals and objectives, during forest management activities.

If disturbed areas are left to re-vegetate on their own, pioneer species appear first. These species have colonizing characteristics such as rapid growth, abundant seed production, and seeds that are easily dispersed. Most pioneer species are not well adapted to sites where root competition and shading may hinder their growth and are usually short-lived.

The pioneer species may give way to shrubby vegetation, after having added organic matter to the soil and stabilizing the site. Shade intolerant tree species, which do not grow well under low light conditions, may grow with shrubby vegetation. Under the shrubs, elm, ash, and juniper seedlings – more shade tolerant tree species– begin to appear. Their seeds are kept moist and protected by the leaf litter layer produced by the shrubs and sun-loving trees (Figure 8)

Next, oaks, hickories, and other hardwoods begin to appear. These trees are semi-shade tolerant as they can grow in low light, but they tend to do better in full sun. Red spruce, balsam fir, sugar maples and basswoods, which are shade tolerant, can reproduce under their own shade. Both groupings are considered mature forest species or a climax community. In the shade of these mature trees, the shrub layer becomes less dense, and the herbaceous layer develops. Mature forest species are usually long-lived and produce seeds that are not easily dispersed; however, they provide extra energy for seedlings growing under an established canopy.

Many factors influence what type of stable plant community, or climax community, develops on a certain site. The soil type, climate, and animals in the area all influence the vegetation. It takes hundreds of years for a climax community to develop. A climax community experiences slight fluctuations in species composition throughout time. The health of the system can be affected by changes in just one of these working forest pieces.

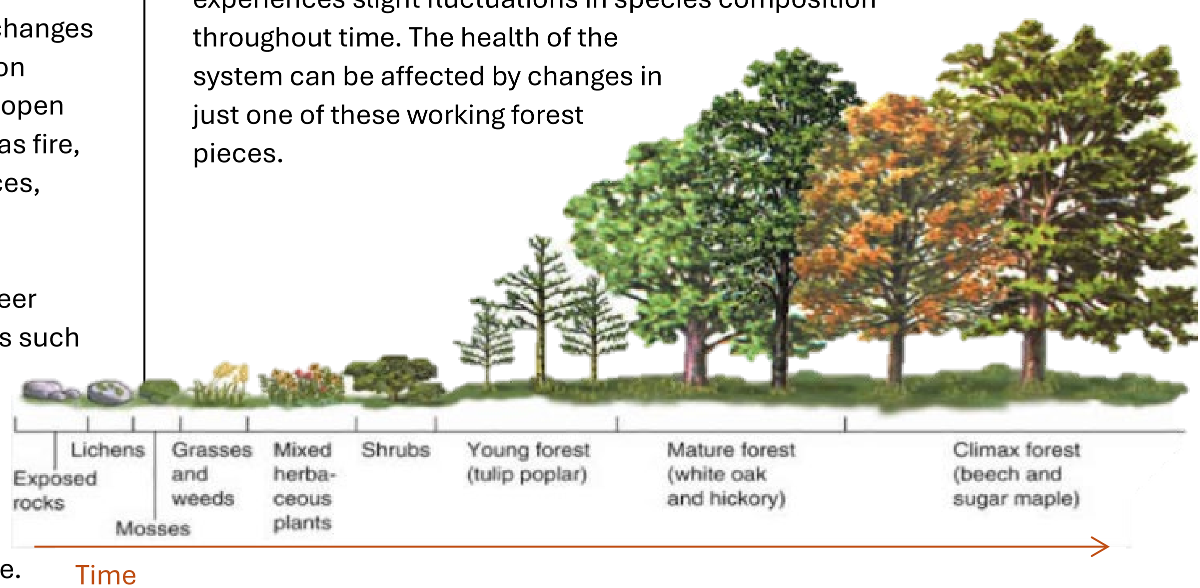


FIGURE 8 EXAMPLE OF SUCCESSION

Fire and the Forest

From the beginning, fire has always been part of the Earth's natural cycle. Periodic lightning fires and volcanic activity caused disturbances that effected plant evolution and natural selection. Over time, plants adapted to periodic fires, developing various mechanisms that enabled them to survive and reproduce in a fire-prone environment. As a result, some types of forests, as well as other natural ecosystems (e.g., grasslands and deserts) have developed because of fire and depend on it as part of their life cycles. The importance of fire and its life sustaining properties were not lost on early inhabitants. The earliest signs of human-use of fire dates back thousands of years to South Africa, where fire was thought to be used for warmth, light, and frightening away predators. Considered one of the four basic elements, fire – along with wind, earth, and water was revered by ancient cultures.

From an ecological standpoint, fire is an integral part of the life cycle of many forests. Fire clears dead and dying trees and understory litter, opening the forest floor for new growth. In addition, fire aids in recycling nutrients as its mineral-rich ash, which contains potassium, phosphorus, and calcium, is deposited across the forest floor. Ash nourishes the soil and provides an ideal environment for germination of many seeds and **regeneration** of post-pioneer-fire plants, such as fireweed and fire cherry. Fire supports the process of natural selection, improving growth opportunities for stronger, healthier trees by thinning small trees and removing weak and insect or disease-ridden trees. Fire is considered a primary agent in preparing **seedbeds** for many forest species. Certain species of conifers that produce closed, or serotinous cones, rely on heat from fire to open the cones and release seeds. The fire-opened cones help reseed the area following a fire.

Finally, fire helps to reverse mesophication. Mesophication is the process that occurs in fire adapted and fire dependent communities when fire is removed. Increased populations of maple and birch into what were oak dominated forests is an example of mesophication. Mesophication also creates conditions that make fires less likely, and less effective, in fire adapted and fire dependent natural communities. Mesophication can also lead to the loss of critical habitats and species.

Fires begin either by natural causes, such as lightning strikes, or by human activities, whether they be accidental or intentional. Nationally, 9 out of 10 (90 percent) fires are caused intentionally or by people.

Regeneration is the process of recovery following a forest disturbance.

Seedbeds are areas prepared to received seeds. They are usually cleared of plants and debris so that natural seed can fall and stablish a new forest.

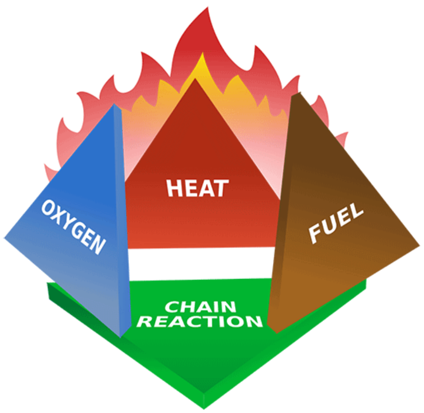


FIGURE 9- HTTPS://FIRE-RISK-ASSESSMENT-NETWORK.COM/BLOG/FIRE-TRIANGLE-TETRAHEDRON/

The Fire Tetrahedron

The original fire triangle consisted of heat, fuel and oxygen. However, there is a fourth component comprising the base of a three dimensional, which is a sustained chemical chain reaction (this is where the flames come from). These four components are known as the "fire tetrahedron." Cut off any one and the fire will not burn. This is the some of the principle behind a wildland firefighters clothing, called Nomex. Nomex will char and begin to burn when exposed to an open flame or intense heat but will not support a sustained chemical reaction once the heat source is removed.

Heat

The initial heat, or ignition, is provided by the ignition source, whether it be caused by human or nature. A lightning bolt can easily generate temperatures more than 20,000 degrees Fahrenheit (11,093 degrees Celsius). This temperature provides sufficient heat to vaporize a tree's fluids, causing the tree to burn as superheated gases expand.

The eastern United States has fewer fires set by lightning than the western part of the country because eastern lightning storms are usually accompanied by rain, whereas many of the storms in the west only produce dry lightning. Although lightning-caused fires are less frequent in the east than in the west, the highest incidences of wildfires in the country are in the southeast, primarily because of higher population density and higher incidences of people-caused fires.

In the southeastern United States, the months of March, April, May, and into June are known as the "fire season," which is when 75 percent of forest fires occur there. Fire season in the west usually runs from June through October, during the very dry months of the year. In the northeast, it is March through May and then again in the fall, corresponding to when leaves drop from the trees. Wildfires do not generally occur when the fuels (e.g., trees, shrubs, and grasses) are wet and cold. By far the most common sources of forest fire ignition are from human activity such as setting fires (i.e., arson), failing to put out campfires, using matches improperly, burning debris, and using construction and logging equipment within or adjacent to flammable forest fuels.

Fuel

Natural fuels include dry or dead trees and limbs, leaf litter, and dry grass. Introduced fuels include human-made structures, such as cabins, barns, fences, and exposed sources of petroleum (e.g., leaking gas or oil tanks, abandoned automobiles), and dumping (furniture, tires, mattresses, household garbage, etc.).

Oxygen

Oxygen is available in the air. When windy conditions prevail, the supply of oxygen available to a fire is replenished more quickly than in still air because a greater volume of air flows over the fire. The rising column of hot air generated by a fire draws in cooler, oxygen-rich air from the surrounding air mass, creating a fire-driven wind that helps a fire sustain itself while fuel is available.

Weather has a great influence on when fires occur and how they spread. Hot temperatures and dry winds can dry out trees and grasses in a forest, making them available as fuel for a fire to consume. The stronger the winds, the more quickly moisture evaporates from the vegetation. Stronger winds also cause the flames to lean causing the vegetation ahead of the flaming front to dry faster and preheat. The leaning flames also expose more ground fuels to direct flame contact. These conditions all make the fire spread even faster.

Benefits of Forest Fire

The natural order of forest succession could not progress without fires. Most of the devastating fires are a result of humans interfering with natural disturbance regimes, in this case excessive fire suppression efforts. Continually suppressing all fires eventually allows so much fuel to accumulate that the resulting fire is uncontrollable. Even in the largest fires, not everything burns. When fires are permitted to burn frequently and with minimal interference, the result is an ecologically healthy mosaic of burned and unburned vegetation. Where there is a large accumulation of deadfall and dry litter restraining new growth, fire can clear a space for seeds and sprouts to thrive. Certain coniferous trees, which depend on extreme heat to open their cones, literally create new life after a fire. Depending on its intensity, a fire can recharge mineral-poor soil. In addition, because recently burned forests contain very little deadfall and litter, a subsequent fire event is less likely to occur in that same area soon after. Fire is a necessary component of forest longevity because it promotes a healthy forest consisting of trees of mixed ages, which reflect a self-sustaining cycle of life and death.

Drawbacks of Fire

For all their benefits to the ecosystem, wildfires do pose a threat to communities, individuals, and forests if the fire is catastrophic. Catastrophic fires usually occur in areas where fire has been excluded for many years, causing a large buildup of fuel. Preventing, controlling, and suppressing wildfires is becoming more vital all the time as more people seek woodland settings for their homes and recreation, called the wildland-urban interface. As the number of people looking to “get back to nature” grows steadily each year, more and more homes, property, and lives are endangered by fire along the wildland-urban interface. This trend has placed an enormous burden on land management agencies and their ability to fight fires.

The effects of forest fires on air quality are of growing national concern. The smoke pollution associated with fires raises many concerns about effects on air quality and human health. Smoke is a **public health** problem that concerns both air quality regulators and citizens.

Fire as a Tool

Today, fire has become a useful tool to help state and federal agencies manage their wildlands, which include forest, grasslands, and other ecosystems. Over the years, fire management policies and techniques have changed. A prescribed burn (one that is ignited and managed by trained personnel with predetermined fuel and weather conditions) can prepare a logged area for reforestation, enhance wildlife habitat, protect native plant species, control insect or disease populations, or reduce fire hazard by reducing burnable fuels.

Most agencies emphasize fire prevention through public awareness of fire safety and through clearing vegetation around homes and businesses near the wildland urban interface. Much of the reason for this is that the safest and least expensive fires to deal with are those that never start. Some agencies will allow naturally started fires to burn (called limited action) if, they correspond with identified prescriptions for fuel and weather, and the agency can supply personnel to continually monitor the fire. However, when such a fire is no longer in prescription, the monitoring personnel are no longer available, or threatens life or property, fire suppression begins. Suppressing unwanted wildfires is expensive, but often necessary.

In areas where fire is suppressed, the build-up of fuel may be controlled by harvesting trees to keep the forest healthy. Fire managers are employed to observe, monitor, and record fuel and weather conditions that may increase the likelihood of a forest fire. Firefighters are often stationed with firefighting equipment in areas with high fire danger. The issue of when, where, how, or whether to control forest fires through preventive strategies, methods of suppression, or prescribed burns has been the subject of debate at the local, state, and national level for many years.

Public health is the science and art of preventing disease, prolonging life, and promoting physical health and efficiency through organized community efforts.

Community infrastructure refers to small scale basic structures, technical facilities and systems built at the community level that are critical for sustenance of lives and livelihoods of community members. Examples include sidewalks, bike lanes, plazas, religious centers, storm trains, trees and more.

The Urban Forest

Managing the Urban Forest

Urban forestry is defined as the management of naturally occurring and planted trees and associated plants in urban areas. This differs from traditional forest management, which focuses on the production of timber and wood products and ensuring the continuation of ecosystem services. Urban forestry is closely associated with arboriculture, which is the practice and study of the care of trees and other woody plants in the landscape. Though an understanding of tree biology and cultivation is necessary to ensure the health of urban trees, the factors involved in maintaining and expanding the urban forest are more diverse than these concerns. While forestry practice remains an element of urban forestry, other professional disciplines including management, sociology, and community administration play roles.

The urban forest, as one element of the **community infrastructure**, must be designed and managed according to the needs of the urban residents. The functionality of a healthy urban forest and that of a well-run human society are synergetic; all living elements of the community share the benefits.

Caring for community trees often begins as a grassroots effort. Community members are the most reliable motivating forces for implementing successful urban forestry programs; citizens' involvement will ensure the continued existence of this important resource in overall management programs that fit community needs and interests.

The success of urban forestry programs is based in effective local activities that depend on a coalition of efforts involving professionals, agencies, and volunteers. With the expansion of urban forests, there will come even greater improvements in the health of the urban environment and in the quality of life for all urban and community residents. The term "urban forest trees" refers to trees in residential areas, parks, common areas and along streets, basically anywhere there are trees and people. Street trees have a shorter average life span than forest trees, due to the stresses put on trees in the urban environment.
The source of these stresses can include:

- Pollution
- Soil Compaction
- Limited soil volume
- Overhead and underground utilities
- De-icing salts
- Pests and diseases
- Nutrient deficient soil
- Vandalism

The Earliest Efforts

The urban and community forestry tradition may have begun as early as 1646, when a planting of public shade trees was completed along the highway between Boston and Roxbury, Massachusetts. Another forest visionary was William Penn, who in 1680, required that for each four acres of land cleared one acre should remain forested in Pennsylvania.

In 1791 Major Pierre L'Enfant, borrowing ideas from French landscape design, laid out the streets of Washington. D.C. with trees as major design elements. An 1807 Act of Territory in Michigan stated that Detroit should have tree-lined avenues and town squares ornamented with city trees. Similarly, Frederick Law Olmsted's design for New York's Central Park in the 1850s emphasized the importance of open space in cities. Olmsted's purpose was to give city workers a chance to experience the beauty and serenity of trees – a privilege only those with greater means could experience in the remote forests of the Adirondacks or the White Mountains. By pursuing this goal, Olmsted demonstrated a clear social concern, offering trees and open space as a means to improve the quality of life for all residents.

Arbor Day was created in 1872, to celebrate and, commemorate the contributions of trees to the urban environment and the benefits of proper community tree maintenance. Urban forestry had its formal beginning in the United States. In the late 1800s several states, (Massachusetts, Pennsylvania, New Jersey, and New York) passed enabling legislation allowing local governmental bodies to spend public funds on the planting and maintenance of shade trees.

The Urban and Community Forestry Resource

The Society of American Foresters at one time defined urban forestry as the cultivation and management of trees for their contribution to the physiological, sociological, and economic wellbeing of the urban society. Other definitions include community forestry as the application of forest management principles to the ecology of densely populated human environments. The International Society for Arboriculture defines urban forestry as the management of naturally occurring and planted trees and associated plants in urban areas. An arboriculturist is a person skilled in the practice and study of the care of trees and other woody plants in the landscape. An urban forester is an individual skilled in managing larger areas of planted trees and associated plants in the urban landscape. Urban foresters and arboriculturists work closely together in managing the trees, plants, and open spaces in urban and suburban communities.

The urban forest consists of the trees in and around the places we live. Those places are cities, suburbs, and rural communities. For the purposes of federal funding through urban and community forestry programs, the definition of community forests includes all tree resources associated with population centers of 100 or more people (of which there are more than 40,000 in the United States).

Some say that when European settlers first encountered North America, a squirrel could travel from the Atlantic Coast to the Mississippi River without ever touching ground. By the late 1800s, however, the state of Connecticut had no timber of commercial value left standing. While the enactment of legislation in several northeastern states to enable use of public funds in planting and maintenance of shade trees has marked a fortunate acknowledgment of the importance of community trees, the devastation of native forests remains a sad commentary on the place our natural environment held in our value system.

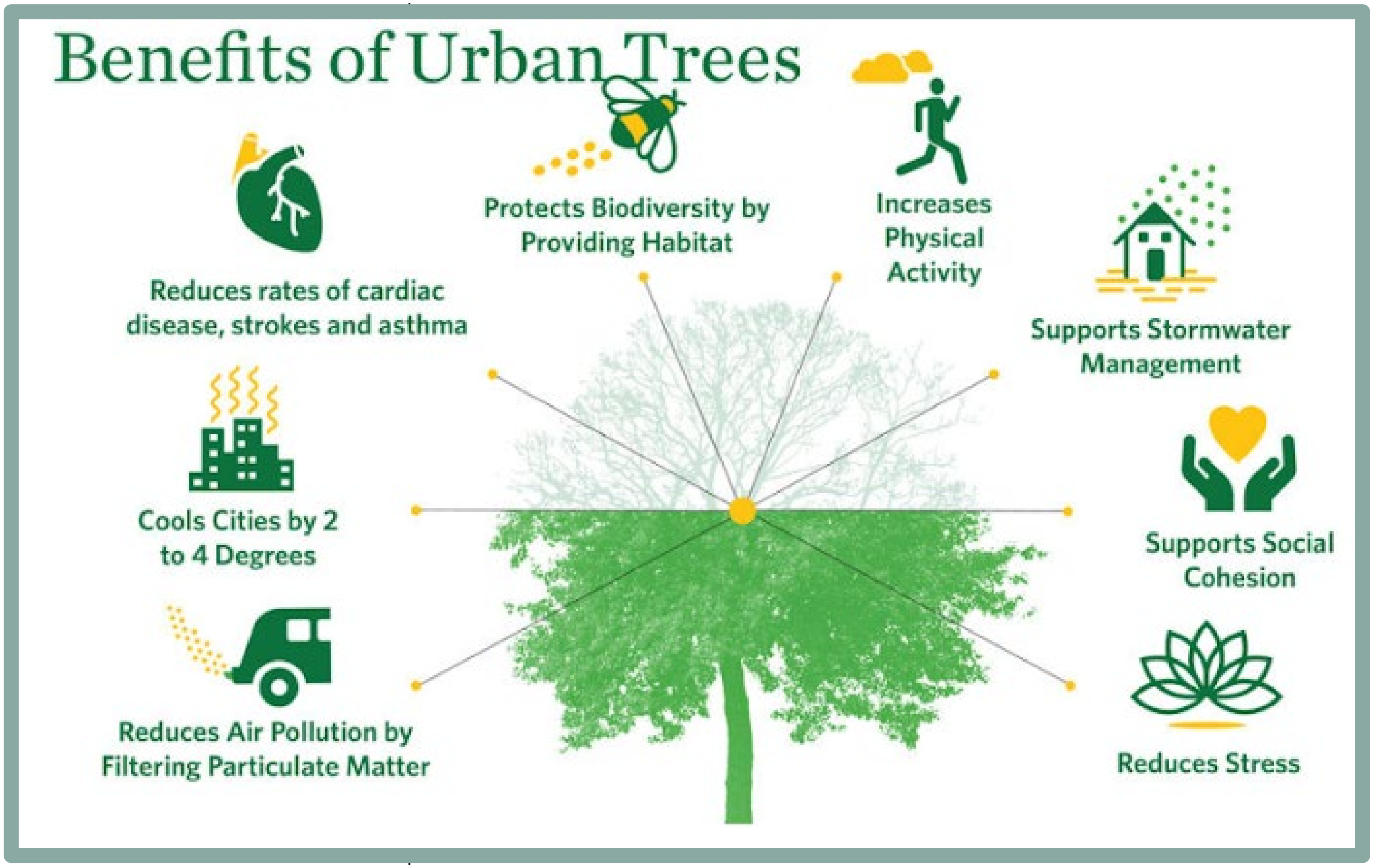


FIGURE 10 GRAPHIC FROM HTTPS://WWW.WASHINGTONNATURE.ORG/FIELDNOTES/ADVOCACY-URBAN-TREES-PUGET-SOUND

Federal Legislation for Urban Forest Management

Early in the nation's history, tree care and concern for the urban forest were very much a part of the urban managers and dweller's philosophy. Two modern developments have helped reverse that attitude: first, the automobile enabled city dwellers to escape to the rural environment; and second the advent of air conditioning reduced the discomfort of urban summers. The shading and cooling benefits of the urban canopy were less appreciated at the time. Urban forestry came to be considered politically valueless, and trees were often seen only as liabilities. In 1990, Congress appropriated $2.7 million for use by the Forest Service in managing urban and community forestry programs nationwide. Then, in conjunction with new authorities given to the Forest Service in the 199O Farm Bill to work with states in developing and implementing urban and community forestry programs, Congress raised the appropriation for urban and community forestry nearly ten-fold, to $21 million in 1991.

These funds have helped to create a urban forestry coordinator position in all 50 states plus the District of Columbia, Puerto Rico, the Virgin Islands, and the islands of the Pacific; to set up state urban forestry councils in all 50 states, the District of Columbia, Guam, and Puerto Rico; and to establish an official or an organization in 32 states to help promote volunteer activities related to planting, maintaining, or protecting the urban forest resource.

Benefits of Urban Trees

Energy Conservation

According to researchers, tree planting is the most cost-effective way to conserve energy resources in both winter and summer. In winter, properly placed trees can help reduce heating costs by serving as windbreaks, conserving between 10 and 50 percent of the energy needed for heating a home. In summer, shade trees on the south and west sides of a house can reduce air conditioning costs by 30 percent.

Economic Vitality

Planting trees around a house increases property value. According to numerous studies, landscaping, especially with trees, can increase property values as much as 20 percent - an increment greater than most family's savings. Studies also show that people linger and shop longer along streets lined with trees, than on those without, that apartments and offices rent faster in wooded areas than in non-wooded locations, and that tenants in wooded neighborhoods stay longer than elsewhere.

Because trees can increase the economic vitality of any community by attracting residents, businesses, and tourists, many cities are engaged in beautification projects that include, for example, the restoration of vacant lots. When local government managers encourage the development of new community parks and gardens, citizens are given a vehicle for community service and the locality is made most attractive to developers.

Air Quality

Trees mitigate air pollution both directly, by absorbing and neutralizing pollutants and indirectly, by cooling communities. This indirect effect, besides saving energy, slows the accumulation of **smog**, which forms faster in higher temperatures. Particulate pollutants - dust, ash, pollen, and smoke - are trapped and filtered by the leaves, stems, and twigs of trees, then are washed to the ground by rainfall. Gaseous pollutants - such as carbon dioxide, one of the major culprits in global warming, or the greenhouse effect - are absorbed through the pores in a tree's leaf surface; the tree replenishes the air with oxygen, while using the carbon dioxide to make food (photosynthesis).

Stormwater Control

According to the Department of Agriculture, the United States loses 5.4 billion tons of soil annually from croplands, pasture, and rangeland. Trees are effective in saving soil because their roots hold it in place and increase water infiltration, thereby reducing soil erosion, sedimentation of streams, amounts of chemicals transported to streams, and wind erosion. Soil scientists estimate that the erosion factor in developed areas is ten times greater than that on cropland, 200 times greater than that on pasture, and 2,000 times greater than that on forests. In some localities, planting and maintaining trees may be the only steps necessary to avoid building new sewer channels for runoff or erecting new waste treatment facilities.

Other Benefits

Other benefits of trees include blocking noise pollution and providing wildlife habitat. Many animals such as birds use trees for nests, food, and shelter from inclement weather. Finally, the presence of tree's directly affects human health. Trees have significant restorative benefits, physiological and psychological on people; known as biophilia.

Urban Forests as Ecosystems

Stresses affecting trees in urban environments include air pollution, soil compaction, drought, urban "heat islands," poor nutrition, and attacks by "killer humans." Much of the time people are often completely unaware of the effects their own activities can have on the health and vigor of community trees.

By tying ribbons or wires around trees, hammering nails or spikes into trees, dumping hot charcoal at the base of trees, or taking maintenance into their own hands, community members can cause serious, perhaps irreversible, harm to trees. Breaking off damaged limbs or incorrect pruning can open wounds that cause stress to a tree, and that may increase the risk of disease or insect attack. Working with trained individuals for tree maintenance, such as an International Society of Arboriculture Certified Arborist, will increase the health and lifespan of urban trees.

Perhaps the most significant effects about tree biology that citizens need to know are the existence and importance of the "cambium layer" and the inability of trees to heal their own wounds (Figure 1). All woody plants except palms and bamboo's have a single cell layer called the cambium that lies just below the bark and contains the living cells that allow trees to grow, and stripping bark, pulling off branches, or leaving planting stakes and ties on for too long, causes permanent damage, and depending on the extent, may even cause death.

The plants we know as trees include the hardwoods or broad-leaved trees (deciduous in temperate climates, evergreen in tropical or subtropical climates), softwoods or needle/scale-leaved trees (coniferous), and woody monocots (palms and bamboos). Woody monocot plants possess no cambium and are more closely related to the grasses than to hardwood or softwood, deciduous or conifer tree species.

Trees, Forests and Climate Change

Smog refers to a mixture of pollutants made up mostly of ground level ozone. It is created by a mixture of pollutants emitted by cars, power plants, and refineries, to name a few. The predominant physiological effect of short-term ozone exposure is being unable to inhale to total lung capacity.

Global Climate Trends

Climate change refers to the long-term shift in temperature and weather patterns. While there have been natural, historical, and cyclical shifts in the Earth's climate, the change that is occurring today is driven by human activities and the burning of fossil fuels, which has been escalating and rising since the late 1800s. In fact, Earth's temperature has risen by an average of 0.14° Fahrenheit (0.08° Celsius) per decade since 1880, or about 2° F in total. The 10 warmest years in the historical record have also all occurred since 2010, where 2022 was the sixth-warmest year on record and 2023 was Earth's hottest summer on record.

Climate Effects on Trees and Forests

Climate change is, and will continue to, have a wide range of effects on all ecosystems. Forests will face a particular set of impacts caused by climate change. Some of the major impacts to trees caused by climate change include:

Climate Effect	Impacts on Trees and Forests
Increasing average temperature	The rate of plant growth and development is dependent upon the temperature surrounding the plant. Each species has a specific temperature range in which they can persist. As temperatures climb, some plant and tree species may no longer be suited for current and future conditions in a given location.
Increasing extreme precipitation events	Without an adequate supply of water, trees can experience varying degrees of stress and mortality. With too much rain and moisture, this can lead to reduced oxygen in the soil, damaging root systems. This, too, can result in stress and mortality.
Increasing storm frequency and intensity	Extreme precipitation events can lead to erosion and reduced soil structure and nutrient degradation. These can negatively affect forests, but the degree of intensity largely depends on the individual forest, as well as the frequency and intensity of each individual precipitation event.
Increasing drought risk	Drought can lead to reduced growth of trees and an increase in mortality. As a result, there may be overall reduced vegetative cover leading to wind and water erosion, in addition to decreased streamflow, dry soils, and carbon storage.
Increasing occurrence of wildfire	Wildfire frequently results in the loss of trees and vegetation. Depending on the size and intensity of a fire, it can also impact wildlife and their habitat, it can increase soil erosion, and lead to a pulse of carbon storage loss in the affected system.
Increasing spread of invasive plants, pests, and pathogens	Invasive plants will experience increased growth and density due to higher carbon dioxide levels. Invasive insects often take advantage of stressed trees, which, as temperatures and droughts increase, more and more trees will experience stress. Both plant and insects are shifting ranges due to warmer temperatures and milder winters, meaning they are continually establishing in new areas.
Decreasing tree species habitat	Climate is the most important influence on the distribution of plants and animals. Trees vary in their tolerance to extremes of climate and are especially influenced by temperature and precipitation. Each tree species differs in the way they interact with their environment, for example, how they utilize water and nutrients and how they compete with other species. Changing climates are predicted to cause shifts of favorable habitats and conditions for many tree species and other plants and vegetation – and the wildlife that depends on them. That more favorable habitat is going to be more north and to higher elevations.
Decreasing biodiversity	Between reduced tree species habitat and an increase spread of invasive plants, pests, and pathogens, overall biodiversity – or the variety of life that exists in an area or ecosystem– is expected to reduce over time as effects of climate change increase
Decreasing snowpack	As temperatures rise and more precipitation falls in the form of rain as opposed to snow, this may lead to root damage and result in lower spring river flows to support aquatic ecosystems during the winter months.

Climate, Carbon, and Forests

Carbon dioxide (CO2) is an important heat-trapping gas, also known as a greenhouse gas. It is released into the atmosphere by processes such as the extraction and burning of fossil fuels, wildfires, and even natural processes such as volcanic eruptions. Importantly, human activities have raised the atmosphere's carbon dioxide content by 50% in the last 200 years. Once carbon dioxide is emitted into the atmosphere, it has a lifespan of hundreds of years, meaning, any carbon emitted today will persist for a very long time, along with the effects of its accumulation. In 2022, the average global carbon dioxide reached 417.06 parts per million (ppm), setting a new record. In just the following year, in May of 2023, the atmospheric carbon dioxide hit a new high of 424 ppm (climate.gov).

Carbon flows between different reservoirs, such as the ocean, the terrestrial biosphere, and sediments, in an exchange called the carbon cycle (Figure 11). Any change in the carbon cycle shifts carbon out of one reservoir and into another. The carbon cycle can be compared to the water cycle, where the total amount of carbon on the planet does not change, but rather, where the carbon is located does.

While sediment and oceans store a large amount of carbon, forests play a critical part in the carbon cycle as well. Trees can absorb carbon as they grow, through the process of photosynthesis, but they can also release carbon into the atmosphere, either temporarily by cutting or burning, or more permanently, through land use change and conversion.

Importantly, forests also play a critical role in both climate mitigation and adaptation. Forests contribute to mitigation because of their capacity to remove carbon from the atmosphere through photosynthesis. Forests relate to adaptation in a couple of ways: (1) adaptation actions, such as increasing resiliency, are needed for forests to maintain their ecosystem services, and (2) forests can help societies adapt to climate change by providing services that reduce the vulnerability to communities, such as clean air and water, flood control, and soil stabilization and erosion reduction.

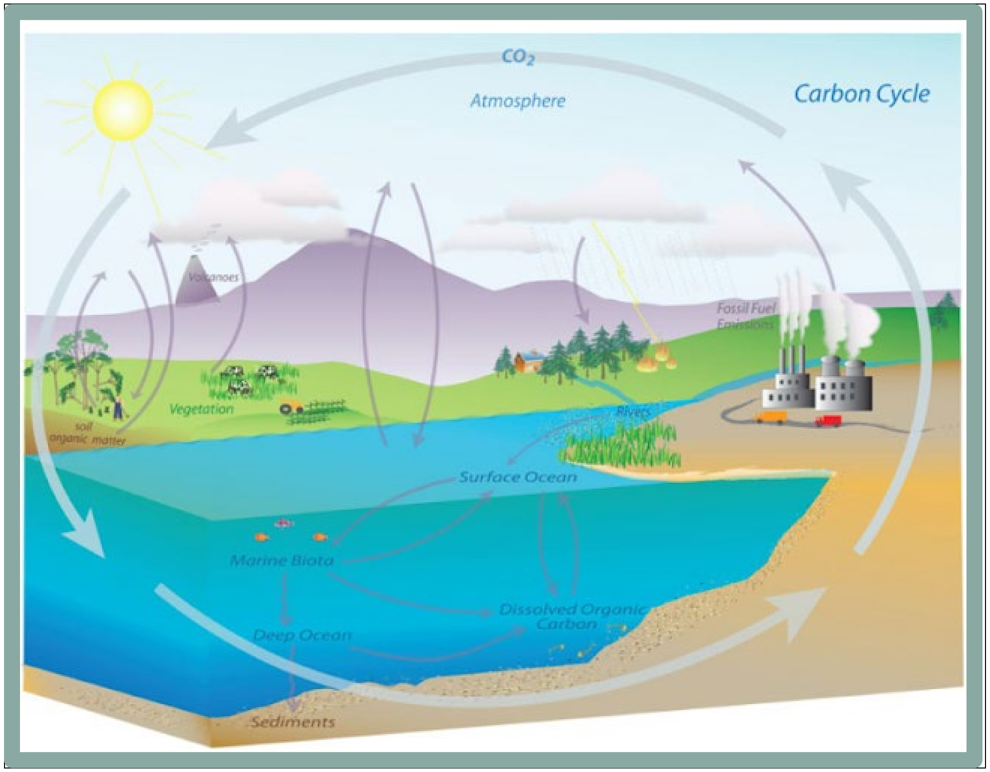


FIGURE 11 PHOTO FROM HTTPS://WWW.NOAA.GOV/EDUCATION/RESOURCE-COLLECTIONS/CLIMATE/CARBON-CYCLE

There are two components of forest carbon: carbon storage and carbon sequestration. Carbon sequestration is the process of removing carbon from the atmosphere through the process of photosynthesis. Carbon storage is the amount of carbon that is retained in a carbon pool (i.e., the parts of the forest that stores carbon and can accumulate, or lose, carbon over time) within the forest. These pools are live aboveground (i.e., living vegetation: trees, shrubs, plants), live belowground (i.e., roots), deadwood (i.e., snags, downed logs), litter (i.e., leaves, needles, small branches), and soil (i.e., organic matter: dead and decaying biomass).

Like the global carbon cycle, carbon in these pools is constantly changing. For example, a living oak tree would store carbon in both the live and belowground pools. When that oak drop leaves and acorns, these components will also temporarily store carbon on the forest floor. However, once this oak dies, it will eventually move into the deadwood and soil pools.

Outside of the forest, carbon is stored in byproducts of the forest as a variety of wood products, whether that be construction materials, flooring, boxes and pallets, or everyday items like paper. This is important because it is sometimes assumed that when a tree is harvested, all its carbon is lost. However, all carbon removed from the forest during a timber harvest is not immediately returned to the atmosphere.

Forest Resiliency

Forest resiliency is the capacity of a forest to respond to a disturbance by resisting damage or stress and recovering quickly. In other words, if an invasive insect establishes in a forest or an ice or windstorm affects a substantial acreage, can that forest and its functions persist and bounce back to a previous state, or is it unable to do so?

While forest resiliency can look different from one place to another or be highly localized or region-specific, increasing components of forest resiliency is important for maintaining ecosystem services and functionality, including wildlife habitat, clean air and water, and carbon storage and sequestration.

Highly resilient forests are those forests that have few stressors impacting them (e.g., invasive plants, pests, and pathogens; deer and moose browse), those that have high physical and biological complexity (i.e., diverse structure and composition), those that have (or can support) the regeneration of species that are expected to fare well under anticipated future conditions (e.g., oak species, American basswood), those that have vigorous trees, and those that have (or can support) at-risk or endangered species, including tree, plant, and wildlife species.

While a forest's ability to store and sequester carbon is extremely important in the context of climate change, it cannot be the only aspect of our forest we manage and care for. Much like we cannot solely focus on wildlife habitat or timber, we cannot just focus on forest carbon, especially given the land use history of Massachusetts and the continual stressors impacting our land. A resilient forest – one that is healthy and one that continues to provide a wide array of ecosystem services – is the only way to secure forest carbon over the long-term. To achieve forest resilience, this may require varying degrees of forest management.

Forest Silviculture & Management Options

Aesthetics

Each of you reading this section are future potential landowners of varying acreages. As a landowner, you will have decisions to make on what you want your forest or woodlot to look like. A park-like area? Thick woods? Or as it is the moment you are looking at it? Whichever you choose, the forest will change with time. Trees will grow and shade out others, and they will eventually die. You can control or alter this process by managing your forests. Cutting trees can expose a view to a stream, pond, mountain, or a unique tree.

You can create a low or high screen of brush by altering the amount of sunlight in an area. If an area is cut heavily, there will be more sun, the vegetation will be denser, and the visual or noise screen will be low. If only 50% of the trees are cut, less sun will reach the forest floor; the vegetation and consequently the screen will not be as dense, but it will be more complete; low, moderate, and tall vegetation will grow.

In addition to providing access for vehicles, roads in a forested area are beneficial as visual corridors, walking paths, and for maintenance, fire protection, and wood production. A curved ("S" shaped) road in the woods near the highway will provide a visual barrier, and the road or houses will not be easily seen from within the forested area. If wood is harvested from this area the landing can be kept some distance from the main road to limit the view. To maintain the wooded appearance of an area, buffer strips can be left along streams and roadways by allowing only light cuts of 20-30% of the trees.

The important thing to remember is to keep your woodland "healthy." Forests will change with time, and you can influence the way they change. Set goals and work towards them with the knowledge of what is happening.

Managing Land for Wildlife

Wildlife or game management is the art of making land produce sustained annual crops of wildlife for recreational use. Wildlife benefits the sightseer, the photographer, the hunter, trapper, and those who derive pleasure from a sense of good resource conservation.

Since most of the woodland is privately owned, individual landowners have the more important role in determining the production of wildlife. You control the range or habitat of wildlife with respect to available food, and shelter on your land. Most of the development of good game habitat has been the result of other good land practices such as timber, agricultural or water management. There are five major kinds of habitat commonly found in Massachusetts:

1. Active agricultural fields
2. Abandoned fields and pastures.
3. Forest lands
4. Aquatic habitat (ponds, lakes, streams)
5. Swamps and marshes

The place where the two meet is called the "edge," and this is where the greatest concentration of wildlife will be found. Where all the ranges occur in a relatively small area is the most productive situation for wildlife. Some animals may use all five ranges, like the whitetail deer. Others will only use one, like brook trout.

What You Can Do to Improve Habitat

The first step is to decide what species of wildlife you want to attract and what your woodland might be able to support. There will be limiting factors, but you can make the most of what you have.

- Carry out good agricultural, forestry, and wetland use practices. This improves the habitat for all wildlife.
- Plan for and set aside special areas for wildlife, for example, **deer-wintering areas** that are used every year. These locales require special forestry practices to maintain or improve the area for deer. To favor birds and small mammals leave 3-5 den trees per acre. Planting wildlife shrubs or releasing old apple trees present on your woodlot will provide a much-needed food source.
- If you are interested in a particular wildlife species, or in a special group of wildlife, land use practices should be aimed at improving their regular habitat. Develop an over-all "game plan" for your lands and work it into your land management plans.
- Game or wildlife management requires technical knowledge of species and their habitat. You should make use of all resources available. The Massachusetts Division of Fisheries and Wildlife, the USDA Soil Conservation Services and Massachusetts Audubon Society can assist you. Your county forester can recommend a local agency to work with on wildlife management questions.

Deer-wintering areas are those to which deer return year after year when seeking winter shelter.

Forest Land for Recreation

Forest land has been used for recreational purposes for a long time. Hunting, fishing, cross-country skiing, snowshoeing, bird watching, and snowmobiling are a few of the uses. They are generally compatible with other forest land uses such as growing timber.

Forestland owners benefit from determining whether their land can be used for recreation and whether it can provide an income from such uses. The use can vary from the more passive forms listed above to the intensive uses such as camping, picnicking, or swimming. The landowner will have to consider many factors before venturing into any recreational development plan:

- Do you have the ability to meet and serve the general public?
- Is your land close enough to major transportation routes and population centers?
- What is the demand in your area for this type of recreation development?

- Are you willing and able to build, manage, and maintain such a development?
- What is the cost of constructing such a development?
- Can you finance the operation on the anticipated rate-of-return from the business?

Whether you have active or passive recreational uses in mind, your forest land should be managed to stay healthy and grow vigorously.

Christmas Tree Management

Christmas tree production is a special type of forest management. Forest landowners have seen that in 8 to 12 years trees can be harvested from areas which may have produced nothing for decades. Cut-over areas, abandoned fields and pastures make good areas to plant trees. These areas should have some site preparation done on them prior to planting, which aids in the caring for the trees, so that quality trees will be produced to maximize the dollar return. Many varieties of Christmas trees are grown in Massachusetts. Balsam Fir, Fraser Fir, White Spruce, and Scotch Pine are the most common species, but White and Red Pine, Austrian Pine, Douglas Fir, Black Hill Spruce and Concolor Fir are also raised.

Christmas trees can also be produced in some cases from wild stands of trees which are three to six feet tall. They must be weeded and thinned to allow better growing conditions, and shearing will improve the tree quality. Working with a wild stand of trees is good because a harvest can begin in two to three years, and the area usually has trees of varying ages and sizes to produce a continuous crop.

If no suitable trees are present on your land and you want to plant Christmas trees, it is best to start with an open field on a small scale and expand from there. It will take 8 to 12 years (depending on the species) to produce a quality tree. You will have to make a commitment to controlling competing vegetation, insects, and diseases, and make provisions for fertilizing, and shearing your stand of trees.

The produce of all the work is the mature Christmas tree, which can be sold in various ways; individually or by volume, on a retail or wholesale basis, made available to the buyer at the roadside, delivered, or on the stump (“cut your own”). Depending on where the trees are, each method has merits, and many places use several methods to market their trees. The urban character of much of Massachusetts has made “cut your own” marketing technique very successful in most of the state.

Maple Sap and Syrup Production

Certain areas of Massachusetts are capable of growing Sugar Maples, which are the best and most efficient resource to produce Maple Sugar. Tree farming of this kind can range from a hobby to a large-scale business. Small farm-type setups are the trend, where its farming activity helps to tap the optimum potential of the forest.

Syrup production is labor intensive and can only take place during late winter to early spring, when the days are warm, nights get cold, and the sap “runs” in the maples. The tin bucket hanging on the tree to plastic tubing, where possible, to collect the sap is the current situation. Also, gasoline-powered pumps, vacuum pumps, and pressure-filter presses are used to reduce labor costs, and they produce a better-quality syrup.

To manage a stand for sap production, it is important to take a close look at the trees. All maples will produce sap, but Sugar (Rock) Maple is the best. It produces the lightest syrup and has the least amount of sugar sand. Red Maple produces a darker syrup, but the tree will also bud out sooner and shorten the collection time.

To maximize sap quality and quantity, the landowner must manage the “sugar bush” properly. Trees of other species should be thinned, but not completely removed from the stand to allow for the development of large maple tree crowns, which resulting in more and sweeter sap.

A small farm attempting to produce syrup for an income should be able to put out at least 500 taps. The trees should be at least 10 inches in diameter at 4.5 feet above the ground. For additional taps a rule of thumb is one more tap for each additional six-inch increase in diameter. Sap production might be as far as you want to go with the process. There are syrup producers who will pay for your sap, or in some cases, lease your trees for their syrup production.

Fun Maple Sugar Facts

- A maple tree can yield sap for 100 years.
- A maple tree must be around 45 years old before it is tapped for syrup making.
- It takes an average of 40 gallons of sap to produce one gallon of syrup.
- When buds appear on the trees, in late March or April the sap turns bitter in flavor.
- Massachusetts has more than 300 maple producers producing about 50,000 to 60,000 gallons of maple syrup per year.

Wood Production

The care and treatment of a stand of trees is referred to as “silviculture”. This is derived from the Latin words for forest and to cultivate or grow. Silviculture literally means growing a forest and requires the application of knowledge to control the establishment, composition, and growth of the forest. Silviculture makes it possible for the manager to produce the best quality product in the shortest amount of time. For example, it takes approximately 120 years to grow White Pine to 24 inches diameter breast high (DBH) without management, but about 100 years with management. When managing stand of trees for wood production, you are either applying a thinning to improve the existing growing stock or you are treating the stand for regeneration and harvesting the growing stock.

The silvicultural treatment of a forest stand during the growth period is referred to as “timber stand improvement” (TSI) or woodland improvement of the growing stock. Three kinds of work are involved: weeding, releasing, and thinning. They are carried out at successive age periods.

Practice	Age of Stand	Type and Diameter of Trees
Weeding	5-20 years	Seedlings & saplings less than 4”
Releasing	10-40 years	Pole 4-10”
Thinning	25 plus years	Pulp and saw logs 8”

Although weeding, releasing, and thinning are distinct activities there is no exact timetable to indicate just when one should end, and another begin. Often the natural forest growth is such that all these practices may be carried out simultaneously on the same acre. You may hear the terms used interchangeably.

<u>Weeding</u>

Weeding is the first management practice in a stand of very young trees, which are from 5 to 20 years of age. The objective is to remove undesirable species, which are crowding and overtopping the potential crop trees. Weeding improves the species composition of the stand.

<u>Releasing</u>

Releasing is the second step in timber management, when stands are 15 to 40 years old. The goal is to further remove inferior trees, which improves growing conditions for the crop trees and helps to select desirable species for later growth.

<u>Thinning</u>

Thinning is the removal of trees from dense stands to gain faster growth of trees that will be held another 30 to 50 years. Thinnings every 5 to 10 years are needed to maintain maximum growth and continually improve quality until final harvest is reached.

<u>Cull Tree Removal and Stand Improvement</u>

Remove cull trees or kill them. The better-quality trees that remain will have more room to grow. A cull tree has usually been left from earlier logging operations. It is old, large, often very limby, crooked, or rotten and has little or no economic value. It may cost you less to kill them than to cut them down for usable products, and trying to fell them may cause extensive damage to adjacent valuable trees.

Slow killing is often better than an immediate kill. Too sudden a change from shade to direct light may damage adjacent desirable trees. This is often the case with White Pine. Shade trees, with thin and tender bark, will “sunscald” if they are suddenly exposed to direct sunlight. Sunscald or sunburn can kill a vertical strip of bark and expose the tree to disease and rot. Another benefit in addition to releasing new growth, the decaying tree frequently provides a den for wildlife and adds complexity to the stand.

Pruning

Pruning is the removal of limbs from young trees to provide first quality logs. Trees chosen for pruning will be the crop trees harvested at the end of the long growing period. The proper time for pruning is when trees are pole size, 4 inches to 10 inches DBH. The trees selected should be straighter, healthier, and more vigorous than their neighbors otherwise the financial advantage of rapid growth will be lost.

White Pine is the species pruned most often. In a pure pine forest as many as 100 to 150 trees can be pruned per acre. One hundred pruned trees per acre gives a spacing of approximately 20 by 20 feet.

Selected hardwood can also be pruned. Usually there are fewer hardwood crop trees per acre that qualify for pruning. Hardwoods have fewer limbs to remove per tree because, if a limb dies, it tends to fall off soon after.

Forest Harvest Cuttings

Harvest cuttings have three timber management objectives:

- to harvest the mature crop.
- to replace the trees cut with a new crop, known as the regeneration of the stand.
- to improve and protect the growing stock reserve in uneven-aged forests.

Deciding which trees to cut and which to leave is the most critical decision facing the landowner contemplating a timber sale. The importance of selecting a suitable harvest-cutting method cannot be overemphasized if the forest is to be developed. The technical assistance of a professional forester should be employed in most cases.

Here are the five most common management systems used in Massachusetts forests. They are selection cuttings, clear-cutting, shelterwood cuttings, seed tree cutting, and crop tree management (which is a non-system harvest method).

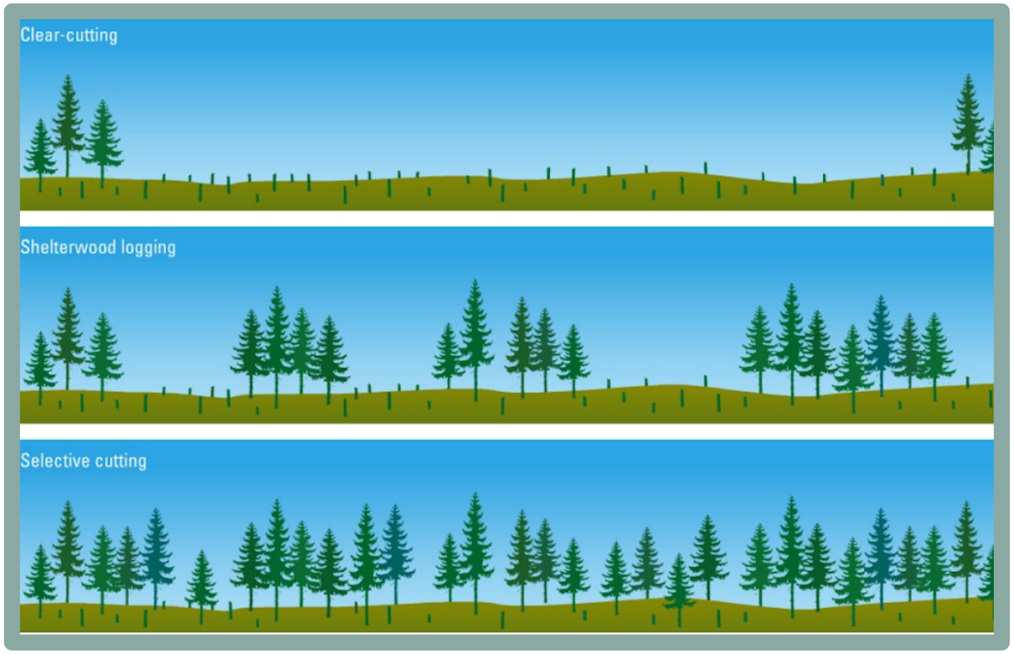


FIGURE 12 GRAPHIC FROM HTTP://CANADASFORESTINDUSTRY.WEEBLY.COM/ECONOMIC-IMPACT-OF-FORESTS.HTML

Selection Cuttings

This is the only management application that is an un-even aged system. In a true un-even aged system, there are three age classes of trees and trees of all ages are present in such a forest. One third (or 30%) of all trees should be harvested as they mature in an uneven-aged stand. The older trees ready for harvest are cut every 10 to 15 years. If they are of good quality and healthy, the young and middle-aged trees are left to grow for future cuts. New seedlings later become established where the mature trees were removed. Mature trees are cut either singly here and there, or in small groups or patches, in an area from 1 to 3 tree heights in diameter. Single tree selection favors shade-tolerant species because the openings in the canopy are not big enough to allow the appropriate amount of sunlight in for the less shade-tolerant species, while group selection is better adapted to the less shade-tolerant species.

The uneven-aged application provides a continuous periodic yield of products and mimics natural disturbances in the forest. Natural disturbances occur periodically through the forest when there's storms, lightning strikes, or an outbreak of insects and disease. These events create holes in the forest canopy allowing more sunlight to reach the forest floor. Uneven aged forest stands are more resilient to future disturbances, if a mature tree is knocked down by wind or other event, there are already young trees waiting to fill the niche unlike even age stands. Unfortunately, uneven-aged stands are more labor intensive than even age stands.

To create an uneven age stand, only a small part of the forest is cut at any one time, which promotes resiliency to future disturbances but also promotes, aesthetics, recreation, wildlife values, and enhances the management of watersheds. Hardwoods, mixtures of Hemlock and hardwoods, White Pines, and Spruce are well suited to selection cuttings, if the stands are uneven-aged.

Not only are the good mature trees harvested in a selection cutting, poor trees and less desirable species are also cut or killed. Middle-aged groups may be simultaneously thinned to improve the forest.

Clear Cutting

Clear-cutting (which removes all the trees in the cutting area in one operation) is the simplest and most economical harvesting method. It is suitable for even-aged stands in which most of the trees have reached marketable size. This is an even aged management system.

Since this system removes all trees from the stand, careful thought must be given to regenerating it, which is usually accomplished by: clearcutting in narrow strips or small blocks to allow natural seeding from adjacent stands, tree planting, or sprouts coming from hardwood stumps.

Clearcutting should be used with caution. It takes a long time to get the next stand to marketable size and the initial stand may regenerate to less desirable species. Other negative aspects of clearcutting are:

- Increase risk of soil erosion. Clearcutting removes ground cover which can allow for soil erosion into nearby waterways.
- Increased sunlight causes changes in temperature which disrupts the ecosystem.
- Loss of biodiversity.

These are some reasons why expert opinion is worth seeking out.

Finally, only rarely is just one cutting system used exclusively on an entire lot. In Massachusetts, our complex forests do not lend themselves to such uniform management, and it is often necessary to use more than one technique in a given area.

Shelter Wood Cuttings

Shelter wood cuttings remove the mature forest in several steps (usually two or three) over a period of 5 to 15 years (Figure 13). In each cutting operation, trees are removed uniformly throughout the stand, similar to severe thinning. The opened stand provides seed for the new crop of seedlings, which germinate and develop in the shade of the protective overstory (the shelterwood). This shelterwood is removed eventually when the new stand underneath is well established. About half of the trees would be removed in each part of a 2-cut shelterwood, about one-third in a 3-cut. Usually, the best trees are left to increase the diameter and height until the final cut. Shelterwood cuttings are adapted to even-aged stands of most species except the very shade-tolerant. Even-aged White Pine and Northern Red Oak are best managed by this technique, and for most even-aged stands, shelterwood is a better method than clear cutting. This is an even aged management system.

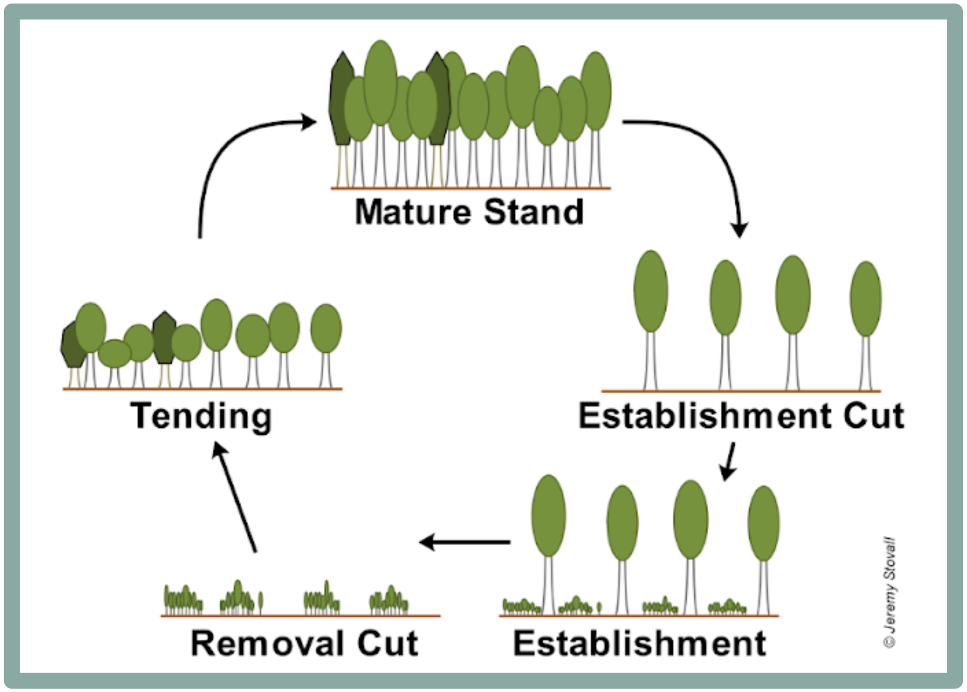


FIGURE 13 GRAPHIC FROM [HTTPS://WWW.SFASILVICULTURE.COM/INDEX.PHP/TEXTBOOK/3-4-REGENERATION-METHODS-SHELTERWOOD](https://www.sfasilviculture.com/index.php/textbook/3-4-regeneration-methods-shelterwood)

Seed Tree Cutting

This system leaves only widely scattered trees of excellent crop trees to serve as a seed source; but, unlike the shelterwood system, the sparse canopy cover has little effect on conditions of the environment near the ground.

The seed trees requirements:

- light-seeded species (requiring full sun)
- full healthy crown
- superior crop trees
- prolific seed production
- sturdy and healthy enough to withstand increased wind and sun exposure.

The number of seed trees per acre retained will depend upon the target species and their regeneration requirements. The trees removed in the seed cuttings are the least desirable remaining in the stand. It is particularly important that trees other than target species be cut or killed regardless of crown class. Seed cuttings should be carried out during a year in which the desirable species bear seed in abundance. The residual seed trees should be spaced to provide an adequate amount of seed to assure regeneration of the desired species. Seed tree cuts are most effective with seeds that do not have a long viability in the soil. For example, seed tree systems do very little to promote black cherry because the seeds can remain viable for over 40 years. This is an even-aged management system.

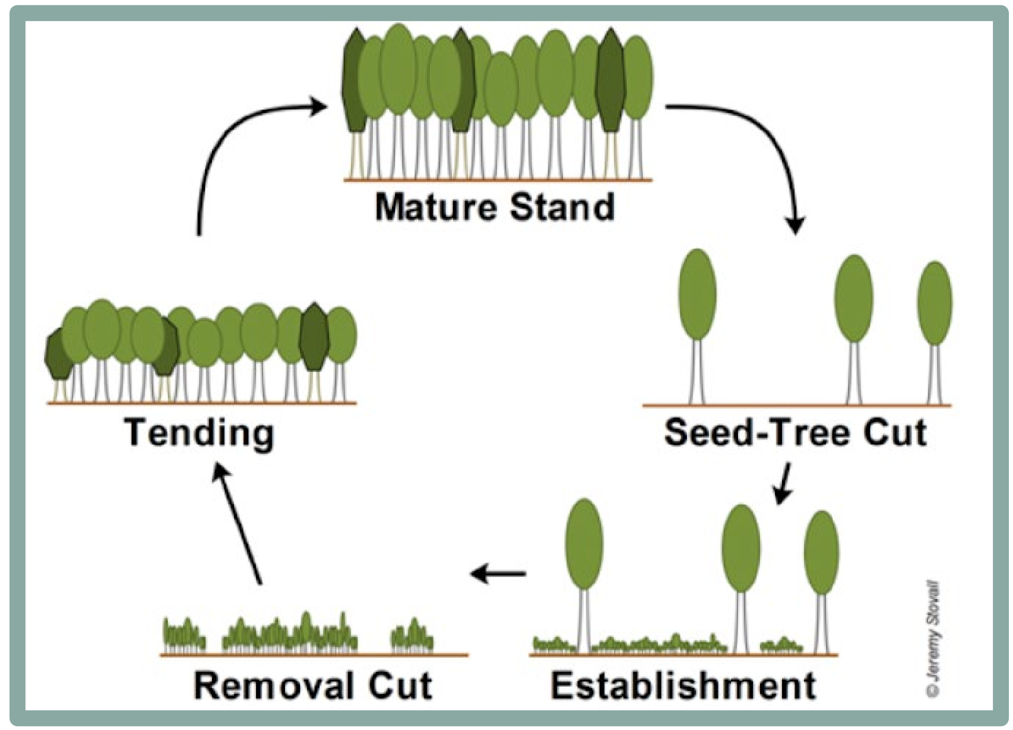


FIGURE 14 GRAPHIC FROM [HTTPS://WWW.SFASILVICULTURE.COM/INDEX.PHP/TEXTBOOK/3-3-REGENERATION-METHODS-SEED-TREE](https://www.sfasilviculture.com/index.php/textbook/3-3-regeneration-methods-seed-tree)

Crop Tree Method

The crop tree method has no precise definition, except for the emphasis on crop tree release and is best classified as an intermediate treatment. In applying a crop tree method, crop trees must first be identified based on landowner objectives.

In general, crop tree characteristics include:

- dominant/co-dominant trees
- high- value commercial species
- longevity of 20+ years
- well adapted to the site
- Vigorous and healthy enough that survival is anticipated, at minimum, until the next entry

A crop tree simply represents the best main canopy trees available. Crop trees should be in a dominant or co-dominant crown position, with good tree form, and well-spaced from other crop trees.

In addition to the above crop tree attributes, crop trees may also have additional characteristics for objectives other than timber. For example, wildlife objectives include crop trees that can produce mast and cavity/den trees. Spacing between crop trees will depend on landowner objectives and the location of available crop trees in the stand. The number of crop trees/acre should assure full site utilization. Only trees in direct competition with the crop trees should be removed. The thinning frees space around all sides of the crowns and promotes rapid diameter increase. In crop tree management, **overtopped trees** may be removed or retained, and even some intermediates may be as trainers. This is an even-aged management system.

Regenerating the Woodlot

When you harvest timber from your forest, you usually will usually plan to establish a new crop of trees. If special provisions are not made for regeneration, nature will do it her own way. What you do, or do not do, will largely determine what you get for a new crop of trees, and the future of your forest.

Forest trees periodically produce variously sized crops of seeds. Often, less preferred species produce the heaviest crops. The parent seed trees may be single trees or groups of trees. The more numerous and vigorous the seed trees, the greater probability of securing a good crop of seedlings. Seed trees of weed or unwanted species should be removed. Seeds vary in size from the very small like birches and poplar, to heavy nuts produced by oak and hickory. Some of the smaller and lighter seeds will be blown away for considerable distances. Many will be carried by wildlife, which may account for why in some forests there are scattered clumps or single trees that are different from their neighbors. The survival of the seedlings growing from these seeds will depend on adequate soil moisture being available to their roots, protection from excessive sun or drying winds, and the wildlife present. Fortunately, most trees produce sufficient seeds to ensure the survival of the species, even though birds and animals may consume a large portion of the seed crop. Other trees and shrubs, or the slash on the ground from a forest management operation help act as "nurse" trees and provide the shade and wind protection that will permit the seedlings to become established.

A serious obstacle to germination and survival is a thick, dry layer of needles or leaves covering the ground, which prevents the germinating seeds from reaching mineral soil and an adequate water supply. You can keep your new tree crop by preparing the site so that the seeds will find a favorable environment. A good method is to **scarify the soil**, which will expose mineral soil and make a better seedbed. Logging operations on

Overtopped trees, also known as suppressed trees, are those whose crowns are below the general level of the canopy, where they are unable to get any direct light.

There are two types of **soil scarification:** natural and silvicultural. Natural soil scarification results from natural disturbances such as wind, heavy rain and snowmelt, and even wildlife removing leaf little and debris. Silvicultural soil scarification involves disturbing the forest floor in a controlled way by scuffing the forest floor.

bare ground sometimes serve this purpose. Where there is a dense grass or shrub ground cover, mowing or prescribe burning can be used to suppress the competition. Natural seeding or regeneration obviously is the least expensive alternative. It yields trees that are already adapted to the area, and usually results in an excess of seedlings, which permits a wide choice from which to select the new crop trees.

Artificial Regeneration

Certain forested areas lack seed trees that can provide the desired natural regeneration. In these areas it may be necessary to plant trees. Planting gives you the opportunity to establish an even-age crop of preferred and genetically superior trees. Soil and site conditions should be considered when choosing the species of tree to plant.

KNOWLEDGE CHECK

Forest Ecology

- What are the 6 vertical layers in a forest?
- What is the role of pioneer species in forest succession?

Fire and the Forest

- How can fire benefit forest ecology?
- What is mesophication?
- What are the 4 components of the fire tetrahedron?
- When would a forester prescribe fire for forest management?

The Urban Forest

- How does urban forestry differ from traditional forest management?
- What are some of the threats that trees face in the urban environment?
- List the benefits that trees offer to urban communities.

Trees Forest and Climate Change

- In your opinion, what are the top 5 most concerning impacts of climate change on trees and forests?
- How do forests contribute to climate mitigation and adaptation?
- What is the difference between carbon storage and carbon sequestration?

Forest Resiliency

- What is forest resiliency?
- What are the 5 characteristics of resilient forests?

Forest Silviculture & Management Options

- List the 5 major types of habitat in Massachusetts, and briefly describe where most wildlife will be found.
- Which of the maple fun facts do you find most interesting?
- There are 3 kinds of work involved in timber stand improvement (TSI). What is the objective of each?
- Read over the 3 types of forest harvest cuttings. Based on your understanding, draw your own version of Figure 12.

FORESTRY AND SOCIAL JUSTICE

As an introduction to the topics of social justice and environmental justice, this section serves to illustrate only some of the pressing issues in communities across the state. Please see the end of this section for additional resources where you can learn more about environmental justice, social justice, and the ways in which they interact.

Environmental Justice Is Social Justice

While environmental justice and social justice are distinct terms, one heavily relies on the other. Social justice pertains to the fair and equitable treatment of all individuals regardless of their income bracket, identity, or beliefs. Conversely, environmental justice (EJ) is based on the principle that all people have a right to enjoy, access and benefit from an equitable distribution of environmental benefits: financial, physical, mental, and spiritual. Besides focusing on the many advantages of having access to nature, EJ initiatives uphold communities' right to be *protected from* environmental hazards.

Environmental injustices often occur in communities in need of social justice. For instance, air and water quality in poor and racially diverse communities are more likely to be lower when compared to wealthier, predominantly white areas. These disparities in environmental quality result from decrease in tree canopy cover, proximity to landfills, industry and even transportation hubs like highway and airport systems, to name a few. While these factors are not always purposefully planned to affect certain communities, systemic factors do in fact impact how quickly remedial actions are set in place. It is these kinds of injustices that impact communities' mental and physical health, businesses, and even real estate prices.

FIGURE 15 SPRINGFIELD, MA 2009 FROM HTTPS://EJATLAS.ORG/CONFLICT/PALMIER-RENEWABLE-ENERGY-PROPOSES-BIOMASS-WASTE-INCINERATOR-TO-BE-CONSTRUCTED-IN-SPRINGFIELD-MA-USA

It is important to keep in mind that environmental injustices can occur in both urban and rural settings. For example, air quality can be deplorable in urban settings due to a combination of smog and a declining, if not non-existent, tree canopy (Figure 15). In rural settings, a decline in air quality may be observed, but this may be due less to car emissions and more from practices such as industrial meat production and waste management.

Upon exploration of the many benefits of forestry, it becomes obvious that it is more than a powerful contender in the fight against climate change. Environmental injustice has symptoms that can be

Impervious surfaces are those that impede the natural infiltration of water back into the soil. This includes compacted soils, paved surfaces like parking lots and roads and lastly, buildings and rooftops.

alleviated by forestry. But there is more to it than that. Before the land was developed into pavement and buildings, all communities in need of EJ were thriving natural ecosystems. Expanding the forest into these now urbanized areas is the beginning of restoring healthy ecosystems and thus justice.

Issues Present in EJ Communities

Communities in need of Environmental Justice tend to see a decline in tree cover and an increase in **impervious surfaces**. These two factors not only take away these communities' access to the benefits of trees introduced on page 32: deforestation and inadequate development are significant culprits in environmental injustice. The United States Environmental Protection Agency and other research institutions have identified several specific challenges brought about by environmental injustice, most of which will be exacerbated as our climate continues to change.

To further complicate the matter, not one of these issues is isolated from the other: they are all interconnected. Therefore, to conceptualize these issues and their possible remedial actions more easily, it is useful to analyze them from a sustainability standpoint.

A sustainability approach (Figure 16) helps us untangle the interactions between environmental, social, and economic factors. While some environmental issues will fall in more than one category, this holistic approach can help us in strengthening arguments in favor of justice.

In the next page, you will see a table outlining focus points for environmental justice, and how each impacts the presented sustainability pillars. Thinking back to the benefits of trees you have learned thus far, consider how each issue could be alleviated by trees and forests.

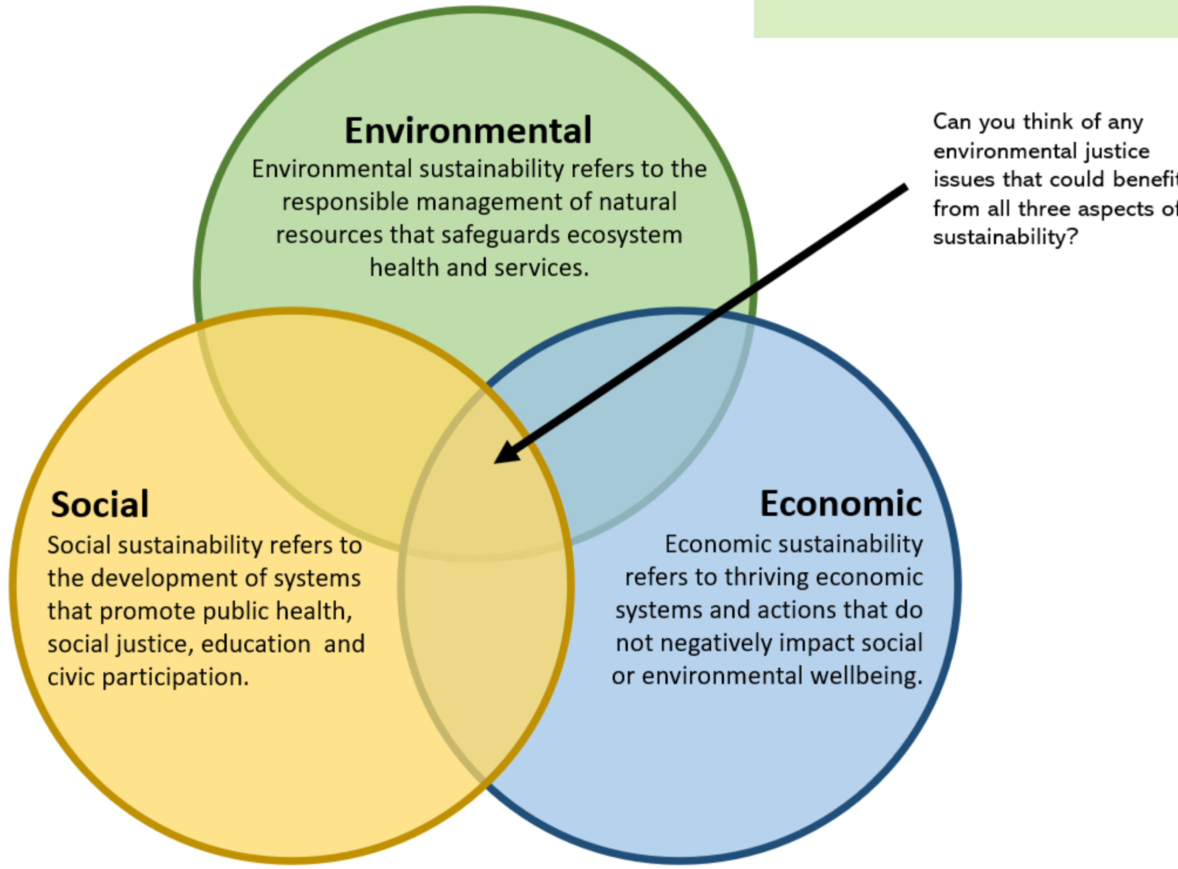


FIGURE 16: THE SUSTAINABILITY PILLARS

EJ Issue/Impacts	Environmental	Social	Economic	Forestry-based solutions
Water quality	Watershed health decline is associated with harmful algal blooms	A decrease in water quality increases exposure to waterborne infections and chemical pollutants that may lead to acute illness and even chronic diseases such as cancers and neurological diseases.	Water infrastructure demands, costs, and complexities disproportionately impact low-income communities.	How could you apply the benefits and ecosystem services that trees and forests provide to each of these issues?
Air Quality	The burning of fossil fuels contributes to greenhouse gasses. These pollutants in our atmosphere mix with water and other materials, resulting in acid rain. This then leads to the acidification of water and soil, affecting flora, fauna, and humans.	Studies have shown that schools with higher proportions of POC and students eligible for free or reduced lunch are associated with an increase in air pollution. Exposure is associated with oxidative stress and inflammation in human cells, leading to some cancers and chronic diseases.	Air pollution affects our economy by increasing healthcare costs and work absenteeism, as well as decreasing crop yields. Air pollution in the form of acid rain also damages building structures over long periods of time.	
Flooding Hazard	Flooding can affect ecosystems by causing soil and bank erosion, damaging vegetation, and impact wildlife habitat, to name a few.	Flood waters tend to carry elevated levels of contamination. Communities experiencing flooding are more likely to come into contact with mosquito-borne diseases, mold, sewage, and other hazardous substances.	Besides the expenses associated with medical treatment for affected populations, flooding impacts housing and the belongings in them, business operations, worker's productivity, and overall losses in GDP.	
Energy access and costs	An increased demand on energy impacts the environment by increasing demand for fossil fuels and encroachment of green lands through the installation of renewable energy sources such as solar farms.	Burning fossil fuels for energy impacts air quality, affecting EJ communities. Extreme weather events increase energy costs for families to cool and heat their homes. Low-income and communities of color are disproportionately burned by climate change impacts and costs.	Increased energy needs require updating and upkeep the electric grid. Overburdening our energy supplies causes black outs that affect businesses, schools, hospitals etc. These further impacts productivity and thus the economy.	

Forestry-based Solutions to EJ Issues

Water Quality

Trees, their root systems and soil in which they live are powerful filtration systems. An increase in forest cover in both urban and rural areas has been found to increase water quality in the long-term by reducing stormwater runoff.

Air Quality

Air quality is a twofold issue. Firstly, it is caused by pollution emitted from factories, major roadways, and ports with diesel truck operations. It can even be caused by windstorms carrying eroded soil and debris from wildfires. Secondly, a limited tree canopy is unable to filter day-to-day air pollution. EJ communities tend to experience a disproportionate number of pollution sources located in their own communities at the same time that their canopies are drastically smaller than those in non-EJ communities. Restoring neighborhoods' canopies indisputably delivers some relief from air pollution, as trees filter our air, help in reducing greenhouse gasses and **particulate matter (PM)**.

Flooding Hazards

Flooding can occur as a result of several factors. In the case of rising sea-levels, the melting of ice sheets into the ocean is a significant culprit. Research shows that the restoration of coastal habitats, specifically the restoration of coastal forests made up of mangroves and other trees and shrubs, could be greatly beneficial in protecting those populations living in areas prone to flooding. Healthy coastal ecosystems protect wildlife, people, and property.

As previously discussed, the combination of rainfall and impervious surfaces increases stormwater runoff, which can develop into street flooding. Reducing impervious surfaces and increasing vegetation land cover, particularly as it relates to trees and shrubs, allows water to percolate into the soil, where roots will take up water and help create conditions that promote infiltration and reduce soil erosion.

Energy Access and Costs

In the winter, trees and shrubs act as a protective barrier between homes and strong winter winds that would otherwise require homes to consume more energy by turning up their thermostats. By contrast, in the summer, trees lower surface air temperatures through shade and evaporation and transpiration of water through their leaves. This in turn reduces the need for extended use of air conditioners. Trees quite literally reverse the **heat island effect** that urbanized communities experience every summer. The U.S Department of energy's calculations point to a 25% savings in energy use due to carefully positioned trees. Now that's cool!

Justice, in Conclusion

Climate change and other environmental disasters make it obvious that we need to come up with creative solutions. Trees and forests provide food, shelter, clean water, clean air, and recreation. Their expansion into urban and even agricultural areas has the potential to deliver justice to communities that have historically had to live without it

Particulate matter (PM) is a mixture of liquid and solid particles. Some are big enough to be seen with the naked eye, such as smoke and dust, while some are small enough that can only be detected with an electron microscope. PM contains particles so small that they can get deep into our lungs and even blood stream. If you needed a sign to check your local Air Quality Index (AQI), this is it!

Heat Islands are caused by a high concentration of infrastructure, such as buildings and roads, that absorbs and re-emits the sun's heat more than natural ecosystems. The EPA estimates that the **heat island effect** results in an increase of up to 7°F in temperatures when compared to non-urban areas.

Additional Resources

Massachusetts Climate Report Card- EJ: https://www.mass.gov/info-details/massachusetts-climate-report-card-environmental-justice

Environmental Justice Populations in Massachusetts: https://www.mass.gov/info-details/environmental-justice-populations-in-massachusetts

EPA Environmental Justice https://www.epa.gov/environmentaljustice

Yale Experts Explain Environmental Justice: https://sustainability.yale.edu/explainers/yale-experts-explain-environmental-justice

Environmental Justice Factsheet: https://css.umich.edu/publications/factsheets/sustainability-indicators/environmental-justice-factsheet

KNOWLEDGE CHECK

Environmental Justice is Social Justice

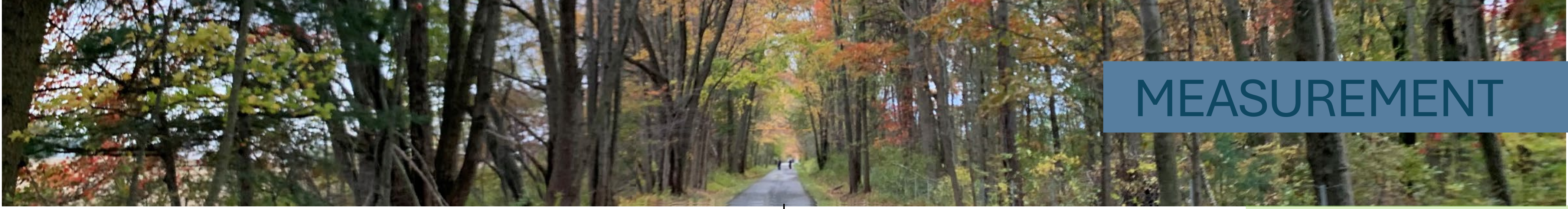
- How do the terms Environmental Justice and Social Justice differ? How do they relate?

Issues Present in EJ Communities

- Why is it useful to think about EJ from a sustainability standpoint?
- Revisit the EJ issues listed. Are there any other specific issues of injustice you can think of? How would you describe their environmental, social and/or economic impacts?

Forestry-Based Solutions to EJ Issues

- The solutions to many of the EJ Issues are interconnected. For example, water quality is impacted by flooding hazards. Do you see any other issues that could be connected?



Forest Mensuration / Statistics and Probability

This covers methods of obtaining information (numbers, species, size, value, or health) on natural populations (ex. trees, chipmunks, mushrooms), when it is impossible or impractical to measure every member of the entire population.

Forest Inventory

Forest inventory is usually concerned with characteristics of the trees within the forest, but may also deal with fire hazard, wildlife habitat, understory vegetation, etc. Data is collected from different sample designs. Some may rely on randomly located plots while others might use randomly selected starting point and then sample along a grid or transect. The gathered data is **extrapolated** to yield information on the whole forest. Plots may be installed permanently so they can be periodically re-measured, or as a one-time measurement.

Most commonly, we are looking for information on species volume, size, health, and density. These factors will influence our management of the forest. The person collecting the data needs to be knowledgeable about tree species, forest types, **aerial photogrammetry**, or other GIS (geographic information system), and the use of forestry tools.

Diameter

Measuring tree diameters is an important part of forestry and can be used to estimate the volume, biomass, and carbon storage of trees. <u>Tree diameter measurements are always taken at 4.5'.</u> Since cutting the trees to measure directly across the center is not an option, diameter can be found by using circumference to Diameter calculations:

Divide the circumference by π (3.14)

While using this formula will get the answer, it is not efficient to use this for each tree in the field. To make measurements in the field easier and more efficient, multiple tools have been developed and are commonplace when collecting data in the field. The different tools that may be used to measure a tree's Diameter at Breast Height (DBH) are:

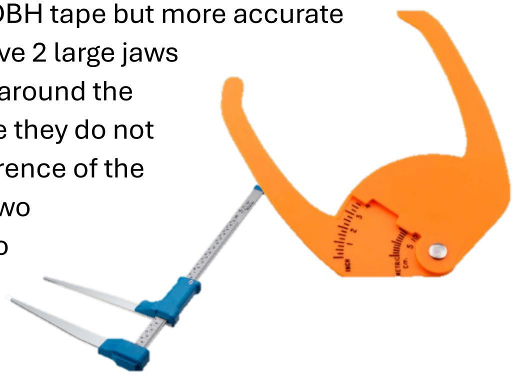
DBH Tape – The most accurate tool for measuring diameter. The tape has normal inches on one side and the other side has been modified to exercise the circumference formula.

Extrapolating data refers to estimating or projecting values based on known data.

Aerial photogrammetry is normally used to create topographical maps. These maps are based on pictures of the Earth taken from a high point, such as an airplane. These maps are used in conjunction with Geographic Information System (GIS) data.

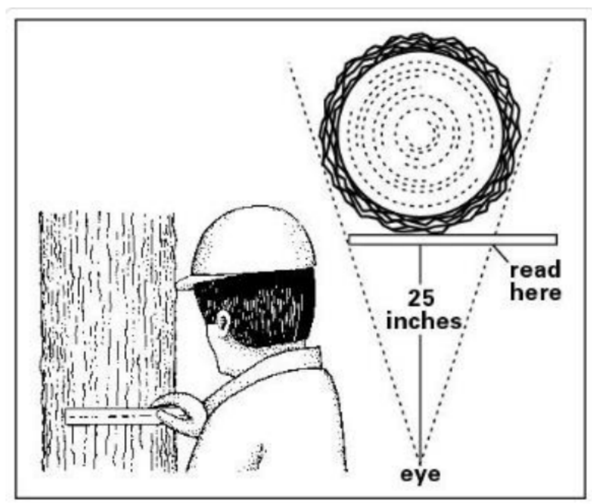
GIS (geographic information system) is a computer system that analyzes and displays geographically references information.

Calipers – Less accurate then DBH tape but more accurate than the Biltmore stick. They have 2 large jaws that can be opened and closed around the outside of the tree's trunk. Since they do not encompass the entire circumference of the trunk. It is best to take at least two measurements perpendicular to each other and then average the results.



Biltmore stick- This is the least precise of the three tools but is regarded by many as the most convenient to use. To use this tool, follow these guidelines:

1. Hold stick level against tree 25" from eye and 4 ½' above ground on uphill side.
2. Move the stick to the left or right until your line of sight to the left-hand side of the tree crosses at the left-hand end of the stick.



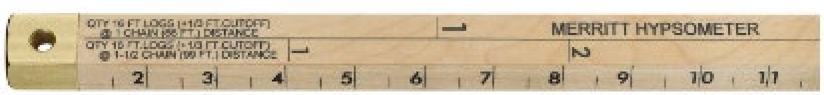
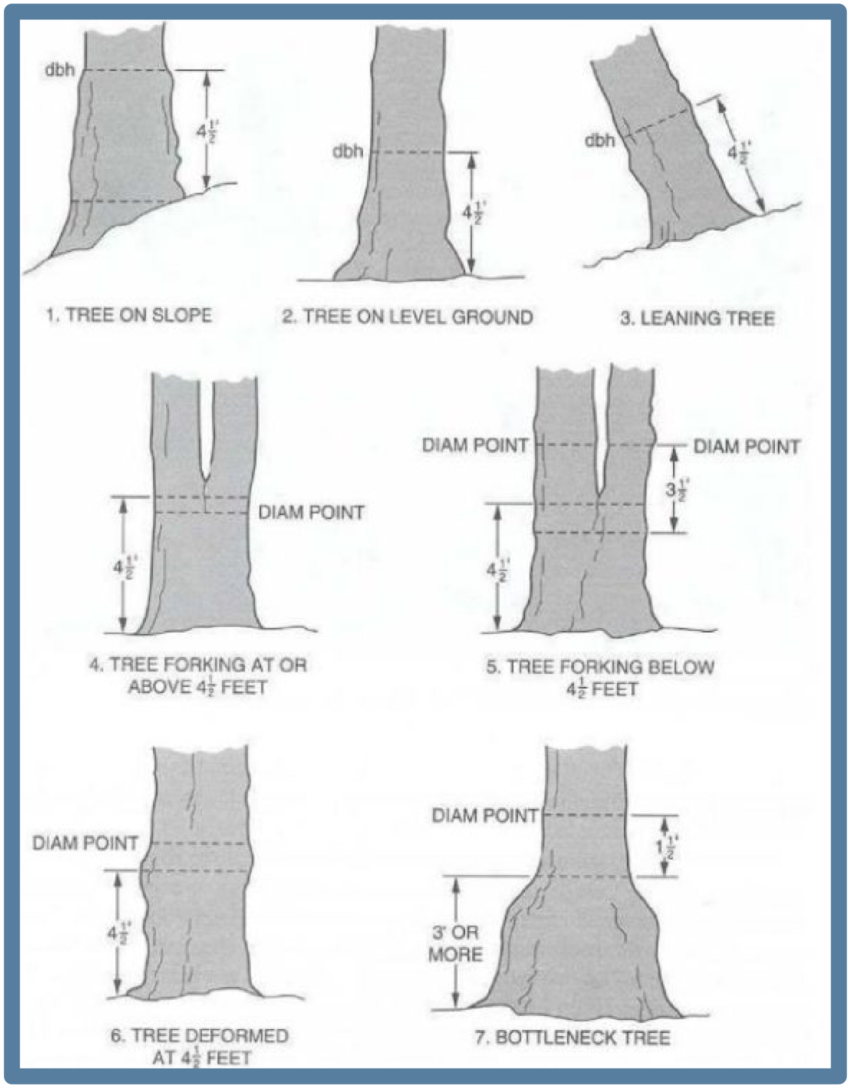


FIGURE 17: GRAPHIC FROM [HTTPS://CONTENT.CES.NCSU.EDU/WOODSCAPING-YOUR-WOODLANDS](https://content.ces.ncsu.edu/woodscaping-your-woodlands)

Deciding on which measurement tool to use is based on how accurate the data needs to be. If the data is being used for research or monitoring, then it is best to use the most accurate tool possible. When foresters are measuring stands for cuts/lumber, they need to do it quickly and get a firm understanding of the amount of timber the stand holds. Since they work with large numbers of trees, the data is statistically viable.

In an ideal measurement situation, a tree is perfectly round and is growing on level ground. Frequently we encounter situations that are less than ideal. The following guidelines and graphic should help when a tree has irregularities:

- Trees that are growing on slope require DBH measurements taken on the uphill side of the tree.
- In measuring the DBH of a leaning tree, the 4.5 feet (1.3 m) is measured perpendicular to the upper most side of the tree. Trees with a deformity that causes an unnaturally large diameter at 4.5 feet (1.3 m) above the ground are measured at a point above the deformity where the stem is unaffected.
- Some species of trees are prone to forking, which leaves us with the dilemma of whether to measure each merchantable stem individually.
- Trees that fork below a point 4.5 feet (1.3 m) from the ground have the stem's diameters measured individually, at a point 3.5 feet (1.0 m) above where the tree begins to swell before the fork.
- Trees that fork at or above 4.5 feet above ground are measured as a single stem, at a point just below where the tree begins to swell before the fork.



MEASURING DIAMETER AT BREAST HEIGHT DIAGRAM (in the U.S. units of feet & inches)

The metric system of measurement consists of converting the above English measurements to metrics. Specifically: 4.5 feet to 1.37M, 3.5 feet to 1.07M, 3 feet to .9M and 1.5 feet to .46M.

Height

The two most basic measurements of individual trees are diameters and heights. The tables used later in this manual for calculating volumes of individual trees are based on these two measurements.

Total Tree Height is from the bottom (ground level) to the very top of the tree and used in determining a unit of measure known as Site Index or the producibility of the forested site.

Merchantable Height is the highest point at which the tree is still useable for lumber and receive payment for. It is at the point where either a minimum diameter is reached, or, because of branching or defects, the tree no longer has the proper form above that point.

It's one of the two essential measurements in estimating the saw timber volume of a standing tree. In volume estimation, we are interested in the merchantable height of the tree and not necessarily the total height. Merchantable height can be difficult to define and difficult to judge when making measurements in the field.

Utilization standards for trees vary by region and by consumer. For example, a sawmill owner purchasing standing timber may use all the hardwood logs down to a minimum diameter of 8 inches. A logger in the same area may only be able to sell logs down to a diameter of 10 inches. In this case, the sawmill owner makes tree height measurements to a higher point in a tree than the logger would.

The forester's view of where the merchantable portion of a tree ends is often obscured by other trees. Even when the merchantable top of the tree is clearly visible, proper judgment of the usable height comes only with experience. For the purpose of this manual, the minimum standard of merchantability at the small end of the last sawlog is eight inches in diameter with at least three clear sides.

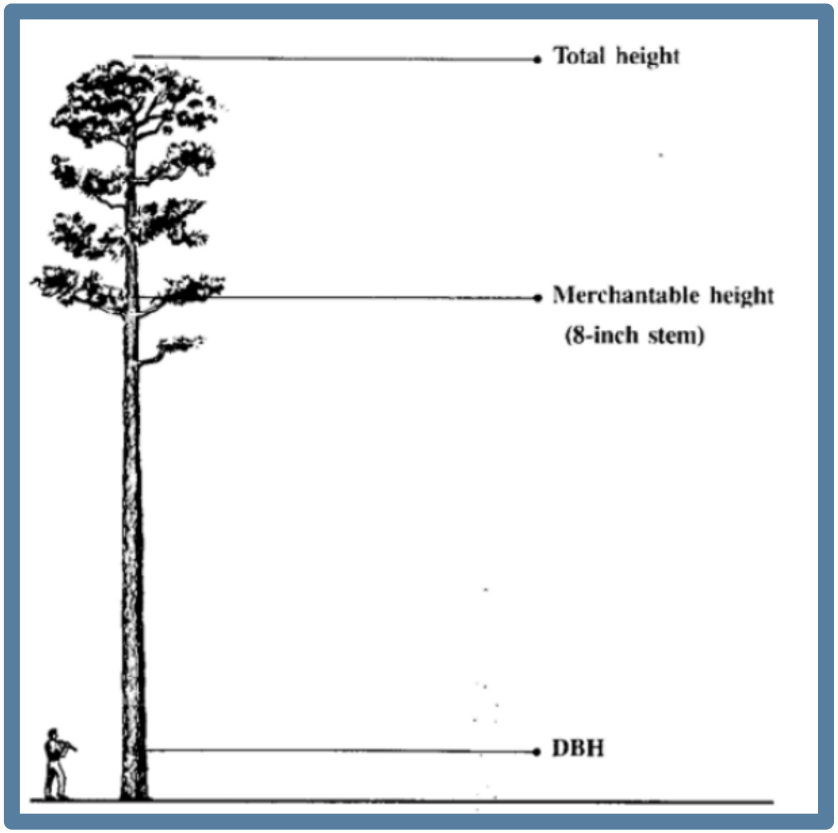


FIGURE 16 GRAPHIC TAKEN FROM HTTPS://EXTENSION.MSSTATE.EDU/PUBLICATIONS/4-H-FORESTRY-MAKING-TREE-SCALE-STICK

As with diameter, there are several different tools which can be used to measure Merchantable Height of a tree. The following tools can be used in measuring heights:

- Clinometers
- Abney levels
- Spiegel relaskops
- Tangent Height Gauges
- Merritt Hypsomete
- Laser Rangefinder

Heights are usually measured using hypsometers, clinometers, although digital laser rangefinders are becoming the norm. Hypsometers and clinometers are based upon the measurement of angles and triangles. If you know 2 angles and 1 side, you can determine the height of another side. A hypsometer works at distances of 66 or 132 feet and measures 16-foot logs. A clinometer works at 66 or 100 feet and measures feet.

Merritt Hypsometer

A very common tool used in height measurement is the Merritt Hypsometer. One side of the Biltmore stick is graduated as a Merritt Hypsometer. Even though the hypsometer is graduated in 16 foot log lengths, it is common practice to measure heights down to a half log interval (½, 1, 1 ½, 2, 2 ½, etc.). Volume tables contain saw timber volume estimates for heights in this fashion.

The Merritt hypsometer is calibrated for measurements taken one chain (66 feet) from the tree. As with the Biltmore stick, the hypsometer is held out 25 inches from your eye. The bottom of the stick is held even with the potential stump height and the stick is held even with the tree in your line of vision. The merchantable height measurement is taken by reading the number of logs (in full and half log intervals) from the hypsometer at the point where it is even with the uppermost usable portion of the tree.

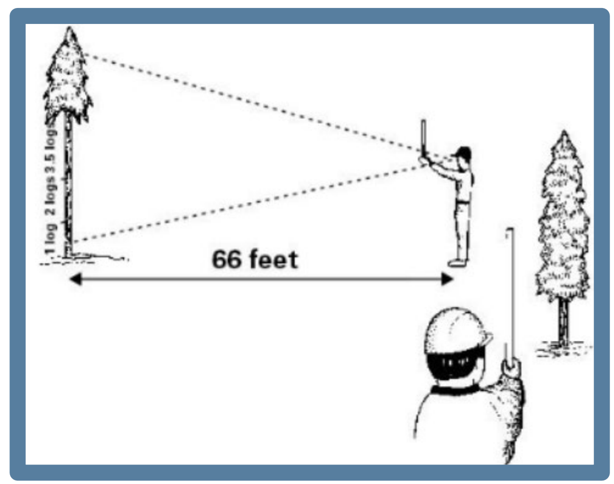
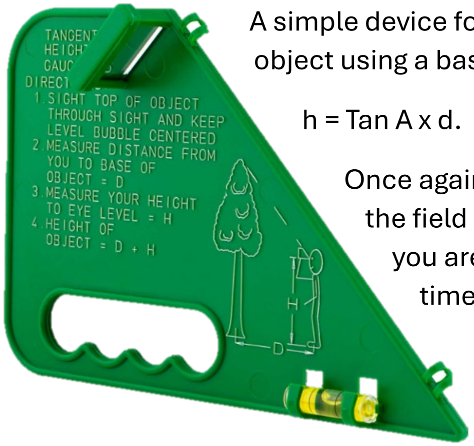


FIGURE 19: GRAPHIC FROM HTTPS://CONTENT.CES.NCSU.EDU/WOODSCA

Tangent Height Gauge



A simple device for measuring the height of nearly any object using a basic trigonometry formula:

$h = \tan A \times d$.

Once again it is not efficient to do math formulas in the field and tools that do most of the work for you are a great way to get the job done in a timely manner.

Tangent Height Gauge instructions for measuring the height of objects.

1. The user sights the top of the object being measured through the two circular sighting rings and alters their position by moving forward or backwards along the 100-foot tape measure, until the level bubble is centered (as viewed through the mirror).

   Hot tips:

   a. Try estimating the height of the tree and stand at that point on the tape measure.
   b. I start by getting the level's bubble centered and see where I am pointing it, above the tree top or below, then I move forward or backward (keeping the bubble centered) until I am pointing at the top.
2. The distance from the user to the base of the object plus the distance from the ground to the user's eye level is the height of the object. Don't forget to convert units to the required unit of measure, whether it is in inches or in feet. Instructions for use are printed directly on the gauge.

Board Foot Volume

The board foot is a common measurement of wood volume. One board foot is equal to a piece of wood 1 foot long, 1 foot wide, and 1 inch thick or 144 cubic inches.

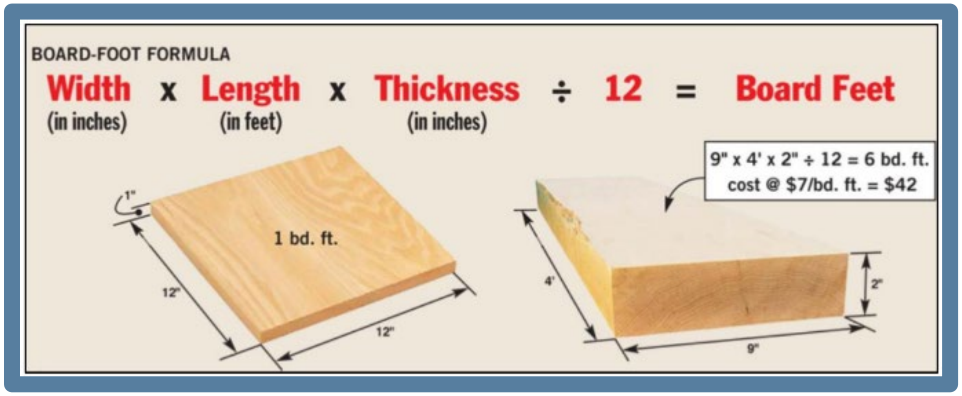


FIGURE 19: GRAPHIC FROM HTTPS://CORMARKINT.COM/POSTINGS/HOWTODETERMINEBOARDFOOTAGE/

It is relatively easy to determine the board foot volume of lumber, but much more difficult to determine the board foot volume of standing trees. By measuring the actual volume of sawlogs milled at a sawmill from measured trees, foresters develop equations, or log rules. There are many different log rules in use today.

In Massachusetts, we commonly use the International ¼ inch log rule:

Volume= .0460436 x DBH 2.2312 x HT 0.75951 x F 2.34055

DBH = diameter at breast height in inches HT = merchantable height in feet F = 0.78 (form class)

From these equations, we develop volume tables, such as the one on most Biltmore sticks.

Measuring Trees for Board Foot Volume

Once you have the DBH and the height of the tree, you can determine the board foot volume by using the Tree Scale International ¼ inch log rule chart.

TREE SCALE – International ¼ inch log Rule

D.B.H. Inches	Height - Number of 16 foot logs - to 6" top						
	1	1.5	2	2.5	3	3.5	4
6	10	15					
7	10	25	40				
8	20	35	50				
9	30	45	60				
10	40	55	70	85	95		
11	50	65	80	95	110		
12	60	75	95	110	125	145	165
13	70	90	115	130	145	165	190
14	85	110	135	150	165	190	215
15	95	130	160	180	200	220	250
16	110	150	190	215	240	260	285
17	125	165	215	250	280	300	325
18	140	195	245	285	320	345	370
19	160	220	275	320	360	390	420
20	180	245	310	355	400	435	465
21	200	270	345	400	450	490	525
22	220	300	380	445	505	545	585
23	245	330	420	490	560	605	655
24	270	365	460	540	615	670	730
25	295	400	505	590	675	735	800
26	320	435	550	645	735	805	875
27	345	470	600	700	800	875	955
28	370	515	655	760	870	950	1035
29	400	555	705	820	940	1030	1120
30	430	595	760	885	1010	1110	1205

To determine the board foot volume of a tree:

Measure the tree's DBH and merchantable height, (to the nearest half log). Locate the DBH on the left side of the chart above and read across to how many sawlogs you measured. Then read down the chart to where the two measurements intersect, and that number is the Total Board Foot Volume of the tree you measured.

EXAMPLE: If a White Pine had a DBH of 20 inches and a merchantable height, (not the total height) of 3 logs, it would have a total volume of 400 board trees.

KNOWLEDGE CHECK

Forest Inventory

- What do foresters look for when they conduct a forest inventory?

Diameter

- At what height of a tree is diameter measured?
- What are the 3 tools you can use to measure diameter? Describe each.

Height

- When would you use the total tree height versus the merchantable height of a tree?
- How far away do you have to be from a tree in order to use a Merritt Hypsometer?
- How does the Tangent Height Gauge work?

Board Foot Volume

- Calculate the board ft and draw a piece of wood that is 7 in long, 4 in wide and 3 in thick.

Measuring Trees for Board Foot Volume

- A tree's DBH is 18 inches, and it is 32 ft tall. What is the tree's board ft volume?

FOREST HEALTH

The U.S. Forest Service states that forest health has been defined by the production of forest conditions which directly satisfy human needs and by resilience, recurrence, persistence, and biophysical processes which lead to sustainable ecological conditions. Our definitions and understanding of forest health are also dependent on spatial scale.

Like all worthwhile things in life, owning and managing forestland involves some risks. Your forest is vulnerable to damage or destruction by many natural and manmade threats. Forest threats include fire, insects, disease, wind, ice, snow, grazing and man. Let's consider some of these hazards and how you can minimize them.

Insects and Disease

Native insects and pathogens are an important part of a healthy forest ecosystem, but when environmental and biological conditions favor their development into outbreak status, they can cause significant losses to forests. Several of these insects and pathogens, such as bark beetles and root diseases, have had extensive impacts in western and southern forests in the U.S.

Several species of insects, native to North American forests, occasionally cause significant tree mortality across the landscape. For many years these insects may be a low or endemic levels but when conditions favor them, their populations can build up to damaging levels which is known as an outbreak.

Historically, the southern pine beetle (SPB) has affected forests from Maryland and Virginia south to Florida and Texas but has been moving northward into New England due to the warmer winter temperatures. Massachusetts had its first outbreak of SPB in 2023 on the islands of Martha's Vineyard and Nantucket. The SPB attacks mostly 2 to 3 needle pines, in Massachusetts the preferred host is Pitch Pine. All trees that have signs of the insect were cut down to knock back the population.

Insects and diseases kill more timber each year than all the other hazards combined. Each species of native tree has its insect and disease predators. You cannot rid your forest completely of insects and disease, of course, but you can minimize their negative impacts.

Invasive Species

An invasive species is an alien (non-native) species whose introduction does or is likely to cause economic or environmental harm or harm to human health. Non-native invasions are one of the main ecological consequences of global trade and global changes in climate and land use. Most invasions over the past several centuries have involved species transported directly or indirectly by humans.

Improvements in transportation have made it even easier for humans to move products from all over the world to any location. Unfortunately, non-native species have been imported intentionally and unintentionally through world trade and foreign travel. These species have been able to adapt to new environments and spread rapidly. Their success is due in part to the lack of host resistance and natural enemies, thus allowing them to become established unimpeded. Non-native species and pathogens have caused enormous ecological and economic damage to U.S. forests, and they continue to be introduced at an alarming rate.

Invasive Forest Insects

Non-native invasive insects have had a significant impact on the forest of Massachusetts as well as North America. The ecological functionality of some host trees has been severely reduced by species such as the emerald ash borer and hemlock woolly adelgid. These insects have impacted both urban and forest host trees. The following chart list some of the major invasive insects found in Massachusetts. To see which insects are currently posing a threat visit the MA Forest Health Story Map at https://arcg.is/j8TiD.

Insect Common Name	Scientific Name	Origin	Host Treer	Present in MA
Spongy Moth	*Lymantria dispar*	Europe	Oaks and other deciduous species	Statewide
Hemlock Woolly Adelgid	*Adelges tsugae*	Asia	Hemlock	Statewide
Emeral Ash Borer	*Agrilus planipennis*	Asia	Ashes	Statewide
Asian Longhorned Beetle	*Anoplophora glabripennis*	Asia	Maple, birch, horsechestnut, poplar, elm, ash, willow, sycamore, plane tree, mimosa, katsura	Worcester, West Boylston, Boylston, Shrewsbury, Holden, Auburn

Invasive Forest Pathogens

Preventing or reducing undesirable impacts of invasive forest diseases are a difficult challenge facing all land managers. Invasive forest diseases such as White Pine Blister Rust, Chestnut Blight, Dutch Elm Disease, Butternut Canker, and Beech Leaf Disease, continue to have serious impact on landscapes across the U.S. through changes in the structure, composition, and successional pathways of native forest communities.

Pathogen Common Name	Scientific Name	Origin	Host Trees
White Pine Blister Rust	*Cronartium ribicola*	Asia	White Pines
Chestnut Blight	*Cryphonectria parasitica*	Asia	Chestnuts
Dutch Elm Disease	*Ophiostoma novo-ulmi*	Asia	Elms
Butternut Canker	*Ophiognomonia clavigignenti-juglandacearum*	Asia	Butternuts

Invasive Forest Plants

Non-native plants are referred to by many names: exotic, nonindigenous, alien, or even noxious weeds. Non-native plant species become invasive when they spread and reproduce beyond their area of origin. Invasive plants in the forest replace locally evolved species and decrease tree regeneration. In general, invasive species are defined as species that did not evolve in the ecosystem where you found them and cause harm by outcompeting native species and in some cases creating a monoculture. The following are some of the invasive plant species commonly found in Massachusetts forests.

Plant Common Name	Scientific Name	Origins
Asiatic Bittersweet	*Celastrus orbiculatus*	Asia
Glossy Buckthorn	*Frangula alnus*	Europe, Asia
Garlic Mustard	*Alliaria petiolata*	Europe
Japanese Barberry	*Berberis thunbergii*	Asia
Burning Bush	*Euonymus alatus*	Asia

Integrated Pest Management

Integrated Pest Management or IPM is the most recent approach to the control of forest and other crop pests. IPM is a system of pest control to maintain pest populations at levels below those causing economically important injury in as ecologically sound a manner as possible. The approach involves management of the entire pest complex of a forest, including damage inflicted by birds and mammals.

IPM involves these approaches:

Biological	• Releasing Parasites or predators that prey on the pest population. • Using biological insecticides containing Nuclear Polyhedrosis Virus (NPV), or the bacterium Bacillus thuringiensis (Bt).
Chemical	• Conventional pesticides. • Pheromone behavior modifiers (attractants, repellents, confusants, inhibitors, and sex attractants). • Fumigants.
Mechanical and Manual	• Eliminating tree debris, used by pest populations as feeding, breeding, and over-wintering sites. • Eliminating alternative host species. • Reducing undesirable seed sources.
Silvicultural	• Harvesting of mature and over-mature stands. • Cutting lightning-struck, wind-thrown, or trees susceptible to insect attack. • Thinning overstocked stands to maintain tree vigor. • Using risk-rating schemes to determine degree of susceptibility to insect attack and prescribe appropriate preventive action.
Wildlife	• Reducing the quality of the land as a habitat for wildlife species causing tree damage
Regulatory	• Abiding by quarantine regulations • Don't Move Wood

This list is constantly changing. New methods become available and older methods become obsolete. Not all the methods are appropriate to the control of a given pest; nor is any one method usually a satisfactory control used alone. But used wisely and in combination, they do the job. Your forester will be able to advise you which methods are appropriate for your situation.

Girdling a tree occurs when a piece of bark around the circumference of a tree is removed. This prevents the tree from sending nutrients throughout its body.

Weather

Protecting your forest from damage by climatic forces is very difficult. No one knows when nature will create a major disturbance on a property. Whether you own a few trees on an acre and a half in a suburban town, or dozens of acres in a rural area, you by now know that excessive wind, snow, ice, and water do damage to trees. Maintaining a healthy forest will help to lessen damage and speed recovery from natural causes. Less healthy stands are the ones most seriously damaged by natural causes. Maintaining correct stand density, and other techniques can minimize damage from wind and snow loads.

Animal Damage: Wildlife

Damage to a forest stand is common from a variety of wild animals. Mice **girdle** young saplings and seedlings, particularly when there is a heavy snow cover. Squirrels also girdle young plants by feeding on the cambial layer of the bark. Porcupines often damage the upper portions of larger conifers by feeding on the cambial layer of the bark. Deer browsing is often a serious problem in hardwoods, when there is a hard winter, it is evident on conifers. Rabbits, and birds such as the yellow-bellied sapsucker, damage hardwoods; the grosbeak can cause damage by feeding on the buds of young conifers. Beavers may build dams in wetter areas of the woodlot, the water backing up behind them may flood areas and permanently damage valuable species. Of course, many additional species of wild animals can damage your forest. If you suspect that they are at work, contact your District Forester or Forest Health Specialist.

Domestic Animals

When pastured in the woodlot, domestic animals, can kill young trees and herbaceous vegetation by grazing on foliage and stems and by trampling the root systems, but grazing in the woodlot can be beneficial in controlling unwanted vegetation at certain periods in the life cycle of a forest. A forester can advise you of the appropriateness of pasturing animals in your woodlot.

Human Damage

Man has run a close second to insects and disease as having the greatest negative impacts on forests. We can be careless with fire and the more forestland that we use, the greater the risk of damage. Machinery of all types can cause damage. We are continually breaking branches, peeling bark, and hacking trees with our axe while we're in the forest. It's a hazard that a woodlot owner encounters sooner or later, but it can be minimized by good public relations. Plan to protect your forestland at the same time you plan to manage it.

Snow Vehicles

Indiscriminately driving these popular vehicles across your plantations in open fields, where the young treetops are at or near snow level, damages the trees: not just at the tops, but also below the snow level.

You can legally prohibit the use of these vehicles on your property. It may be more realistic though, and even to your advantage to contact the local snowmobile clubs and work with them to plan trails. Require the club to be responsible for maintaining them in return for using them. Require the club to advise local snowmobile groups of the fact that you are cooperating. Before opening your property for public use, check to see what your liability will be.

Soil Erosion

Exposed soil on steep slopes can cause erosion, making forest land management difficult. Proper planning and location of logging and access roads will keep most soil erosion problems from occurring in the first place.

Soil Compaction

Heavy vehicle traffic in a concentrated area, over time, can compact the soil covering tree roots. This keeps air and water from percolating through the soil to the roots slowing growth and can cause permanent damage.

Climate Change

The Earth's climate is changing. Many trends have been tracked across the globe, some reaching back hundreds of thousands of years. Although the climate has always changed, the changes that have occurred over the past century are more profound, and occurring much faster, than anything that has happened since the start of human civilization. These rapid and significant changes have important negative effects on our current environment. The average annual temperature in the area has risen more than 2°F since the late 1800s. Temperatures warmed in all seasons, with winter warming by more than 3°F. Temperature records show that warming has accelerated in recent decades. Changes will continue and it is impossible to predict exactly what will happen in the future, so global climate models can help us understand how the climate may react under various scenarios.

You can go to the following websites for more detailed information:

Massachusetts Forest Health: https://www.mass.gov/info-details/forest-health-program

- Massachusetts Forest Health Story Map: https://arcg.is/j8TiD
- MA Asian Longhorned Beetle Cooperative Eradication Program Story Map Collection: https://storymaps.arcgis.com/collections/e071fd383e7f4022a242ef4c87b16e44
- USDA/U.S. Forest Service Forest Health Protection: https://www.fs.usda.gov/foresthealth/
- Northern Institute of Applied Climate Science: https://www.niacs.org/
- Massachusetts Department of Agriculture (MDAR) MA Introduced Pest Outreach Blog: https://massnrc.org/pests/blog/
- Massachusetts Wildlife Climate Action Tool: https://climateactiontool.org/

KNOWLEDGE CHECK

Insects and Disease

- True or false: any single disease or insect can kill many different tree species.

Invasive Species

- Sketch each of the 4 invasive forest insects listed on page 59.
- What do trees infected with forest pathogens listed on page 59 look like? Sketch them.
- Look up what each of the invasive forest plants look like. Have you noticed any of them in your community? Where?

Integrated Pest Management

- What is IPM?

Weather

- What can landowners do to protect their forests from weather events?

Animal Damage: Wildlife

- List 4 animals and the possible damage they can cause to forests.

Domestic Animals

- List the benefits and dangers to allowing domestic animals in the forest.

Human Damage

- Have you noticed a tree in your community that has sustained human damage? What happened to it?

Snow Vehicles

- What are some things landowners can do to protect their forests from snowmobiles?

Soil Erosion and Soil Compaction

- What causes soil erosion and compaction?

Climate Change

- Visit one of the websites listed on page 64. What are 2 new things you learned about climate change?

FOREST LAWS & REGULATIONS

Forest Cutting Practices (M.G.L. Ch. 132, sections 40-44)

The Forest Cutting Practices Act was created to ensure that working forests will remain in a condition that will not jeopardize the public interest. It states that public welfare requires the rehabilitation, maintenance, and protection of forestlands for the purposes of conserving water, preventing floods and soil erosion, improving the conditions for wildlife and recreation, and insuring a continuous supply of wood products.

Visit the following website for more information. Massachusetts Forest Cutting Practices Act: https://www.mass.gov/guides/forest-cutting-practices-act

Forest Tax Law (M.G.L. Ch. 61, 61a, &61b)

Chapter 61, the Forestland Taxation Act, requires that municipalities reduce assessments of forest land when a landowner is enrolled and observes the Ch. 61 program requirements. Chapter 61 enables landowners to realize the value of the current use of the land in exchange for a ten-year commitment to grow forest products while also keeping their land undeveloped. The Ch. 61 programs give Massachusetts landowners an opportunity to reduce their property taxes in exchange for providing important public benefits like clean water, wildlife habitat, rural character, wood products, food, and outdoor recreation. There are many types of forest products while some of the more common types are wood, timber and Christmas trees. Other kinds of tree forest growth, and any other product produced (and sold) from forest vegetation would also be considered a forest product. There are three Ch. 61 programs. Each program provides a means to assess land at its current use (forest, agriculture, or open space/recreation) as opposed to its development value. For more information about Massachusetts Chapter 61 Current Use Tax Program visit https://masswoods.org/sites/masswoods.net/files/Ch-61-Web.pdf

Chapter 61 **Forestry**	**Chapter 61A** **Agriculture**	**Chapter 61B** **Open Space and Recreation**
Intended for landowners interested in long-term, active forest management. Assessment of forestland under Ch. 61 is based on the land's ability to grow timber. Program requirements include: • 10 or more contiguous acres • A state-approved forest management plan developed by a licensed forester or landowner. Periodic forest management as recommended by the forest management plan.	Intended for landowners engaged in agricultural or horticultural use. Assessment is based on the land's ability to produce the agricultural or horticultural product being grown. Forestland may be enrolled in this program and is based on your land's ability to grow timber. Assessments and program requirements for Ch. 61A forestland are the same as they are in the Ch. 61 program.	Intended for landowners interested in maintaining the land in a substantially natural, wild, or open condition. Assessment of forestland under Ch.61B is 25% of the current assessed value of the land. Assessments and program requirement: • Landowners must have at least 5 contiguous acres of land. • Land does not have to be open to the public. Forest management under Ch. 61B is not mandated. However, landowners do have the option of managing their forest if they develop a state approved forest management plan.

Massachusetts Best Management Practices

The forests of Massachusetts provide tremendous public benefits including clean water, clean air, forest products, employment opportunities, outdoor recreation, wildlife, and carbon sequestration.

Harvesting renewable wood products can be a tool to enhance these benefits. However, harvesting using heavy equipment can disturb soil through compaction and rutting. It can also result in overland flow that can carry sediment. If sediment gets into rivers, streams, lakes, ponds, or wetlands, it is called nonpoint source pollution.

The basic principle behind Best Management Practices (BMPs) is to minimize the overland speed and volume of water carrying sediment, reducing the opportunity for sediment and associated nutrients to reach streams and wetlands. This keeps soil and nutrients in the forest and protects aquatic resources from degradation by nonpoint source pollution. BMPs are not only important to maintain forest benefits; BMPs are required under MGL Ch. 132, the Forest Cutting Practices Act (Ch. 132). Use of BMPs and compliance with Ch. 132 regulations meet the conditions for the agriculture/forestry exemption from MGL Ch. 131, the Wetlands Protection Act (Ch. 131) as amended by the Rivers Protection Act in 1996.

Visit the following website for more information. Massachusetts BMP Manual: https://www.mass.gov/doc/massachusetts-forestry-best-managementpractices-manual-0/download

KNOWLEDGE CHECK

Forest Cutting Practices

- How would you explain the Forest Cutting Practices Act to a 6^{th} grader?

Forest Tax Law

- What are the main differences between Ch. 61, Ch. 61A and Ch 61B?

Massachusetts Best Management Practices

- Why do we have Best Management Practices (BMPs) in Massachusetts?
- Visit the MA BMPs Manual. Describe in detail 1 specific practice.