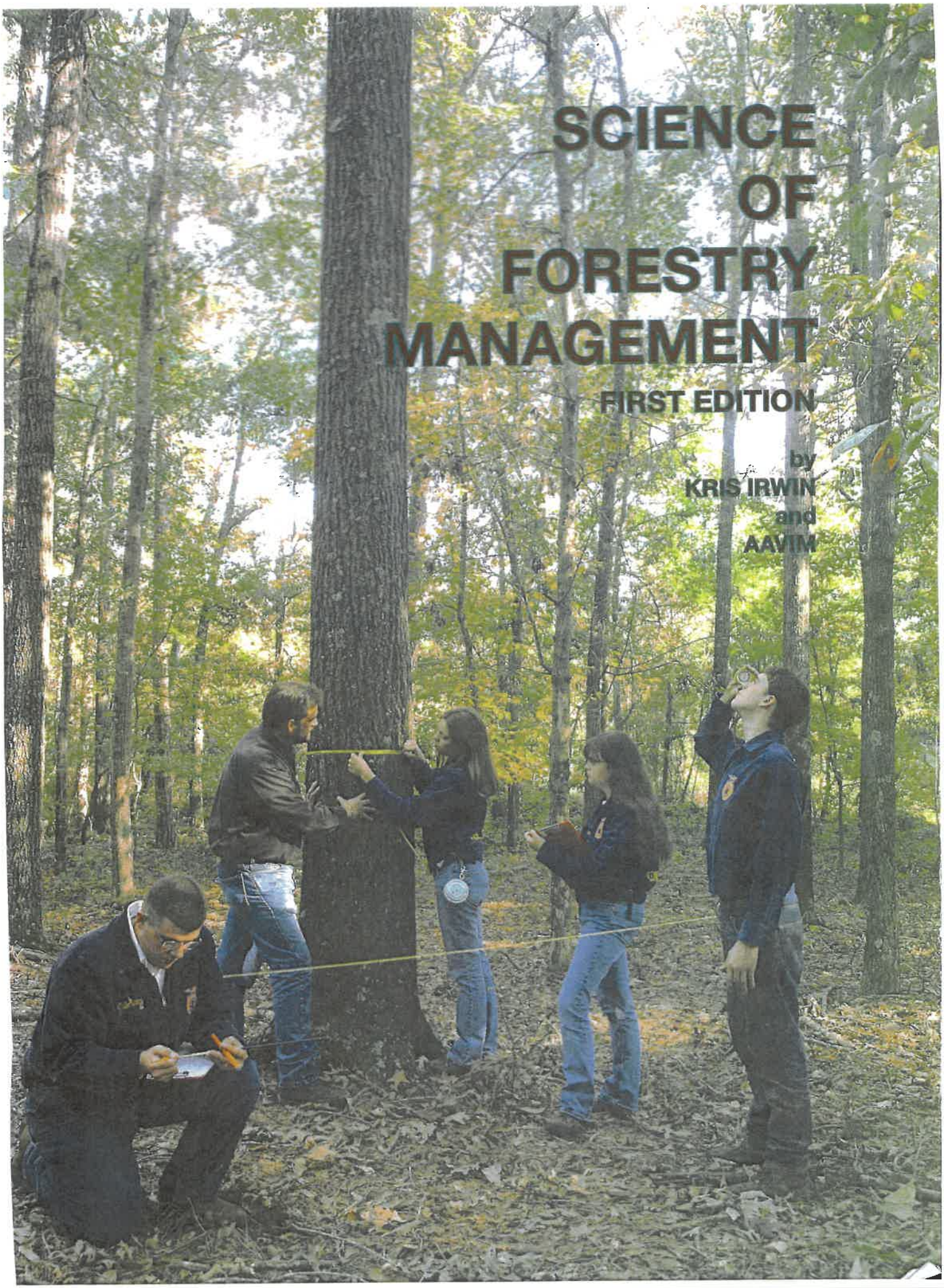

SCIENCE OF FORESTRY MANAGEMENT

FIRST EDITION

by
KRIS IRWIN
and
AAVIM

SCIENCE OF FORESTRY MANAGEMENT

AMERICAN ASSOCIATION
FOR VOCATIONAL
INSTRUCTIONAL MATERIALS

220 Smithonia Road
Winterville, GA 30683

www.aavim.com

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The American Association for Vocational Instructional Materials (AAVIM) is a nonprofit association embracing universities, colleges, and divisions of vocational education. AAVIM's mission is to prepare, publish, and distribute quality instructional materials for effective teaching and learning. Representatives from member states and agencies direct the organization. AAVIM provides excellence in instructional materials through collaboration with teacher organizations, government agencies, and industry.

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Section A:

Glossary

Abiotic - Term used to describe a disease caused by non-living organisms.

Acarina - An order of wildlife that includes ticks.

Accelerated erosion - Movement and removal of soil caused by human and animal activities, or catastrophic natural events.

Accessibility - The integration of all people in facility preparation without segregation.

Accident - An unplanned event that results from unsafe acts or conditions.

Acre - A measure of land equalling 43,560 square feet.

Active ingredient (AI) - Effective compound present in a chemical product.

Adze hoe - Instrument used to remove vegetation or create a trench in the soil.

Aerial photograph - A pictorial image taken above ground.

Agricultural drought - Water shortage that occurs when there is insufficient moisture for average crop or range production.

Agroforestry - The area of study that combines agricultural and forestry techniques.

Alaska National Interests Land Conservation Act - Federal law that gave 100 million acres of land to the National Park Service.

Alder - Deciduous tree in the birch family.

Altimeter - Instrument used to measure elevation.

American Forestry Association - Organization founded in 1875 to educate the public about conservation.

Anaphylactic shock - A severe systemic reaction to a specific antigen (such as wasp venom).

Angiosperm - Flowering trees or plants, with seeds enclosed within an ovary that matures into a fruit.

Angle gauge - A measuring instrument used to select trees in a stand to sample.

Annosus root rot - Disease caused by airborne spores that spreads between trees by root contact.

Annual increment - The amount of wood produced by a stand over a one-year period.

Antigen - A substance, such as a toxin, capable of stimulating a systemic response.

Aphid - An insect that sucks liquids from a plant.

Arrangement - A leaf characteristic, referring to the point where a leaf is attached to the twig of a broadleaf tree. Common arrangements are alternate, opposite, and whorled.

Artificial regeneration - Planting of new trees, conducted by the forester.

Ash (substance) - Grayish powder left after something has burned.

Ash (tree) - Deciduous tree in the olive family.

Aspen - Deciduous tree in the willow family.

Asset - Anything owned that has value, such as a financial value.

Azimuth - Compass reading system that denotes degrees only.

Azimuth ring - See "**Bezel**".

Backpack sprayer - Water-filled tank or rubber bladder, carried by straps on a forester's shoulders.

Bacteria - Micro-organisms that reproduce by simple division; often cause disease.

Bald cypress - Coniferous tree in the taxodium family.

Bark - The outside covering of trees and woody plants. Common types are smooth, furrowed, scaly, blocky, plated, warty, fibrous, and papery.

Bark gauge - Instrument used to determine the thickness of tree bark.

Basal area (BA) - A measurement of a tree's cross-sectional area, expressed in square feet per acre.

Basal area factor (BAF) - Calculation, specific to the prism used, that helps determine cross-sectional area of a tree stand.

Base layer - A thickness of clothing worn next to the skin.

Baseplate - The section of printed information that forms a compass's foundation.

Bearings - Compass reading system that denotes cardinal directions plus degrees.

Beech - Deciduous tree with smooth, gray bark.

Beetle - An insect that belongs to the coleoptera order, and feeds on plant and animal matter.

Best management practices (BMPs) - Voluntary, recommended forestry procedures that minimize impact on the environment.

Bezel - The rotating ring on a compass, graduated from zero to 360 degrees, and labeled with cardinal directions and quadrants.

Biltmore stick - See "**Log scale stick**".

Biodiversity - The totality of species and ecosystems of a region, and the interactions between them.

Biotic - Term used to describe a disease caused by living organisms.

Birch - Deciduous tree with smooth bark in thin layers.

Black turpentine beetle - Insect that is prevalent after drought, floods, fire, storms, and harvest.

Black walnut - Deciduous tree with heavy, strong, durable wood.

Black widow - A venomous spider.

Blowup fire - An effect at the center of a fire, creating a cyclone-like effect that lifts and carries burning materials into the air.

Board foot - A measurement of lumber volume (1"x12"x12").

Bole - Tree trunk.

Bore - To make a hole in, as an insect does to a tree.

Breast height - As relates to the diameter of a tree, four and one-half feet from the ground on the high side of the tree.

Brown recluse - A venomous spider.

Brown spot needle blight - Disease that affects longleaf pines.

Browse plant - A taller plant with a woody stem, such as a shrub or vine.

Business timberland - A section of woodland managed to generate profit on a regular basis.

Calipers - An instrument consisting of a pair of hinged legs, for measuring thickness or diameter.

Cambium - Cells between the bark and wood of a tree.

Canker - An infected area on an organism, such as a tree or plant.

Canopy layer - The layer of a forest comprised of branches, leaves, and tree tops.

Cant hook - Instrument used to roll and position logs.

Canthardin - A poison secreted by the blister beetle.

Capital - A stock of accumulated goods and their worth or value.

Capital asset - A business property (such as a tract of land) that can be deducted for tax purposes when it is sold.

Capital expenditure - A business cost that is listed for tax purposes as helping to create an asset.

Capital gain - Income that comes from the sale of an asset that has increased in value since its purchase.

Capsule - The housing of a compass that contains the compass needle, orienting arrow, and bezel.

Cardinal directions - Directions on a map or compass that denote North, South, East, and West.

Cardiopulminary resuscitation (CPR) - A procedure designed to restore normal breathing after cardiac arrest.

Casualty loss - A business deficit resulting form a fire, storm, or other natural catastrophe.

Cedar - Coniferous tree in the cypress family.

Chain-flail debarker - Bark-removing implement that features chains.

Chainsaw - Gas- or electric-powered hand tool used to fell trees.

Chainsaw chaps - Protective equipment required when using a chainsaw.

Chemical preparation - Readying a forest site for planting by use of herbicides and other chemicals.

Chip'n'saw - Small saw timber.

Chipper - Heavy implement used to reduce logs to small pieces.

Chips - Small pieces of wood.

Chlorophyll - Green pigment found in plant cells.

Chokers - A device attached to a cable for securing logs.

Cicada - Insect that causes root damage to a plant.

Civilian Conservation Corps (CCC) - Federal program, started in 1933, that greatly improved US natural resources and infrastructure.

Clarke-McNary Act - Federal law passed in 1924 that made provisions to improve private and public forest land.

Clay - A firm, plastic earth made up of fine particles of mineral.

Clean Air Act - Federal law passed in 1970 that regulates the allowable levels of impurities that can be released into the atmosphere.

Clear cutting - Removing all trees in an area.

Climax species - A distinct type of tree found in a mature forest.

Clinometer - Instrument used to measure tree height.

Commercial - Made or prepared for financial gain.

Commercial thinning - Removing smaller trees in fully-stocked stands.

Commodity - A valuable item that can be bought and sold, such as timber.

Compass - A hand-held tool used to show direction and physical location.

Compass card - See "**Baseplate**".

Compass housing - See "**Capsule**".

Compass needle - Long, thin portion of a compass that is magnetized on one end and points to Magnetic North.

Composition - A leaf characteristic, referring to the number of leaves attached to the petiole. Common compositions are simple, compound, pinnately compound, bipinnately compound, and palmately compound.

Compound fruits - Groups of simple fruits. Aggregate compound fruits come from the same flower; multiple compound fruits from separate flowers.

Conditions of sale - Portion of a contract that defines both parties' responsibilities.

Cone - A scaly fruit borne by coniferous trees.

Conifers - Trees that bear cones, usually softwoods.

Conk - A hard shell- or shelf-shaped structure that appears on the bark of a tree.

Conservation Reserve Program - Federal program, started in 1985, that helps landowners work with the USDA to plant for erosion control.

Contour lines - Plotlines on a topographic quadrangle map that represent changes in elevation.

Contract - Legally binding document that governs a business transaction.

Cooperative Forest Management Act - Federal law passed in 1950 that coordinated technical services for forest landowners and industries.

Cooperative Forestry Assistance Act - Federal law passed in 1978 that allowed the USFS to coordinate closely with state forest agencies.

Coral snake - A venomous snake.

Cord - A unit of wood measurement, equal to 128 cubic feet.

Cost - An amount of money lost or sacrificed in order to own or maintain something (such as a plot of land).

Cottonwood - Deciduous tree in the willow family.

Council of Environmental Quality - Federal agency to coordinate the National Environmental Policy Act.

Creative Act - Federal law passed in 1891 that allows the President to designate public land as forest reserves.

Crown - The branches and foliage of a tree.

Crown thinning - Removing trees within the dominant and co-dominant size class.

Cruise line - A straight path along which a forester marks sample points to create a sampling grid.

Cruise percentage - The proportion of a stand that will be evaluated as part of a timber cruise.

Cruising vest - Foresters' apparel containing several pockets of varying sizes.

Cut-off point - Top limit of a tree's merchantable height.

Damping-off disease - Disease that affects newly-planted seedlings.

Data recorder - Hand-held computer used to record, retrieve, and process field data.

DDT - Dichloro-diphenyl-trichloroethane, a powerful insecticide.

Deciduous - Trees that shed leaves seasonally, usually hardwoods.

Declination - A factor, used in compass readings, that indicates the difference between true North and magnetic North.

Defoliation - Removing a tree's leaves.

Degree dial - See "**Bezel**".

Delimber - Heavy implement used to remove limbs from trees.

Densiometer - Instrument used to estimate percentage of canopy cover.

Description of sale area - Portion of a contract that defines the relevant land portion for which services are sought.

Designation of trees to be sold - Portion of a contract that specifies which trees are affected, by marking trees or boundaries.

Diameter - Distance of a line segment running through the center of a circular shape, such as a tree.

Diameter at breast height (DBH) - A standard location for measuring a tree's basal area, four and one-half feet from the ground on the high side of the tree.

Diameter tape (D-tape) - Instrument used to measure a tree's diameter.

Dibble bar - A hand implement with a hollow tip, used to prepare soil to plant seedlings.

Digester - Pressurized tank that processes wood chips for paper.

Direction ring - See "**Bezel**".

Disability - A condition that makes it difficult or impossible for a person to perform activities of everyday living.

Dominant canopy - Trees with crowns extending above the crown canopy and receiving full light from above and partly from the side.

Dominant thinning - Removing dominant trees from the canopy.

Dot grid - Instrument used to determine land area.

Douglas fir - Coniferous tree in the pinaceae family.

Douglas-fir beetle - Insect that is prevalent in the Western US, Canada, and Mexico.

Douglas-fir tussock moth - Insect that is prevalent in the Western US.

Drip torch - Hand-held equipment used to ignite small areas of land.

Drought - Systemic shortage of water.

Dumpy level - Instrument used to read a leveling or measuring rod from a distance.

Dutch Elm disease - A disorder that affects American elm trees.

Eastern tent caterpillar - Insect that is prevalent in the Eastern US and Canada.

Ecology - The branch of biology that deals with the relation between living organisms and their environment.

Ecosystem - A community of plants and animals, together with its environment.

Elm - Deciduous tree in the ulmaceae family with hard, heavy wood.

Elytra - The hard covering over an insect's wings.

Emergent layer - The layer of a forest comprised of the tallest trees.

Endangered species - A distinct kind or sort of animal or plant, at risk of becoming extinct.

Engineer's chain - A surveyor's measurement that is 100 feet long with 100 one-foot links.

Environment - All the conditions surrounding, and affecting the development of, an organism.

Environmentalist - One working to address environmental problems, such as pollution.

Erosion - The movement and removal of soil by wind, storm water, or other conditions.

Establishment cutting - Part of shelterwood cutting, where areas of the stand are opened to allow new seedling growth.

Even-aged stand - A forest stand wherein all trees are the same approximate age class.

Expenditure - A spending of money.

Expensed cost - A cost that is listed for tax purposes as a function of maintaining a business.

Extinct - No longer in existence.

Feller-buncher - Heavy implement that cuts trees using a hydraulic shear, circular saw, or chainsaw head, then collects them.

Feller-director - Heavy implement that cuts a tree without holding it in place.

Feller-forwarder - Heavy implement that cuts trees, then deposits them into a trailer.

Fertilization - The process of making soil more able to produce a crop, usually by adding a chemical substance.

Fiberglass measuring tape - Flexible rule.

Field microscope - Instrument used to view items with significant magnification.

Filter strip - A vegetative cover area next to a stream, used to remove sediment.

Fire plow - Heavy implement with a V-shaped blade, used to create a fire break.

Fire rake - Hand-pulled tool with a V-shape blade, used to create a fire line.

Fire shelter - Portable compartment made of foil-covered glass cloth; provides a barrier against radiant heat.

Fire swatter - Hand tool designed to fight grass fires.

Fire weather kit - Set of equipment used to measure climactic conditions.

Fire-resistant clothing - Protective equipment required for all workers on a fire line.

First aid - Emergency care or treatment given to an ill or injured person before regular medical help can be obtained.

Fishery - A business enterprise wherein fish are caught or bred.

Fixed expense - Business costs that are consistent from one time period to another.

Flagging - Material used to temporarily mark trees, property boundaries, and other objects.

Flow/current meter - Instrument used to measure the velocity of flowing water.

Foliage - Leaves, as of a tree or plant.

Forage - Food for domestic animals.

Forb - A broad-leaved herb other than a grass, especially one growing in a field, prairie, or meadow.

Forest - A thick growth of trees and other vegetation, covering a large tract of land.

Forest certification - Verification that individual forests comply with international standards for environmentally responsible practices.

Forest engineer - An employee who plans timber harvest activities.

Forest entomologist - A scientist who studies insects, investigates the damage they cause in trees, and determine a management strategy.

Forest floor - The layer of a forest comprised of organic humus and the layer of soil it covers.

Forest manager - An employee who coordinates and tends forest land.

Forest management plan - A set of detailed activates for forest stand improvement, developed by the landowner and forest manager, and carried out according to a set timeline and budget.

Forest pathologist - A scientist who studies tree diseases and fungi, and finds ways to control their spread.

Forest Pest Control Act - Federal law passed in 1947 that developed policies to protect forests from pests and diseases.

Forest reserve - Woodland that is set aside for a particular purpose.

Forest Reserve Act - Federal law passed in 1891 that set aside forest land for management; led to national forests.

Forest technician - An employee who cruises timber for a forest products company.

Forest tent caterpillar - Insect that is prevalent in the Eastern US and Canada.

Foresters' axe - See "**Pulaski**".

Forestry - The science of planting and taking care of forests.

Forestry professor - An instructor who teaches forestry science at a college or university.

Forestry technician - An employee responsible for timber cruising and supervising tree planting.

Form class - Expression of a tree's taper, used to select the appropriate local table volume for a stand.

Forty - A portion of a map township one-sixteenth of a section in size (or 40 acres), used in Public Land Survey System (PLSS).

Forwarder - Heavy implement that carries short wood from a harvest site.

Frostbite - Injury to the tissue of a body part, caused by exposure to intense cold.

Fruit - The mature, seed-bearing part of a flowering tree or plant.

Fungicide - Chemical that eliminates fungus.

Fungus - A plant that lacks leaves, chlorophyll, and stems, and reproduces by spores.

Gallery - A beetle's home in an infested tree.

Germination - The process by which a new plant develops from a seed.

Geometric thinning - Removal of trees from a stand according to a predetermined pattern or spacing plan.

Girdling roots - Tree roots that grow around one another, or around the tree stem.

Global Positioning System (GPS) - A satellite navigation system used to determine one's precise location and provide an accurate time reference.

Grade - Classification of a tree's product characteristics.

Grapple - A clamping device for transporting logs.

Green Movement - A political philosophy, begun in the 1970s, that encouraged "political ecologists" to advocate for environmental and conservation gains in the context of global decision-making.

Greenhouse effect - Warming of the Earth and its lower atmosphere, caused by trapped solar radiation.

Greenhouse gases - Gaseous components of the atmosphere that contribute to the greenhouse effect: usually water vapor, carbon dioxide, and ozone.

Ground-water hydrology - The study of water distribution and movement beneath the earth's surface.

Group selection cutting - Removing small groups of trees throughout a stand.

Group system - A selection cutting method where small portions of a stand are removed.

Gum - A sticky substance exuded from certain trees and plants.

Gunter's chain - A surveyor's measurement that is 66 feet long with 100 links, each equal to eight inches.

Gymnosperm - Trees whose seeds are not formed in an enclosed ovary, but are on the scales of a cone-like structure.

Gypsy moth - Insect that is prevalent in the Northeastern US.

Habitat - The region wherein an animal or plant naturally lives.

Habitat manipulation - A method of promoting the population of an organism by making conditions more favorable to it.

Hand compass - Hand-held instrument used to show direction.

Hand lens - Instrument used to view items with modest magnification.

Hard hat - Headgear designed to provide protection from electric shock and falling objects.

Hardwoods - Trees that produce a dense, hard wood suitable for many uses.

Harvest - Gathering in of a crop, such as timber.

Heart rot - Disease caused by fungus that affects hardwood trees.

Hemlock - Coniferous tree whose wood is used for construction and pulp.

Herbicide - Chemical that eliminates plant life.

Hickory - Deciduous tree in the walnut family.

High grading - See "**Individual tree selection cutting**".

Hip chain - Instrument used to measure distance traveled.

Hoedad - A hoe used for planting seedlings.

Homestead Act - Federal law passed in 1862 that allowed US citizens to buy unappropriated land.

Honeydew - Liquid excreted by an aphid.

Humus - Decaying leaves, twigs, and logs.

Hydrologic cycle - The rotation of water movement between land, ocean, and air.

Hydrologic drought - Water shortage that occurs when available water reserves fall below a statistical average.

Hydrology - The study of the occurrence, distribution, and movement of water in, on, and above the earth.

Hypo-hatchet - Instrument used to release a preset volume of herbicide into a tree.

Hypothermia - A subnormal body temperature, often life-threatening.

Improvement cutting - Removing older trees and leaving younger ones to grow.

Incendiary - Designed to create fire.

Income - Money received in a given time period.

Increment borer - Instrument used to remove a core of wood from a tree or pole.

Index contours - Lines shown on a topographic quadrangle map to indicate elevation.

Index mark - Notation on a compass bezel that represents the letter "N", usually in red.

Individual tree selection - Removing selected trees based on size and desirable cutting characteristics.

Infestation - An attack on trees by insects or disease.

Infrastructure - Installations and facilities such as roads, bridges, power plants, and other facilities.

Injury - Physical damage.

Insecticide - Chemical that eliminates insects.

Insulation layer - A thickness of clothing worn over the base layer.

Intangible - Assets without intrinsic value, or without material being.

Interest - A right to, or a share in, something (such as a plot of land).

Internal Revenue Code - Federal laws that govern tax rates and collections; also known as the "tax code".

Investment timberland - A section of woodland managed to generate a profit, but not as a primary income source.

Isogonic chart - A table, used in compass reading, that indicates degrees of declination.

Juglone - Substance found in a back walnut tree that inhibits germination of other trees and plants.

Knuckle-boom loader - Heavy implement that can load several logs at one time.

Larva - The early form of any insect or animal.

Latitude - Distance North or South of the Equator.

Layering - A method of wearing clothes in order to offer protection from cold temperatures.

Leaf - Short, flat growth, usually green, from a tree or plant stem.

Leaf spot - Disease caused by fungus that resides in leaf tissue.

Littleleaf - Disease affecting shortleaf and loblolly pines.

Live-crown ratio - The fixed relation between the heights of the live crown to the total heights of a stand of trees.

Loblolly pine - Coniferous tree representing a majority of commercial pine forest land in the Southeastern US.

Lodgepole pine- Coniferous tree often used by wildlife for food and shelter.

Log - A section of a felled tree.

Log rule - Table that estimates amount of lumber that can be sawn from a log of given length and diameter.

Log scale stick - Instrument used to measure a tree's diameter, height, and volume.

Log truck - Diesel-powered vehicle fitted with a trailer to carry newly-cut trees.

Logging - Felling trees, cutting them into logs, and transporting them to a sawmill.

Logging contract - Legally binding document that governs details of a transaction for removal of trees from a stand.

Longitude - Distance East or West of the prime meridian.

Longleaf pine - Coniferous tree found in the Southeastern US.

Loss - Financial deficit, especially the sum of money a business expends.

Low thinning - Removing smaller trees beneath the main crown canopy.

Lumber - Timber sawed into boards.

Lump-sum method - Agreement whereby timber is sold for a specified amount.

Lyme disease - A bacterial illness that is borne and transmitted by ticks.

Magnetic North - The Northern point at which the geomagnetic field points vertically.

Management and operating expenses - Business costs that maintain and improve the profitability of a property (such as a tract of land).

Map - A representation, such as an illustration or chart, of part of the Earth's surface.

Map scale - The relationship or ratio between the distance on a map and the corresponding distance on the ground of the land area being charted.

Maple - Deciduous tree with hard, heavy wood, distinctive leaves, and sap used for many food products.

Margin - A leaf characteristic, referring to the edges of the leaf. Common classifications include entire, toothed, lobed, divided, serrate, and dentate.

Mechanical preparation - Readying a forest site for planting by use of heavy implements.

Merchantable height - Area above ground of a tree's stem suitable for sale.

Meteorological drought - Water shortage caused by a prolonged period of below-average precipitation.

Meteorology - The study of the atmosphere and weather.

Metes and bounds - Survey method that used physical descriptions to divide land.

Minute - One-sixtieth (1/60th) of a degree.

Mistletoe - A plant parasite that grows in the crown of a tree.

Mulch - Organic material spread around a tree or plant to protect roots and promote growth.

Multi-function harvester - Heavy implement that fells, delimbs, and cuts a tree.

Multiple-use forestry - A concept of forest management that manages the land for more than one purpose.

Multiple-Use Sustained-Yield Act - Federal law passed in 1960 that recognized and coordinated a variety of uses of forests and their products.

National Environmental Policy Act - Federal law passed in 1970 that set a national priority for cooperation of the people and the environment.

National forest - Woodland coordinated by the US Department of the Interior for governmental protection.

National park - Multi-purpose land coordinated by the US Department of the Interior for use by citizens.

National Park Service - A Federal agency, part of the US Department of the Interior, charged with administering national park areas.

National Science Foundation (NSF) - Organization founded in 1950 to promote science.

Natural erosion - Movement and removal of soil caused by normally-occurring forces of the physical universe.

Natural regeneration - Planting of new trees by naturally-occurring effects of nature.

Nectia canker - Disease that affects deciduous and coniferous trees by creating infected patches.

Needle - Short, pointed leaf found on a coniferous tree,

Needle cast - Disease that affects coniferous trees, caused by fungus.

Nematode - Very small worm that feeds on other organisms.

Non-commercial - Not made or prepared for financial gain.

Non-consumptive - In forestry recreation, the observation, photography, and feeding of fish and wildlife.

Non-restricted use pesticide - Chemical that is sold "over the counter" and designed for use by any consumer.

Nut - A dry, one-seeded fruit consisting of a kernel in a woody shell.

Nutrient - Food or nourishment for an organism.

Obligate - Needing a living host to survive, as a parasite.

Occupational Safety and Health Administration (OSHA) - Federal agency founded in 1971 that seeks to reduce workplace injuries and develops job safety and health standards.

Oceanography - The study of water in the oceans.

Organic - Of, like, or derived from living organisms.

Organic Administration Act - Federal law passed in 1897 that establishes forest reserves for timber and water.

Organism - Any living thing.

Orienting arrow - Portion of a compass that aligns the compass needle to True North.

Orthophoto map - Color-enhanced photographic images that show land features.

Outer layer - A thickness of clothing worn to protect the insulation and base layers.

Overstory - Foliage found in a forest canopy.

Paper - Thin, flexible material, usually in sheets, usually made from wood and its by-products.

Parasite - A plant or animal that lives on or in another organism.

Pay-as-cut method - Agreement whereby timber is sold on a per-unit basis (such as cord, ton, or board foot).

Pecan - Deciduous tree in the walnut family.

Peeler - See "**Veneer**".

Personal timberland - A section of woodland held by an individual for non-income purposes.

Pesticide - See "**Insecticide**".

Petiole - Leaf stem.

pH - A symbol for the degree of alkalinity of acidity of a substance.

pH meter - Instrument used to determine whether a solution is alkaline or acidic.

Physical map - A map that shows landforms and bodies of water.

Pioneer species - A distinct type of tree that establishes early stages of succession.

Pit viper - A classification of venomous snake.

Pitch - Resin obtained from some conifers.

Pitch canker - Disese that affects Southern pines through infected fluids.

Planimeter - Instrument used to measure the area of a map or aerial photo.

Plant feeders - Insects that cause physical damage in plants.

Plant press - Instrument used to press leaf samples.

Planting shovel - A spade with a long, flat blade, step plates, and foot pads.

Plot sampling - A method whereby the forester establishes and compares land areas at specific distances along a compass line.

Point sampling - A method whereby the forester marks sample localized places along a compass line, and uses a prism or angle gauge to select trees for sample.

Pollution - Making something (such as water or air) unclean or impure; also, the substances that cause this condition.

Ponderosa pine - Coniferous tree found in the Western US.

Preamble - Portion of a contract that defines basic terms.

Precommercial thinning - Removing poorly-formed, diseased, or defective trees.

Prepatory cutting - Part of shelterwood cutting, the stage that first thins the tree crop.

Prescribed burning - Deliberately set and carefully tended fires, used to clear a forest site.

Prescription - Specifics about a type of planned burn, and how it will be carried out.

Professional consulting forester - A person who manages timberland.

Profit - Financial gain, especially the sum of money a business retains after subtracting its costs.

Profit and loss statement - A tabulation of a business's income compared to its incurred expenses.

Pruning - Removing lower limbs from trees.

Public Land Survey System (PLSS) - Method that established survey guidelines in the US.

Pulaski - Hand-held tool with an axe blade on one end and a hoe blade on the other.

Pulp - Ground-up, moistened wood byproducts used to make paper.

Pulpwood - Trees grown and harvested to produce paper.

Quadrants - On a compass, the directions NE, NW, SE, and SW.

Quarter section - A portion of a map township one-fourth of a section in size (or 160 acres), used in Public Land Survey System (PLSS).

Raised-relief map - A three-dimensional map with sculptured forms projecting from a flat surface.

Range (agriculture) - A large, open area for grazing livestock.

Range (map) - Units East and West on a map.

Raw wood - Hard, fibrous tree substance in a natural, unprocessed state.

Recreation - Play or amusement, as in an outdoor setting.

Rectangular survey system - A survey method that divides land by longitudinal and latitudinal reference lines.

Recycled paper - Wood by-product material that has been recovered for repeated use.

Red oak - Deciduous tree in the beech family.

Red pine - Coniferous tree found in the Northeastern US.

Red-headed pine sawfly - Insect that is prevalent in the Southern US.

Reforestation worker - An employee responsible for site preparation and tree planting.

Regeneration - Reseeding, stump sprouting, and planting of new trees.

Relaskop - Instrument used to measure a tree's basal area, diameter, height, vertical angles, slope, and distance.

Relief map - A map that indicates elevation differences.

Removal cutting - Part of shelterwood cutting, where merchantable trees are taken out.

Representative - Similar to its surroundings, as trees in a stand.

Research forester - An employee who conducts field and laboratory experiments related to forestry.

Research technician - An employee who collects field data.

Resin - A substance exuded from certain trees and plants, used to make varnishes, plastics, and other products.

Restricted use pesticide (RUP) - Chemical that is regulated to allow use by trained professionals only.

Road map - A map that shows interstate highways and other roadways

Root - The part of a tree or plant that anchors it, usually underground.

Roundheaded pine beetle - Insect that is prevalent in the Western US.

Row thinning - Removal of an entire line of trees from a stand.

Rust - Disease that causes discolored areas on a tree.

Safety goggles - Eyewear designed to provide protection from impact and sharp objects.

Sale - An exchange of goods for money.

Salvage cutting - Removing damaged trees for harvest.

Sample - A measurement, as of timber.

Sample points - Narrowly localized places along a cruise line.

Sampling grid - Graphic depiction of a timber stand measurement area.

Sand - Loose, gritty grains of deteriorated rock.

Sap - A thin, watery fluid that circulates through a tree or plant.

Saw timber - Trees suitable to yield sawlogs.

Sawlog - A tree section suitable for producing sawed lumber.

Scale - Microscopic insect that attacks cultivated trees and shrubs.

Section - A portion of a map township one square mile in size (or 640 acres), used in Public Land Survey System (PLSS).

Sediment - Matter deposited by natural conditions that settles to the bottom of a body of water.

Seed tree cutting - Removing mature trees in stages to allow younger trees to seed.

Seedling - A tree or plant that has recently sprouted.

Selection cutting - Planned removal of a portion of a tree stand.

7.5 minute topographic quadrangle - A topographic quadrangle map that covers an area that is 7.5 minutes of latitude by 7.5 minutes of longitude.

Shaded relief map - A map that uses different tones to represent sunlight and shadows.

Shake-and-bake - See "**Fire shelter**".

Shape - A leaf characteristic, referring to its basic physical form. Common classifications include elliptical, ovate, obovate, lanceolate, oblanceoate, and linear.

Shelterwood cutting - Staged removal of mature trees over a number of years.

Shortleaf pine - Coniferous tree found in the Southeastern US.

Silt - A fine-grained sediment carried or deposited by water.

Silvics - The growth and development of single trees and the forest as a biological unit.

Silviculture - The science of tending a forest by applying effective management procedures.

Silvopastoral systems - Areas of forest land that integrate trees with forage and livestock production.

Simple fruits - Seed-bearing part of a tree with a single, enlarged overy. Common classifications include nuts, sumar, pomes, drupes, berries, legumes, achenes, and capsules.

Single-tree system - A selection cutting method whereby individual trees are harvested over short time intervals.

Site class - Overall evaluation of a tree species' comparable quality, based upon site indexes.

Site index (SI) - A measure of forest site quality based upon tree height.

Site preparation - Treatment of soil and ground vegetation as part of a forest management plan.

Skidder - Heavy implement that hauls stacks of trees.

Slash - Logging debris.

Slime flux - Disease caused by bacterial growth in tree sap.

Slurry - A mixture of wood fiber and water, used to make paper.

Small-end diameter - Recommended size of a tree's cut-off point.

Social forestry - Sustainable management of trees and forests to provide products and services that meet local needs.

Softwoods - Trees that produce a less dense wood.

Soil - The surface layer of earth, made up of the primary components of sand, silt, and clay plus other aggregate material.

Soil auger (or sampler) - Instrument used to collect a soil sample.

Soil test kit - Set of equipment used to analyze soil material.

Southern pine beetle - Insect that is prevalent in the Southern US.

Species - A distinct kind or sort of animal or plant.

Spice - An aromatic vegetable substance derived from tree and plant by-products.

Spider mite - Insect that live in soil and leaf litter and attack plants.

Spirochete - The bacteria that causes Lyme disease.

Spore - A small reprodcutive body, as found in fungus.

Spruce - Coniferous tree used for pulp.

Spruce beetle - Insect that is prevalent in the Western US and Canada.

Spruce budworm - Insect that is prevalent in the Northern US and Canada.

Staff compass - Large-diameter instrument used to show direction.

Stand density - Quantity of trees per a unit of volume; thickness.

Stand volume - Quantity of trees in a particular area.

Stereoscope - Instrument used to view two aerial photos simultaneously.

Stocking level - The number of trees per acre in a stand.

Stocking table - A list of values that helps the forest manager estimate stocking levels and establish timetables for thinning.

Stroke-boom delimber - Limb-removing implement that features a circular knife.

Stump height - Area where a tree's trunk is severed, usually six inches or less from the ground.

Stylet - Mouthpart of a nematode.

Succession - The process by which one community of plants and animals slowly replaces another over time.

Sunscald - Damage to the cambium of a tree caused by extreme temperature.

Surface-air hydrology - The study of water in and above the earth's surface.

Survey - To determine the location, form, and boundaries of a tract of land.

Sustainable development - A concept of forest management that meets immediate needs while preserving forestland for future use.

Sustained Yield Forest Management Act - Federal law passed in 1944 that helped forest communities respond to timber shortages.

Sweetgum - Deciduous tree in the witch hazel family.

Sycamore - Deciduous tree with distinctive patchy bark.

Symbiotic - A relationship bebween organisms that provides each a mutual advantage.

Tally book - Notebook used to log information from a timber cruise.

Tally meter - Instrument used to count objects, such as trees in a timber cruise.

Tangible - Assets having real substance and able to be appraised for value.

Taper - Gradual decrease of a tree's stem diameter from base to top.

Tax - A compulsory payment of income to support a government.

Tax code - See "**Internal Revenue Code**".

Theodolite - Instrument used to read a leveling or measuring rod from a distance.

Threatened species - A distinct kind or sort of animal or plant whose population is in danger of being diminished.

Tick - A wingless, bloodsucking, crawling animal.

Timber - Trees, collectively.

Timber cruise - A systematic survey to gather information needed for forest management planning.

Timber Culture Act - Federal law passed in 1873 that encouraged tree planting.

Timber sale contract - Legally binding document that governs details of a sale of timber.

Timber sales income - An amount of money taken in from sale of land, timber, or equipment.

Timber stand - A growth of trees.

Timber stand improvement (TSI) - Actions prescribed by a forest manager to improve the composition, structure, condition, health, and growth of a stand.

Timberlands - Commercial forest land.

Topographic quadrangle map (also known as "**Topo map**") - A map that represents three-dimentional features using contour lines.

Township - A map area six miles wide by six miles long, used in Public Land Survey System (PLSS).

Toxin - A poisonous substance that is the product of a living organism.

Transit (or transit level) - Instrument used to read a leveling or measuring rod from a distance.

Travel arrow - The portion of a compass that indicates the objective.

Tree - A large, woody perennial plant with one main trunk and many branches.

Tree caliper - Instrument used to measure a tree's diameter.

Tree planting bar - Instrument used to place tree seedlings into the soil.

Tree-marking gun - Instrument used to mark a tree with paint.

True North - The geographic North Pole; the Northernmost point on Earth as determined by the planet's rotation.

Understory layer - The layer of a forest comprised of trees, shrubs, and vines growing beneath the canopy.

Uneven-aged stand - .A forest stand wherein all trees are of different age classes.

United States Forest Service - A Federal agency, part of the US Department of Agriculture, charged with carrying out forest management activities.

Urban forester - An employee who manages tree resources for a city or municipality.

US Department of Agriculture (USDA) - A Cabinet department of the US government, responsible for developing and executing policies on farming and food.

US Department of the Interior - A Cabinet department of the US government that manages and conserves most Federally-owned land.

US Environmental Protection Agency (USEPA) - A Federal agency empowered to protect human health and safeguard the natural environment.

US Fish and Wildlife Service - A Federal agency, part of the US Department of the Interior, dedicated to managing and preserving wildlife.

US Geological Survey (USGS) - A Federal agency, part of the US Department of the Interior, that studies and monitors geology and publishes standard topographic maps in the US.

Variable expense - Business costs that increase or decrease from one time period to another.

Veneer - A grade of tree, often used to create furniture.

Venom - Poison secreted by some snakes or spiders.

Venomous - Containing venom, as a snake or spider

Vertical photo - An aerial photograph taken so that the image does not tilt more than three degrees.

Volume - Amount of usable wood provided by a tree.

Volume table - Grid that reflects standardized diameter measurements of trees in a species, for calculating amounts of usable wood.

Water sampler - Instrument used to collect a water sample.

Water test kit - Set of equipment used to analyze water.

Watershed - A region of land that drains into a specified body of water.

Wedge prism - A wedge-shaped piece of glass that deflects an image, used to determine a tree's basal area (BA).

Weeks Act - Federal law passed in 1911 that gives the USDA authority to purchase lands for water flow protection.

Western pine beetle - Insect that is prevalent in the Western US, Canada, and Mexico.

Western tent caterpillar - Insect that is prevalent in the Western US and Canada.

Wheeler caliper - Instrument used to measure the diameter of a tree.

White oak - Deciduous tree with hard, strong wood.

White pine - Coniferous tree used for construction.

Wilderness Act - Federal law passed in 1964 that recognized and coordinated non-product uses of forests.

Wildfire - A spontaneous conflagration that spreads widely and quickly.

Wildlife - Animals and birds in their natural surroundings.

Wildlife biologist - A scientist who evaluates and and prescribes forest management activities.

Wind chill - The combined effect of cold temperature and high winds on exposed skin.

Wind throw - Swaying action of a tree, caused by high-velocity wind, that can pull it out of the ground.

Windbreak - A row of trees or shrubs positioned to provide protection from the wind.

Wood - The hard, fibrous substance beneath the bark of trees and shrubs; lumber or timber.

Wood borer - Larvae of any one of numerous species of boring beetles.

Woods worker - An employee who operates heavy implements such as skidders.

Yellow poplar - Deciduous tree in the magnolia family.

Youth Conservation Corps - Federal program that teaches young people to conserve land and water resources.

Section B:

Forest Industry and Environment: Their Economic Impact

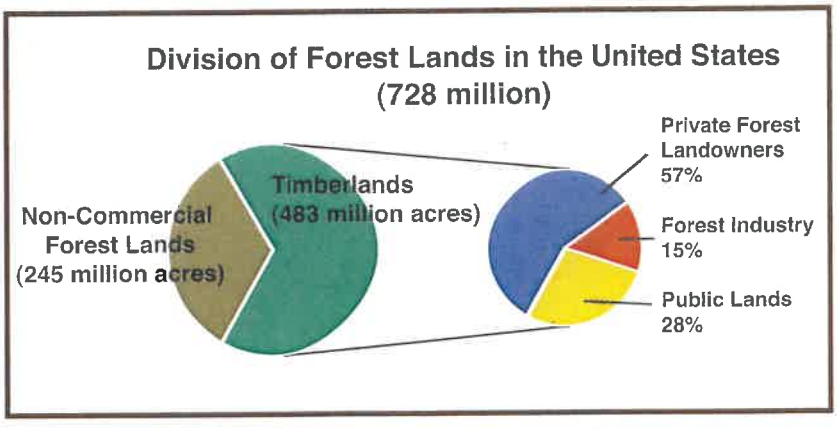
Objective: *The student will be able to explain the importance of the forest industry, describe common forest products, and list career and education opportunities in forestry. He or she will be able to identify the role of forestry agencies and associations, and understand international and social issues regarding forestry.*

What would life be like without forests and the wood they provide? Trees reduce soil erosion, protect water quality, provide habitat for wildlife, and supply raw material for thousands of products we use every day. Trees are the source of the wood fiber that made the paper for this manual, and the lumber that builds our homes. Trees produce many of the food items we eat each day. Trees are the "lifeblood" of the forest industry, helping hundreds of thousands of people make their living.

1. Size of forest industry

The forest and its products are very important to our quality of life. A forest provides both **tangible** (timber and wood by-products) and **intangible** (water quality and recreation) products.

The US has one of the largest and most productive forest resources in the world, with approximately 728 million acres of forest land. About 483 million acres are classified as **timberlands**, or commercial forest land: forests capable of growing 20 cubic feet of commercial quality wood fiber per acre per year. Private forest landowners own about 57 percent of US timberland; the remaining portions are divided between the forest industry (about 15 percent) and public lands, including national forests (28 percent). The remaining 245 million acres of "non-commercial" forest land are held in areas such as national parks, designated wilderness, and other holdings.



DID YOU KNOW:

The Society of American Foresters (SAF) is the professional society for foresters? The US Department of Education and the Council on Post-Secondary Accreditation recognize the SAF as the accrediting agency for professional forestry education in the United States. Note that SAF recognition is not the same as accreditation; only accredited programs offer professional forestry degrees.

The US forest and paper industry is competitive in both domestic and foreign markets: annual sales of wood and paper products exceed $200 billion. This represents about eight percent of the total national manufacturing output. State-of-the-art paper mills, independent family-owned logging operations, and the activities of consulting foresters all contribute to this production figure.

As our world's population grows, so will demand for forest products. Some analysts predict that it will rise as much as 50 percent during the next half-century.

2. Types of forest industry

In 2000, the US forest and paper industries employed more than 1.6 million people. With an annual payroll of more than $45 billion, it ranks as one of our nation's top ten manufacturing employers. And for each job that is directly related to forestry (e.g., a member of a professional timber harvesting crew), two more jobs are indirectly related (e.g., a sales person at a local lumberyard). Many changes have occurred in the industry during the past several years, however, due to fluctuation in the economy and forest markets.

Commercial forest land
Photo: William M. Ciesla, Forest Health Management International,www.forestryimages.org

Forest products come in many shapes and forms, and are produced in every state in the US. Forests are diverse and distributed across the nation: wood and its by-products are used to produce more than 5,000 products. It has been estimated that every person in America uses more than 600 pounds of wood and paper every year, equal to a 100-foot-tall tree. Not all wood, however, is commercially valuable. The **species** of tree (e.g., hardwood or softwood) and merchandised **value** (e.g., pulp or saw timber) determine the final use of a harvested tree. A more detailed discussion about tree types and where they are located in the US can be found in ***Section E.***

Wood has many favorable characteristics as a raw material. It is lightweight, structurally strong, produced at relatively low cost (both financial and environmental), easy to manage, and aesthetically pleasing. These qualities make wood the preferred material of builders and craftspeople; about two-thirds of our domestic wood use is for home building and construction.

Trees are a versatile, valuable, and renewable resource. Each part of a tree can be used to produce a usable commodity. The foliage can be harvested and processed to yield

extracts and oils. Fruits, sap, and nuts are the edible portions of a tree, and are used in products we consume every day. For example:

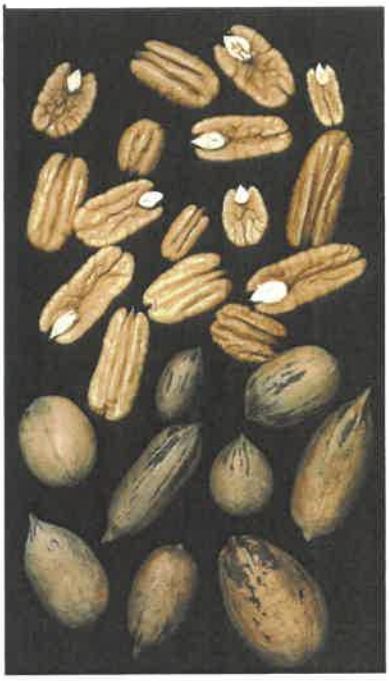
- Common tree **fruits** are apples, oranges, and bananas. **Chocolate** is also produced from beans contained in the fruit of the cacao tree.
- **Sap** from the sugar maple tree is cooked to produce maple syrup. Chewing gum also contains tree sap.
- **Nuts** are considered the "fruit" of many tree species. Pecans, walnuts, and cashews come from trees.

Fruit
Photo: Keith Weller, USDA ARS

Other food products from trees include spices like nutmeg and cinnamon, as well as flavorings like wintergreen, vanilla, and sassafras. Researchers continue to discover new chemical compounds in the bark, wood, and sap of trees that produce potent medicines. Resins and gums extracted from wood are processed and transformed into crayons and shoe polish.

Sugar maple
Photos: Paul Wray, Iowa State, www.forestryimages.org

Tree by-products are all around us: other familiar examples are power line poles, fence posts, dimensional lumber (e.g., "two-by-fours"), plywood, hardwood flooring, shake shingles, decorative trim and molding, and laminated timbers (i.e., boards glued together) used to make arches and curved pieces. Wood is valued by furniture makers for its strength and beauty. Ornamental products include Christmas trees, decorative pinecones, and leaves used in flower arrangements.



Pecans
Photo: Jerry A. Payne, USDA ARS, www.forestryimages.org

Dimensional lumber
Photo: Doug Page, USDA Forest Service, www.forestryimages.org

Ornamental
Photo; Bill Cook, Michigan State, www.forestryimages.org

Paper production-pulp mill
Photo: David J. Moorhead, University of Georgia.
www.forestryimages.org

Paper, of course, is the most common tree product. Paper is made from two types of materials, **raw wood** (either hardwood or softwood) and **recycled (recovered) paper**. The type of paper to be made determines which type of tree is used, and whether to use recycled paper. Trees grown and harvested to produce paper are called **pulpwood**.

To make paper, pulpwood is harvested and brought to the mill where the bark is removed. Debarked logs are run through a chipping mill, which reduces each log into pieces about one-inch in size. The wood chips are dumped into a pressurized tank called a **digester**, along with a mixture of water and chemicals.

The mixture is heated and cooked under pressure, which breaks down the wood fibers and creates **pulp**. The pulp "**slurry**" is a mixture containing 99 percent water and one percent wood fiber. Other materials such as dyes, resins, and fillers are added to the slurry. The mixture is then laid down in a continuous, even layer onto a fast-moving screen that allows the water to drain off. The layer of pulp passes through a series of screens and heated rollers that remove the remaining water. The finished paper product emerges at the other end, and is wound into a roll that can measure up to 30 feet wide and weigh 25 tons.

Products such as cardboard, liner board (used in cereal boxes), high-quality printing paper, newsprint, paper bags, bathroom tissue, and disposable diapers are made from wood pulp. Wood fiber is pure cellulose, and the structure of the cellulose molecule can be changed through chemical processes and converted into plastics. This new material can be molded into various shapes or spun into fabrics. Some products made from cellulose include rayon fabric, cellophane tape, house wares, toys, food, traffic signs, photographic film, smokeless gunpowder, lampshades, eyeglass frames, combs, vacuum cleaner parts, sheets, and towels.

Chemical products are also produced from wood. Cellulose yields such products as pharmaceuticals, adhesives, turpentine, rosin, pine oil, and tannins.

Wood products are described in greater detail in **Section C**.

3. Careers in forestry

A career in the forestry profession is more than "a walk in the woods". Forestry offers numerous choices, with job descriptions ranging from labor-intensive woods work to highly technical forest engineering. The US forest and paper industries employed more than 1.6 million people in 2000, though not all in forester positions.

Employment opportunities vary. A **forest technician** can cruise timber for a forest products company. A **forest engineer** can organize and manage logging operations. A **wildlife biologist** can evaluate and prescribe management activities to enhance habitat. A **forestry professor** can teach at a university. **A research forester** conducts field and laboratory experiments. A **professional consulting forester** can manage timberland for private landowners. Other options include business and finance, communications, computer technology, and mechanics: all entail varying levels of responsibility and require education and experience.

Researcher - field and lab

Photo: Rob Flynn, USDA ARS

Manager in an office

Timber cruiser

Manufacturing/sales

Bottom photos: Doug Page, USDA Forest Service.
www.forestryimages.org

There are many sources of employment in forestry. Employers include private industry, state and federal agencies, non-profit organizations, associations, and special-interest groups. The US Department of Labor's Bureau of Labor Statistics estimates that two out of three conservation scientists and foresters are employed by Federal, state, or local government agencies such as the United States Forest Service, the US Army Corps of Engineers, and the Bureau of Indian Affairs. State agencies hire forestry professionals, and each has its own unique structure and professional career hierarchy.

Private-sector forestry jobs can be found within businesses, organizations, associations, alliances, and interest groups. The type of work performed is as varied as the number of employers. A state forestry association may hire a forester to advise policy-makers regarding natural resource management. Investment firms and private consulting groups hire foresters to manage lands for their clients. Special-interest groups may hire a forester to help support a position on a specific concern or issue.

Selling and marketing forest products can be a profitable career with great opportunities. A salesperson visits and makes sales calls to prospective clients, and markets forestry supplies and tools such as marking paint, **Global Positioning System (GPS)** technology, and harvesting equipment. A private business may hire a forester with wood products background to sell such high-value products as solid wood doors, windows, and decorative trim to wholesale distributors.

Education is often overlooked as a career path for the forester who enjoys sharing knowledge with others. A degree in forestry and a teaching certificate provide a diverse education in biological sciences, and allows one to teach many different subjects in a public or private school. Other paths in education include working as an interpretive naturalist, an educator at a nature center, an agriculture education teacher, or a university professor.

Extension forester
Photo: Chris Schnepf, University of Idaho.
www.forestryimages.org

Extension forestry positions are affiliated with state land-grant universities. (A list of US land-grant universities is provided in ***Appendix 1***.) An extension forester provides technical assistance and educational programs for citizen groups, forest landowners, and individuals. He or she may lead a technical workshop for professional natural resource managers or help a Scout troop earn a merit badge. An extension forester with an advanced degree may conduct research to answer questions that will benefit forest landowners and industry. He or she may also serve as a public resource, answering questions from private citizens via phone or e-mail. Local county extension agents can provide more information about becoming an extension forester.

As in any profession, those who seek work in forestry should ask some important questions:

- ***What career level do I seek?*** As in any field, most everyone starts at the "entry level"; job performance determines when and how far one will advance. When opportunities arise, the direction one pursues depends upon interests, skills, and knowledge.

- ***What level of education must I complete to achieve my career goals, and where can I receive this education?*** Completing a two-year Associate (A.A. or A.A.S.) or technical degree program will provide the skills needed to work in forestry, while a professional degree such as a Bachelor of Science (B.S.), Master of Science (M.S.), or Doctor of Philosophy (Ph.D.) will increase opportunities for professional growth and renumeration. Selecting an appropriate accredited forestry school is important; each college and university has unique characteristics.

- ***Where would I like to live and work?*** Forestry-related jobs can be found across the country, and indeed all around the world. A forester may work in rural communities with private forest landowners in Alabama, or hold a corporate management position in a metropolitan area like Seattle. A salesperson may travel a region that covers several states.

Education is essential to every career. Education is the first step toward a forestry career. A degree from a recognized technical school or accredited university provides the knowledge and skills necessary to enter the work force. While success is possible without a college degree, today's competitive job market makes this difficult. The following descriptions of education levels and the jobs associated with each may help illustrate a career path.

Woods worker
Photo: Deere and Company/New Horizons Productions.

- Examples of jobs performed by a forester with a ***high-school diploma*** include:
  - **Woods Worker**–operating heavy equipment such as skidders and loaders.
  - **Industrial Laborer**–operating machines in a forest products mill.
  - **Reforestation Worker**–site preparation and tree planting.
  - **Fire Fighter**–requires specialized training; dangerous and hard work.
- Examples of jobs performed by a forester with a ***two-year Associate Degree*** include:
  - **Forestry Technician**–timber cruising; supervising tree-planting crews.
  - **Land Survey Crew**–surveying property boundaries; layout of forest roads.
  - **Research Technician**–collecting research data in the field; maintaining equipment.

Forestry Technician
Photo: William M. Ciesla, Forestry Health Management International.
www.forestryimages.org

Note that there are 22 technical forestry education programs in the US that are recognized by the **Society of American Foresters (SAF),** and meet or exceed minimum standards for curriculum, facilities, enrollment, faculty, and administration (see ***Appendix 2***). A recognized program offers a two-year Associate degree in forest technology, or its equivalent.

- Examples of jobs performed by a forester with a ***Bachelor of Science (undergraduate) degree*** include:

  - **Forest Manager**–managing forest land for timber production, wildlife, and water.
  - **Forest Engineer**–planning timber harvesting activities.
  - **Urban Forester**–managing the tree resources for a city or community.

Research forester
Photo: Paul Bolstad, University of Minnesota.
www. forestryimages.org

  - **Forest Resources Educator**–leading educational programs.
  - **Research Forester**–improving the science of forestry.
  - **Business Manager**–responsible for annual budgets, personnel, facilities, and equipment.

Note that to receive a B.S. in forestry, a person must complete a degree program at an SAF-accredited university (see ***Appendix 3***). Accreditation is granted to institutions offering courses that lead to professional degrees at the bachelor's or master's level. Students pursuing a forestry major study many disciplines, both in the classroom and laboratory. A student may be in the classroom learning the fundamentals of forest ecology or timber management in the morning, and in the afternoon be in the woods using a GPS unit in a lab exercise. A student enrolled in an accredited forestry program will study biology, forest soils, hydrology, timber management, forest business, economics, dendrology, ecology, entomology, silviculture, harvesting methods, wildlife management, timber harvesting, and forest products. This list is not complete, and each SAF-accredited program is different.

- A **graduate degree**, such as a Master of Science (M.S.) or Doctor of Philosophy (Ph.D.), can lead to employment in such positions as:

  - **Corporate Management**
  - **Research Scientist**
  - **Program Director**
  - **University Faculty**
  - **Regional Supervisor**

Research scientist
Photo: Scott Bauer, USDA ARS

As in all professions, graduate degrees are becoming more prevalent in forestry. Graduate programs develop critical thinking and analytical skills, an understanding of research, and advanced learning related to specific subject matter (e.g., tree physiology, timber management, or forest business). A graduate student progresses under the guidance of a professor, who serves as a mentor for the duration of the program. In addition to completing classwork, graduate programs require the student to undertake a research project and conduct an in-depth review of relevant literature.

An M.S. degree usually requires two to three years of study and completion of a thesis or research project. A Ph.D. degree may take an additional three to four years to complete. More course work is required, and the candidate completes an extensive research project known as a dissertation. He or she must also pass intensive verbal and written tests.

Note that a bachelor's-level forester may seek a graduate degree in a discipline outside of forestry to broaden his or her employment opportunities. For example, a person who seeks to work in corporate management may earn a B.S. in forestry and a Master of Business Administration (M.B.A.). No matter what field of study, an advanced degree can reward effort and help advance career goals. More people graduate with bachelor degrees today than did a decade ago; thus, a graduate degree may convey an advantage in a highly-competitive job market.

Note too that two skill sets have become common to all forestry professions, and indeed to all careers in the 21st century: **computer knowledge** and **communication skills**. Technical knowledge will not guarantee a job if the student is unable to convey that knowledge to others clearly and effectively. Therefore, good writing, graphics, and public-speaking skills are a must for a forester.

4. Agencies responsible for our forests

Timberland ownership in the US is divided between private landowners, the Federal government, and forest industry. The remaining non-commercial forest land is held by the Federal government and private landowners. Property owners have the right to determine what happens to the land they own.

The Federal government is responsible for managing national forest lands. The US Forest Service is the Federal agency responsible for carrying out management activities, and is part of the Department of Agriculture (USDA). It is organized into three branches, each with its own concentration: the National Forest System, Research and Experimental Stations, and State and Private Forestry. State-owned forest lands are the responsibility of each state's forestry agency.

5. Federal regulation on forestry

When European settlers arrived in North America at the beginning of the sixteenth century, the forest was viewed as an endless resource, stretching from the Atlantic coast to the Mississippi River, and all along the Eastern seaboard from Maine to Georgia. The forest was an important source of raw materials. Settlers harvested trees to provide wood for construction of homes, furniture, fences, farm implements, and ships. Wood was also a plentiful source of heating and cooking fuel.

The forest, though, was also an obstacle to progress. Considerable work was required to clear the land of trees before homes could be built and crops planted. The settlers also saw the forest as a place in which predators could hide and plan attacks; yet another reason to clear trees away from homes and settlements.

As population grew and new settlements increased, impacts on the forests began to change the land. In an effort to control the unchecked growth, Colonial governments initiated conservation regulations to control grazing, burning, timber harvesting, and access. Ineffective because of a lack of enforcement and public support, these regulations were codified into law. Timber availability and access were of great concern; thus in 1626 the Plymouth Colony passed a law requiring the approval of the governor and council before timber could be sold or transported out of the colony.

Forests surrounding the Colonies provided raw materials for private industry. Saw timber was in high demand for construction; this created a business venture opportunity, and establishment of the first commercial sawmill in the Colonies in 1631 at Berwick, Maine. Naval stores were invaluable to the shipbuilding industry, which used them in ship construction and repair.

As the nation grew the need arose for a strong, well-equipped military, and wood was used to build ships and military outposts. The nation also needed improved means for transporting people and goods from coast to coast. The railroad was the only mass transportation at this time, so in 1835 the government granted railroads free right-of-way through public lands. Free use of the timber resources along each right-of-way was granted to the railroads in 1852. They received approximately 200 million acres of timberland from the Federal government during this period.

The late nineteenth century spurred significant legislation and land purchases by the Federal government. Private land ownership increased with the **Homestead Act** of 1862, which allowed citizens to buy unappropriated land: up to 160 acres could be owned for $1.25 an acre.

1872 saw the designation of **Yellowstone**, the first **national park**, and organization of the first **Arbor Day**. The forest industry was growing rapidly; nearly 27,000 forest-related businesses existed at this time. The rate of forest harvest was a concern for the Federal government: an estimated two-thirds of harvested wood was being used for fuel. To counteract the high consumption rate, the **Timber Culture Act** was passed in 1873. This act granted each American citizen 160 acres of public land; in return, each recipient agreed to plant and maintain 40 acres of trees for a minimum of ten years.

Yellowstone National Park
Photo: Kenneth M. Cole. www.forestryimages.org

The **American Forestry Association** was founded in 1875 to educate the public about conservation. Congress recognized forestry as a distinct and separate division of the **Department of Agriculture** in 1886, and the Secretary of Agriculture was made a Cabinet post in 1889. In 1890, Yosemite National Park and General Grant National Park were established as forest reservations; and in 1891, Congress passed the **Creative Act**, allowing the President to set aside public land as forest reserves.

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American Forestry Association
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Congress also enacted the **Forest Reserve Act** in 1891, setting aside large tracts of forest land for Federal management. Later, these became **National Forests** under the management of the **Department of the Interior**. To ensure proper management, Congress enacted the **Organic Administration Act** of 1897, giving the President power to establish forest reserves to secure water flow and timber supply. The nineteenth century ended with the appointment of **Gifford Pinchot** as the first Chief of the **Division of Forestry**.

Many consider the early twentieth century to be the "Golden Era" of US **forestry**. In 1905, the name of the Division of Forestry was changed to the **United States Forest Service** under the USDA. The **Weeks Act** of 1911 gave the Secretary of Agriculture authority to purchase forested, harvested, or highly-eroded lands within the watersheds of navigable streams and rivers with the purpose of managing their continued flow.

The **National Park Service** was established within the **Department of the Interior** in 1916. This defined the purposes for which national parks may be established, and empowered the Secretary of the Interior to establish rules and regulations for their use and management. The first **national forest wilderness area** was established in the **Gila National Forest** through the efforts of **Aldo Leopold**, a prominent figure in the history of conservation and natural resource management.

Congress passed the **Clarke-McNary Act** in 1924. It made provisions to improve both private and public forest lands: coordinating forest fire control with the states, establishing seedling nurseries to grow and distribute planting stock to farmers, promoting proper management of farm woodlots and shelterbelts, and seeking acquisition of lands deemed essential for water quality and for timber production. Both acts spurred the establishment of state forestry organizations across the country.

1929 brought the stock market crash and the **Great Depression** of the 1930s, an economic disaster for the US. About one in four working age people were unable to find jobs. As part of 1933's **"New Deal"**, President **Franklin D. Roosevelt** created the **Civilian Conservation Corps (CCC)**. This program employed about two million people to plant trees, install erosion control structures, build campgrounds and shelters, and perform other jobs to improve America's natural resources and infrastructure.

US involvement in World War II, beginning in 1941, increased demand for wood and forest products. Intensive use of forest resources and the resulting decline in wood quality created a need for better forest management practices and educational programs. The **Sustained Yield Forest Management Act** of 1944 safeguarded the economics of forest-dependent communities from local timber shortages.

In 1947, Congress passed the **Forest Pest Control Act,** establishing a government policy to protect private and public forest lands from forest insect pests and diseases. This included conducting detection surveys and deploying control measures to protect against outbreaks.

In 1950 the **National Science Foundation** was established to promote the progress of science, and continues today as an important funding source for research and technology transfer. Also, Congress passed the **Cooperative Forest Management Act,** enabling the Secretary of Agriculture and state foresters to coordinate technical services for forest landowners and industries.

Congress passed the **Multiple Use Sustained Yield Act** in the 1960s. This act recognized the variety of uses of forests (e.g., wildlife, grazing, erosion control, watershed, recreation and wilderness) and forest products. The **Wilderness Act** of 1964 recognized other valuable and educationally important features of America's forests (e.g., ecological, geological, scenic and historical features).

In 1970, the **National Environmental Policy Act** established a **Council of Environmental Quality**, recognizing compatibility between people and the environment as a national priority. In addition, the **Youth Conservation Corps** began teaching young people to conserve land and water resources.

In 1978, the **Cooperative Forestry Assistance Act** repealed and replaced many earlier laws. This positioned the Forest Service to better cooperate with state forest agencies on non-Federal lands regarding forest management practices. The Act's goals were to increase timber production, control and prevent tree pests and diseases, control forest fires, improve wildlife habitat, and carry out urban forest programs.

The 1980s saw a change in focus in forest policy from management and land use reform to conservation and recreation. The **Alaska National Interest Lands Conservation Act** was the largest conservation law to date and gave 100 million acres of land to the National Parks. The **Conservation Reserve Program,** created in 1985, helped landowners work with the Department of Agriculture to plant trees and vegetative cover for erosion control.

The 1990s brought great attention to the plight of forests and their inhabitants around the world. The **Green Movement**, which had begun in the 1970s, gained momentum as people recognized the need to conserve resources and protect the forest ecosystem. The Greens functioned as "political ecologists" and advocated for environmental and conservation gains in the context of global decision-making.

Though the US economy focused on technology during the 1990s, demand increased for products and services provided by natural resources. Competition between US states for water resources forced re-examination of land-use policy and regulations. In turn, both public and private forestland management were affected by support for forest **certification**, or compliance with international standards for environmentally responsible practices.

As the new millennium begins, the forestry industry faces concerns about private property rights, water quality regulations, and sustainable forestry management.

6. International Issues

Forests here and around the world are affected by changes in environment, economy, and society. Individual countries need to identify and implement policies and practices for sustainable forest management, and develop cooperative efforts to promote this sustainability. Forest managers need to provide the values, services, and products people need for economic and social well being, protect environmental quality, and respect the sovereign status of all nations.

International issues are discussed in greater detail in **Section D**.

Some information used in this discussion is from "World Forestry", a position paper of the Society of American Foresters, and is used by permission.

Martin Aitkin (left), director of the M&M Mars, Inc., Almirante Farm, and a local farmer assess damage from a large, dry witches'-broom growth in a cacao tree at the Luz de Maria farm in Uruçuca, Brazil.
Photo: Scott Bauer, USDA ARS

7. Social Issues

Forest managers respond to societal changes as professionals do in all fields. The objectives and resource implications of public investment in forestry often are matters of discussion. More and more, policy makers and the public expect forest professionals to involve stakeholders in management decisions. Therefore forest managers are faced with several issues, such as who to include in the decision-making process and how to make it equitable. Public involvement skills are critical, as well as ways to resolve conflicting demands.

Social forestry is defined as the sustainable management of trees and forests to provide products and services that meet local needs. The principal stakeholders are the people who live in the local communities located close to the forest. Social forestry includes a wide range of activities such as tree planting, agriculture, management of natural forests, watershed management, and the collection of non-wood forest products.

Fundamental to social forestry is the empowerment of the people in managing trees to improve their economic and social condition. Thus social forestry is the "harmonization" of contending forces on the forest resources, such as governance and public involvement; social and cultural values; health and well-being; education and learning; and recreation, access, and tourism.

Social issues are discussed in greater detail in **Section D**.

Because so many items we use each day are derived from wood or wood by-products, trees are one of our most valuable renewable resources. That is why the forest industry follows a set of land stewardship principles that integrates the growth and harvest of trees while being mindful of soil protection, water and air quality, wildlife habitat, and aesthetics.

For these reasons, forestry is a dynamic field in which to work, and offers a variety of career opportunities. A person who seeks to work outdoors, has a concern for the environment, and is interested in science and business can find an enjoyable and rewarding career in forestry. A wide range of educational experiences can prepare one for these careers; a fulfilling forestry job can be found with a high school education or an advanced college degree.

US history shows a trend toward making better use of forest land for everyone. Forests constitute a third of our country's total land use; still, about one-fourth of all forest land could be improved with better management practices, and provide more and better-quality forest products.

Some information used in this discussion is from "Kaltim Social Forestry Project", a publication of the Canadian International Development Agency, and is used by permission.

Social Issues
Photo: Britt Slattery, US Fish and Wildlife Service
www.forestryimages.org

Section C:

Multiple Uses of the Forest

DID YOU KNOW:

Fuelwood (firewood and charcoal) accounts for almost 50 percent of the wood harvested worldwide?

Objective: *The student will be able to identify and describe multiple-use opportunities in the forest.*

Forestry is the science of managing forests, discovering how to produce and maintain a high quantity and quality of products and services. This not only means maximizing resources for immediate benefit, but also renewing resources so they will be available for future generations. Thus it is important to study the forest and its proper management.

Multiple-use management refers to the concept that a forest can and should be managed for more than one purpose or outcome. All management activities must consider all resources and their uses, and the long-term needs of future generations. In addition to timber resources, multiple-use forests include outdoor recreation, water resources, wildlife (terrestrial and aquatic), and even range land (for livestock).

The **Multiple-Use Sustained Yield Act** of 1960 authorized and directed management of National Forests for many purposes, including a sustained yield of products and services. Note that multiple-use legislation affects only public lands managed by the Federal government and available to all citizens: private property owners are not subject to the policy.

Multiple-use forests are discussed in greater detail in **Section D**.

1. Wood Products for Home and Industry

Unlike other products, **timber** cannot be removed or sold without disrupting the forest environment. Removal of trees causes a major environmental change, and can make it more difficult to produce other forest products. The forest landowner usually has great flexibility when timing the sale, and often can schedule the harvest to minimize disruption and take advantage of favorable market conditions.

Many factors affect timber prices:

- **Competition**: A forest landowner can ask any price for timber: what he or she actually receives is often another matter. The price received depends on the volume

and demand for merchantable products, the time of year, the proximity to a mill, and the logging costs. Greater competition among buyers makes it more likely that a timber seller will receive fair market value or higher.

- **Species**: Some wood products are in greater demand than others: **species** is usually the significant variable. (A stand of black walnut is more valuable than a stand of the same volume of sweetgum, for instance.) Lumber prices fluctuate just like any other commodity prices, as do production costs for various wood products. For example, hardwood pulp prices are usually lower than those for hardwood sawtimber.

- **Quality**: Not all trees are valued equally: wood **quality** is important when it comes to pricing. High-quality hardwood sawtimber is graded by objective standards, and higher grades bring higher prices. Quality also influences lumber use. A low-grade fir 2x4 stud may be used to frame a wall, but a higher-quality, stronger 2x4 stud that is free of knots, warp, and twist may be used as part of a structural member.

- **Harvesting costs**: Several **harvesting** factors affect timber value.

  - **Harvesting equipment** (e.g., chainsaws, bobtail trucks, and large mechanical harvesters) entails high operating costs. Spreading these costs over a greater production volume reduces harvesting cost per unit of wood.

  - **Geographic distance** from the stand to the wood mill impacts harvesting costs.

  - **Terrain and soil conditions** contribute to the cost. Flat, dry sites are ideal; other conditions may cause harvesting machinery to work less efficiently.

Mechanical harvesting
Photo: Deere and Company/New Horizons Productions.

- **Special conditions**: Demand for product can deplete a producer's log supply. Climactic and other **special conditions** may make quality timber hard to procure at times of high demand, forcing the producer to pay higher prices for timber from other areas. Conversely, good logging conditions can cause a producer to experience an oversupply, and thus sales will result in lower-than-usual prices.

Besides timber, many alternative enterprises are available to the timber landowner. Some are described below.

- **Trees for landscaping**: Many forests abound with small trees suitable for residential **landscaping**. Many species (or particular shapes, branch forms, and sizes) are not available in garden centers and nurseries. Natural seedling production in a forest

stand may provide profitable opportunities with proper management, selection, care, and marketing. The forest landowner must know what species exist in the stand, and buyers must be assured of tree quality and hardiness.

- **Firewood**: Trees that need thinning can be marketed as **firewood.** Usual sources are trees unsuitable for higher-value products, those from species without current market demand, or those difficult to use for lumber or other valuable products.

Firewood
Photo: James Strawser.

After a productive timber sale, a cleanup operation can yield firewood and other residual material before the next timber stand. Preparing marketable firewood by hand can be time-consuming, while mechanizing the operation can be expensive. Low-value residual material can be gathered by hand for individual or business use, however, and may provide a productive income stream.

Certain species are more useful for firewood than others. Wood sold for decorative burning (e.g., fireplace logs) or specialty cooking (e.g., hickory, mesquite, maple, and apple) will generally sell for higher prices than that for heating stoves or campground fires.

Not all wood is equal in value. The heating value (**British Thermal Units, or BTUs**) varies with species. **Density** is an important measure of suitability for firewood. Heavier woods require fewer trips to a log stack for the same amount of heat. Note too that high-density wood holds more water than low-density wood: consequently, woods that produce the most heat require the longest drying time. Short, firewood-log-sized pieces dry faster than longer ones, reducing deterioration risks. Finally, woods that split easily, ignite quickly, and are sized for consumer use are most desirable as firewood, while those that are harder to manage or that produce heavy smoke and sparks are less so.

- **Pine straw:** Increased construction across the US creates increased demand for landscaping, and therefore a need for mulches. Different materials are used for mulch in different parts of the country, such as ornamental gravel or pine bark, but most popular in many areas is **pine straw.**

Pine straw
Photo: David J. Moorhead, University of Georgia.
www.forestryimages.org

Though pines are evergreen, they lose old needles every year. These needles can be baled like hay and sold for landscaping. Pine straw mulch does not last long and must be reapplied every one to two years, so the market is renewable.

The needles of the Longleaf and Slash pine trees are considered best for ground cover. Loblolly pine needles are also used to provide satisfactory cover; needles of other

pines are too short, hard to handle, and do not provide good mulch. Ideally, trees should be on level old fields, spaced widely, fertilized regularly, and baled biennially.

Wood chips
Photo: Doug Page, USDA Forest Service. www.forestryimages.org

- **Chips, shavings, excelsior, bark, and sawdust:** These products are usually obtained as by-products from a sawmill or wood-processing plant. Entrepreneurs using wood left from logging operations or thinnings can produce them, however.

  Like pine straw, chips and shredded hardwood bark are useful for mulch. Chips, shavings, excelsior, and sawdust can be used for animal bedding (both household pets and livestock), litter, and compost. Chips and shavings can also be used to make secondary wood products such as particleboard, fireplace logs, and packing material. In most cases, selling these items directly to large producers can be a productive source for the small entrepreneur.

- **Decorative woods:** Bigleaf western maple, mountain mahogany, black walnut, black locust, and yew have become popular as **decorative woods**. **Burls**, or outgrowths, cause trees to grow in irregular patterns which result in beautifully grained woods. **Spalted** woods, or those that have begun to decompose, are also in demand. Spalting occurs when the bacteria in decomposing hardwoods create distinctive "ink lines" or "zone lines"; the most notable effects are in maple, birch, and beech.

  Decorative wood is in constant demand by established wood turners, hardwood retail stores, woodcrafters, and manufacturers. Classified ads in woodworking magazines can also tap a lucrative market.

Decorative woods
Photo: James Strawser.

- **Specialty wood products:** A wide variety of special-purpose wood products are manufactured from locally available forest resources. **Specialty wood** articles may be rough or finished, and may be made entirely or mainly of wood: everything from baseball-bat boxes to yardsticks. Many such products were originally manufactured in local shops when rural people became skilled at making items that could not be purchased in stores. Today many people will pay a higher price for a wooden "widget" rather than a plastic one, knowing that trees are renewable while oil is not, and that a plastic widget can be thrown away when it breaks while wood can be repaired. Most specialty wood producers are officially classed as secondary wood processors, distinct from mills producing primary, intermediate, or unfinished forest products (e.g., cants, timbers, posts, ties, lumber, and panel products). Specialty

products today are often produced from logs cut for the purpose, instead of commercial lumber and plywood, and thus would not include most standardized wood furniture, shelving, cabinets, and millwork.

Starting or joining a specialty wood products cooperative is one way a landowner can improve opportunities for this kind of product. High-quality items of regional significance can bring a good price at a co-op. Starting a woodworking association in conjunction with the co-op is also a good idea.

Pine cone
Photo: Dave Powell, USDA forest Service.
www.forestryimages.org

- **Pine cones, greenery, and other forest decorations:** Tree boughs, leaves, and cones are popular indoor decorations, particularly at holiday times. Evergreen wreaths are the most widely-sold specialty forest product nationwide, and enjoy year-round popularity. Birch, ironwood, and alder "tops" are harvested and sold as decorative trees in interior design settings. Marketable floral products such as peppergrass and baby's breath are actually considered "weeds" in many states in which they grow. Entire trees and other forest plants are harvested for sale in nurseries and garden centers as transplants. These forestland components can be resources for alternative enterprises.

  Removing decorative forest components destined for decorative markets can benefit the stand if done under sustainable management. The remaining trees benefit from improved growing conditions and reduced wildfire hazard. As with pine straw, a leasing approach for this enterprise may have merit.

- **Seed cones:** Seed cones are used by US government agencies (e.g., the US Forest Service and the Bureau of Land Management), large corporations such as Weyerhauser and Boise Cascade, independent seed companies, and state seed-tree nurseries. While many of these harvest their own green pine cones for seed, some buy cones from individual providers.

  Crops are cyclical and seasonal, and are usually harvested from mid-August till late September. Opportunities for those who live near forest resources to gather and sell cones should continue for the foreseeable future. Seed companies generally have agents or producers in forest communities who solicit help from the public when the crop is to be harvested. The agent or producer checks the incoming cones against designated company standards, weighs them, and often pays for them on the spot. Prices paid, of course, may vary from year to year and location to location.

  Successful providers tend to be those who are closely tied to the secondary forest products market, such as wildcrafters who

Seed cone harvesting
Photo: Tom Landis, USDA Forest Service.
www.forestryimages,org

collect other forest products throughout the year. Collectors must climb trees and shake branches to release green cones, which are then gathered and stored. Collected cones are shipped to extraction plants where they are processed. Spent cones are often resold to the decorative market.

- **Aromatics:** Essential oils are the concentrated aromatic oils of plant leaves, flowers, seeds, bark, roots, and the rinds of some fruits. Oils obtained from trees include balsam fir oil, cedar leaf oil, spruce oil, cedarwood oil, and wintergreen oil. All are produced by a steam distillation process, applied either to the chopped wood or to the leaves and branch ends of the trees. Oils obtained from cultivated or wild plants include peppermint, spearmint, mentha citrate, eucalyptus, hop, citronella, and chamomile.

- **Forest botanicals:** Some forest plants have market potential for culinary uses and naturopathic remedies. These include such food seasonings, flavorings, and preservatives as bay leaves, chervil, marjoram, rose hips, tarragon, and thyme; edible greens, roots, and tubers such as amaranth, cattail, milkweed, sassafras, watercress, and wild onion; and medicinal materials such as bitterroot, ginseng, quinine conks, St. John's wort, sumac, and witch hazel.

  Spices and herbs require special dehydration to maintain the quality of volatile oils. Though hand-drying these crops is labor-intensive, the market for "native" wildcrafted or "forest farmed" spices and herbs appears promising. Direct-sale options include roadside stands, "pick-your-own" operations, farmers' markets, gift baskets, and mail order. Sales can also be made to retail outlets, specialty manufacturers, and restaurants.

Forest botanicals (ferns)
Photo: Dave Powell, USDA Forest Service.
www.forestryimages.org

Herbs are potential cash crops in areas not suited to more familiar produce. Areas with limited water and relatively poor soil sometimes can produce as much income per acre as more fertile areas can with traditional crops.

The market for wild crafted fresh greens is limited. Greens are delicate, crushing and wilting easily. Plant identification is difficult, thus the harvester must have good knowledge of botany. Still, wild harvested greens can be marketed successfully to gourmet restaurants, their associated food service operations, and grocery stores. Another option is direct mail order service to individuals.

The popularity of natural remedies and supplements, and the growing interest in plant-derived chemical compounds for pharmaceuticals, both create market opportunities for forest botanicals. Many medicinal plants are marketable through herb and botanical buyers, or to the retail and international markets. An example is ginseng: in 1990 the US exported more than a million pounds, worth more than $80 million. Medicinal plants are marketed primarily through regional businesses that process and package the plant parts for final

processors or the retail market. Often these are small start-up firms. Producers need to become familiar with Federal and state regulations regarding health care products.

Though many biologically-based drugs have been replaced with synthetics, some are still produced from cultivated or wild medicinal plants. Pharmaceutical firms that produce prescription and over-the-counter drugs, therefore, are another potential market. Usually, these firms will first seek cultivated plants grown under very uniform conditions.

Berries and wild fruit
Photos: Carl Dennis, Auburn University, www.forestryimages.org. Scott Bauer, USDA ARS.

- **Berries and wild fruit:** Many types of berries and fruit have commercial potential: examples include wild blackberries, blueberries, currents, plums, raspberries, and strawberries. Most wild berries and fruit are found only in certain regions of the country, and are used in baking and for therapeutic purposes.

  Harvesting, processing, packaging, and distribution account for the greatest portion of the landowner's expense for this enterprise. Most must be picked and cleaned by hand. Note too that the recreational and tourism value of "pick-your-own" operations can be great if promoted well.

- **Mushrooms:** Mushrooms are fungi, saphrophytes that live on dead and decaying material. Their major commercial use is for food, though many species are inedible or poisonous: the ability to identify these, of course, is critical to this enterprise. Other uses include biopulping (converting wood chips to paper pulp), toxin control in municipal dumps, dyes for textiles, and medical research.

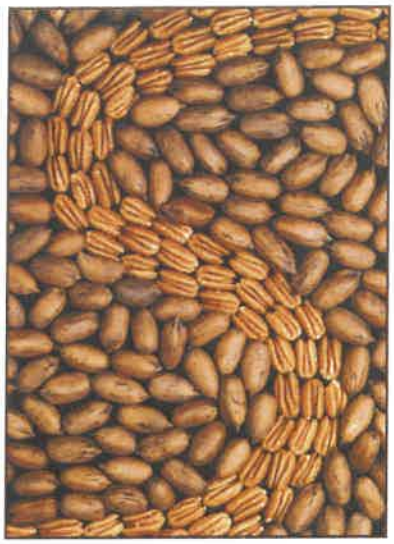
  Picking and selling wild edible mushrooms provides supplemental seasonal income for many. There has been increased competition among dealers of forest-harvested mushrooms in the past few years, attracting the attention of forest landowners. The US Forest Service implements a fee system for selling wild mushrooms to commercial harvesters. Some timber companies allow mushroom harvesting on their land without fees, while others discourage it.

  Cultivated mushrooms are a promising new industry, with new businesses developing every year. There are as many methods of cultivation as there are varieties of mushrooms, and each has its particular requirements. Mushroom cultivation is an excellent method for increasing the profitability of a forest with little disruption of the existing ecosystem.

  Most growers sell their products to two sources, direct to roadside or farmers' markets, or to shipping-point firms which include cooperatives, brokers, and other grower-packers. The product is then prepared for export or sold to direct-sale, wholesale, and retail providers, who market directly to the public, food processors, and restaurants.

Mushroom
Photo: James Strawser.

Mushrooms of lower quality or freshness can be dried, packaged, and sold in retail and restaurant markets. Many are used in dry form in the processed food industry, where visual quality is less important.



Nuts
Photo: Scott Bauer, USDA ARS.

- **Nuts:** A nut is a dry fruit consisting of a kernel or seed enclosed in a woody shell. The nut itself is an excellent source of protein and is commonly used in candies, baked goods, and ice cream. Shells of various nuts have many industrial uses, such as cleaning abrasives and as additives to chemical products. Uncracked nuts are often used as decorative materials for centerpieces and gifts.

- **Honey:** Bees need nectar and pollen over as long a period as possible to produce maximum honey crops. Therefore, certain tree species with a succession of flowering periods are best for honey production (e.g., willows and maples early in the year, basswood and sourwood later on). The forest landowner may choose to explore production of a high-quality regional or specialty flavor of honey, as well as other bee products (e.g., combs, pollen, beeswax, and royal jelly). Note that the honeybee's most important contribution to the forest is the pollination of virtually all plants. The value of pollinated, cultivated forest products far outweighs that of hive products.

Honey
Photo: Scott Bauer, USDA ARS.

- **Charcoal:** Charcoal is a form of amorphous carbon, used for fuel, and produced when wood, peat, cellulose, or other carbonaceous substances are heated with little or no air present. Most charcoal is used as briquettes for recreational, restaurant, and home cooking. (This differs from activated charcoal, made by heating charcoal in a steam furnace at high temperatures to create a microscopic "sponge" that traps molecules of contaminants. It is used in refining, in gas masks, in household chemicals and poison antidotes, in insulation, in soil additives, and as artists' materials.)

The market for the individual entrepreneur seems to be limited for charcoal, though there may be some modest potential in local niche markets for natural hardwood or "lump" charcoal. Most producers sell their product to intermediary operations that process the charcoal for briquette manufacturers or other specialized industrial uses.

2. Wildlife

Whitetailed deer
Photo: Kenneth M. Gale.
www.forestryimages.org

Hunting creates an opportunity that can benefit landowners. Hunters seek solitude, escape, and adventure, and enjoy visiting new places. They are willing to pay for low-density hunting space and the experience it provides.

As with other examples described above, the simplest way to sell access to wildlife is with a lease. This contractual agreement gives the lessee (usually a group of hunters) the exclusive right to hunt on a specific piece of land for a certain period of time. A lease is often the easiest and most profitable way to commercialize hunting, as it usually entails the least work and worries for the landowner. An added benefit for the absentee landowner is the increased control it can provide over his or her land: leaseholders will keep unwanted visitors out.

A similar arrangement is a sale of memberships to the property: this also allows the landowner to select those who have access to his or her land. Generally, the sale of memberships requires high-quality hunting on this property. Availability of a shelter on the property (e.g., an old house, cabin, or trailer) makes membership easier to market.

A resident landowner may want to consider sale of hunting rights by the day or weekend. This provides better control, and ensures that the landowner has the land to him or herself when guests are not booked. This is particularly good if the landowner likes to hunt, or provides free hunting to friends. For forest land with a house on the premises, a bed and breakfast plan is a good way to market hunting. Lodging and food increases the price of day and weekend hunting. The bed and breakfast provider need not own a hunting lease if abundant public hunting lands are located nearby.

Hunting
Photo: Chris Schnepf, University of Idaho.
www.forestryimages.org

An ambitious business opportunity for the landowner is a hunting lodge, providing excellent hunting, food, lodging, service, and hospitality for top-dollar prices. Note, however, that the cost of building, advertising, and managing suitable facilities is beyond the capability of most people. Those ambitious, hard-working, and lucky enough to succeed in this type of venture may find they no longer have time to hunt.

When considering a hunting enterprise, evaluate the wildlife assets and natural features of the land, and consider the probable customer base. If significant modifications must be made to the land in order to make a hunting enterprise practical, there may be no way to realize a good return on the investment. Likewise, if all the land is in valuable timber, it might not pay to take land out of wood production for this purpose.

Consider the people you want to attract to the hunting enterprise. Landowners not eager to provide customer service may be best advised to consider a lease arrangement; those who enjoy public contact might be interested in one of the other options. Regardless, do not "overbook and overshoot": instead, match the hunting enterprise and the intensity of its use to the supply of game.

It is essential to buy adequate insurance coverage. There are many sources of specialized insurance policies for hunting businesses. Note that a "hold harmless" lease clause will not prevent lawsuits.

Opportunities to observe and photograph birds and wildlife can also be commercialized if the landowner has the right facilities and environment. Note too that, in the same way that a registered forester can help organize a timber sale, a certified wildlife biologist can help advise the landowner regarding alternative forestland enterprises.

3. Water

Watershed
Photo: Scott Bauer, USDA ARS

Hydrology refers to the study of water on, in, and above the earth. The cycle of water movement between **terrasphere** (land), **oceanosphere** (ocean), and **atmosphere** (air) is termed the ***hydrologic cycle***. ***Surface-water hydrology*** focuses on water on and above the surface of the earth (e.g., flooding and droughts). ***Ground-water hydrology*** focuses on the distribution and movement of water beneath the earth's surface (i.e., groundwater). Ground-water hydrology is important for applications in water supply and irrigation.

Forest management has been found to be one of the land uses having the least negative impact on ***water quality***. Healthy, stable, and productive forests are closely associated with high-quality surface and ground water. For that reason, forest management should be recognized as a preferred land use in areas adjacent to lakes, rivers, and streams.

Note, though, that forest management practices that cause soil erosion are serious threats to surface water quality. Therefore, water quality protection considerations (e.g., use of non-regulatory **Best Management Practices**, or **BMPs**) must be included in the development of all forest management plans. Water quality issues are discussed in greater detail in **Section D**.

Trees have a direct influence over water yield to the **watershed**. Like other plants, trees extract water from the soil and release it to the atmosphere through ***transpiration***. Rain and snow also stick to foliage, and evaporate or ***sublimate*** back to the atmosphere without reaching the ground. Mature trees have higher transpiration rates than younger ones, and canopies that are uniform and dense cause greater amounts of precipitation to be intercepted and lost to the atmosphere. Thus a thick stand of mature timber combines a high transpiration rate with a high interception loss. Watershed issues are discussed in greater detail in **Section D**.

Soil movement by wind, water, temperature changes, and other forces is called ***erosion***. The amount of erosion is determined by plant cover, land characteristics, soil type, climate, and exposure time. ***Natural erosion*** takes place over long periods of time. Erosion can vary greatly between locations. Plants and root systems shield underlying soils from erosion by wind and rain. Human and animal activities or catastrophic natural events accelerate erosion by exposing the soil, and can in turn affect water quality. Sensible ecosystem management is essential to maintain healthy forest conditions.

Topsoil is formed from underlying "parent" soils by long periods of weathering and chemical action. It contains organic matter and is somewhat "glued together". Some topsoil layers are thinner than others: though the top layer holds moisture, precipitation filters through to ground waters or may run off gradually. Loss of the vegetative layer and exposure of bare soil leads to more rapid erosion. This process can improve if the vegetative cover returns, or if the soil surface is protected by mulches or impervious coverings. Note that some soils are more affected than others by erosion (e.g., those composed of unconsolidated clay, silt, or fine sand).

Erosion
Photo: Chris Schnepf, University of Idaho.
www.forestryimages.org

Even though forestlands serve as watersheds for many communities, water is not generally considered a saleable forest product. However, water that exists on timberlands can be a resource for some alternative enterprises.

Water in streams, rivers, and ponds provides recreational opportunities (e.g., fishing, waterfowl hunting, boating, and swimming). Some property development property may be required, however, and it may be easier and less disruptive to enter into a leasing arrangement.

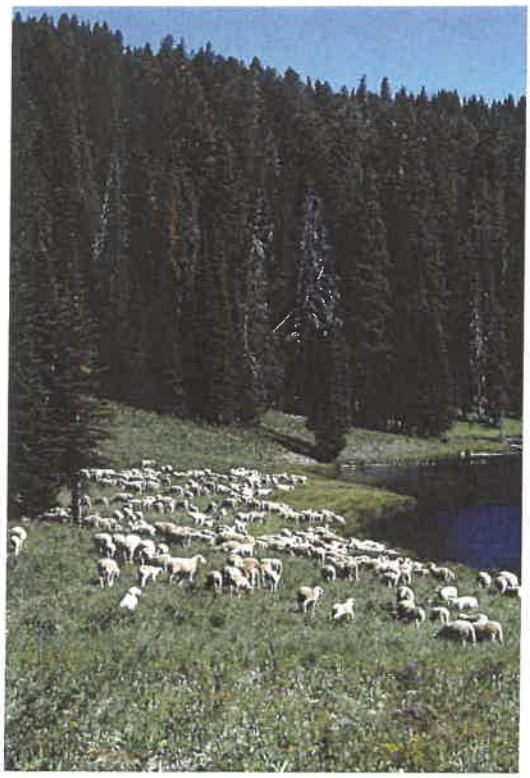
Another possibility is electric energy production. Streams that drop in elevation rapidly or have deep reservoirs can yield water power for electric generators. Such power cam be used by the forest landowner to reduce dependency on electric utilities, or in some cases can be sold to utility companies.

Residential development is another attractive option, especially on the periphery of a body of water. Significant income can be generated, and is usually much greater than the consequent loss of productivity from other forest resources.

Note, however, that greater economic profit may mean reduction of other forestland values, and that more profitable activities almost always require more physical and financial investment.

4. Range

Silvopastoral systems integrate trees with forage and livestock production. These systems traditionally involve grazing livestock in wooded rangeland, and incorporating trees in pastures for shade and timber. Of all **agroforestry** practices (i.e., combining agriculture and forestry technologies), silvopastoral systems perhaps are the most promising in terms of acceptance and potential economic benefits.



Range land
Photo: Scott Bauer, USDA ARS

Ecological, economic, and social aspects of silvopastoral systems in the US are being investigated. For example, research on pine and coastal Bermuda grass systems in the southern US show better land use investment potential than either producing timber or grazing livestock in open pasture. Moreover, if a pine straw harvest is included in the system, the economic benefits can exceed even that of the timber. Other studies show that growth of trees is not negatively affected when intercropped with forage grasses, although observations suggest that uncontrolled or excessive grazing can reduce tree survivability and growth.

Combining timber and livestock production can be a way to recoup the large initial costs of a timber stand, and provide a cash flow source. Natural forest stands with low stocking density have enough light and other resources at the forest floor to support forage production for "running" livestock. Trees also provide protection for animals from summer heat and winter cold.

Grazing opportunities can be developed in existing pines by thinning to reduce basal area; this allows more light to reach the forest floor. A prescribed burn thereafter encourages growth of forage plants. Fertilization and seeding of desirable grasses can improve grazing quality and increase forest productivity. New pine stands can be established to integrate timber and grazing operations: wide spacings are recommended to provide open grazing strips. Livestock can severely pack the soil, and trees cannot regenerate where livestock are grazing. Also, the number of trees per acre must be reduced below that typical for timber production in order to allow sufficient light and water for grass production. More land per animal is required in a combined timber/livestock arrangement than in a "traditional" open-field setting.

Note that grazing by domestic livestock, particularly cattle, is not advisable or recommended in hardwood stands.

5. Recreation

Attractive elements exist in every forest. These allow the landowner to meet the demand for recreational resources. A planned approach is essential, considering such factors as traffic demands, restroom needs, cleanup, and refreshments.

A hunting lease or an art and photography site may require no additional preparation. Hiking, bicycling, or horseback riding may require initial clearing of trails and periodic cleaning. Swimming and off-road trails for motorized vehicles require infrastructure, personnel, cleaning, insurance, and other ongoing expenditures. Inexpensive rustic campgrounds attract users who are careful of their surroundings, but additional facilities generally make a site more popular. In general, more popular activities often cost the most to establish and maintain, but yield the greatest return. Less demanding forms of recreation, however, create less disruption of normal forest management.

Recreation
Photo: Anne Miller, Soil and Water Conservation.
www.forestryimages.org

Forest recreation endeavors can be grouped by anticipated length of stay. Hiking and birdwatching, for example, are one-to-two-day activities; camping may cover several weeks. Longer stays increase demands for service and facilities, but allow access to more distant consumers.

Accessibility refers to the integration of all people in facility participation without segregation. Outdoor environments offer unique psychological, physiological, and spiritual benefits to users. People with disabilities enjoy the same array of personal and social benefits from outdoor recreational pursuits as those without disabilities. With nearly 20 percent of the population having a disability (according to the 2000 US Census), it is imperative that forestland owners and planners provide accessible outdoor facilities and activities without fundamentally altering the nature of the activity itself.

The forest offers a wide spectrum of benefits to the participant. These can include a social experience with family and friends, escape from the stress of work and daily life through access to the environment, and a solitary experience where a person can rely on his or her own abilities and knowledge without modern conveniences. Opportunities available at a site should be evaluated relative to accessibility for people with different types of abilities, and should foster independent use by a person with a disability.

The US Forest Service developed guidelines in the 1980s to maximize accessibility while protecting the resource and its natural settings, making them accessible and appropriate to the setting. According to guidelines suggested by the Americans With Disabilities Act (ADA), forest recreation designers and operators should provide access to the greatest extent possible unless doing so would:

- Cause substantial harm to cultural, historic, religious, or significant natural features or characteristics.
- Substantially alter the nature of the setting or its purpose.
- Require construction methods or materials that are prohibited by Federal, state, or local regulations or statutes.
- Not be feasible due to terrain or the prevailing construction practices.

Some information in this discussion is from the monograph "Campground Accessibility: Issues and Recommendations (Summer 2002)", used by permission of the National Center on Accessibility at Indiana University. Their website is found at www.ncaonline.org.

6. Fisheries

A ***fishery*** is defined as a fishing effort centered on either a particular region, or a particular species or type of fish or aquatic animal. The relationship between forest practices and fish production is complex, because other activities in addition to forest practices affect fish production. The forest landowner must determine how to separate all of these influences, including the effect of past forest practices, from present and future practices in relation to fish production.

Fisheries
Photo: Chris Schnepf, University of Idaho.
www.forestryimages.org

Most forest practice regulations address water quality, but not fish habitat specifically. Large woody debris, however, can be an important component of healthy streams. It moderates the velocity of stream flow, influences the routing and storage of sediment, and increases the quality and diversity of fish habitat.

Foresters must be concerned not only with the immediate effect of forest operations on the fish, but also their effect on the ability of fish to grow, to compete, and eventually to reproduce. Fish management programs call attention to specific habitat requirements such as spawning substrate, sedimentation, cover, pool volume, minimum in-stream flows, and the effect of forest management practices on these requirements.

Fee fishing operations offer an opportunity to supply the growing demand for sport fishing. Some entrepreneurs charge a small admission fee, with an additional charge per fish or per pound of fish caught. If a particular location has an area large enough to be sectioned off, a "fly fishing only, catch-and-release" area can be added and a fee charged for time. Note, though, that catch-and-release areas require constant surveillance and supervision, and are not as profitable as "catch 'em and keep 'em" ponds.

Other services available at fee fishing enterprises might include bait sales, picnic and camping sites, fish cleaning, rod and reel rentals, swimming, lodging, and in some cases, boat and motor rentals. Operations near large urban centers often have the greatest potential for success.

7. Aesthetics

Aesthetics refers to human perceptions of natural beauty (including sight, sound, smell, touch, taste, and motion). The forest offers multiple opportunities to discern its natural beauty: the sight of beautiful flowers, the sounds of birds, the smell of pine trees, the

rough feel of bark when touched, the taste of wild berries, and the motion of leaves in the wind. For many, the forest provides a place to feel at peace, escape the fast pace of work, and relax.

Note that some forest areas must be managed for their "visual sensitivity", such as roadways, trails, lakes and waterways, campgrounds, and picnic areas. In a managed forest the visual impact of harvesting, site preparation, reforestation, prescribed burning, and other practices that require construction or disturbance of the forest are reduced as much as possible. Other activities may enhance forest aesthetics such as planting native tree, shrub, or grass species, establishing special habitats to attract wildlife, or constructing a trail that leads to a vista overlooking a forested valley. Aesthetics can be connected to many uses as a "value-added" benefit.

San Isabel National Forest, Colorado
Photo: Dave Powell, USDA Forest Service.
www.forestryimages.org

8. Natural Areas

Many who yearn for contact with nature and anticipate opportunities to "head for the hills" are willing to pay for back-to-nature experiences. Most, however, do not seek game or fish. Many US states seek to help landowners capture the economic value of wildlife viewing and similar activities as important tourism and recreation options.

Non-consumptive wildlife-related recreation means the observing, photographing, and feeding of fish and wildlife; it has been estimated that three out of four people in the US participate in these appreciative uses. A 1985 study by the US Fish and Wildlife Service found that 47 percent of those traveling to natural areas for non-consumptive activities visited woodlands most often. For the landowner in the urban outskirts, this demand could be met by providing areas for birdwatching and general observations of other animals in their normal habitat.

Rural farms and forestlands provide resources that may attract those interested in the beauty of nature. Landowners can provide guide services and lists of habitats and species, cautioning guests to avoid disturbing wildlife, particularly in the breeding season. School districts and other institutions may pay to bring classes to private habitats if the quality of information services is high.

9. Wilderness Areas

Although trees appear to dominate the forest, they are only part of the complex **forest ecosystem**. A forest is home to many wildlife species and provides necessary shelter and food for their survival. Many plants, animals, and micro-organisms contribute to the forest's ecological balance, growth, and health. The forest ecosystem provides the necessary diversity of habitat to support trees, plants, wildlife, and other organisms as they fulfill their ecological roles. Even dead and dying trees play an important role in the forest life-cycle.

A forest is comprised of four basic layers, each playing an important role.

- The **emergent layer** is made up of the tallest trees that rise above all others.
- The **canopy layer**, or upper layer, is comprised of branches, leaves, and tree tops.
- The **understory layer** is made up of trees, shrubs, and vines growing beneath the canopy.
- The **forest floor** is the layer of organic **humus** (decaying leaves, twigs, and logs) and the layer of soil it covers.

These forest layers can be compared to buildings in a large city. The emergent layer represents skyscrapers that tower above everything else; the canopy represents taller, medium-sized buildings; the understory represents the smallest buildings; and the forest floor represents surrounding streets and sidewalks.

The physical characteristics and structure of each forest layer creates unique habitats within which many species of plants, animals, and micro-organisms adapt to life. For example, the emergent layer allows birds to perch. The canopy and understory provide habitats for tree-climbing vines, birds and climbing animals, and insects. The forest floor provides habitat for terrestrial animals to make homes and forage for food. This layer also provides habitat for insects, bacteria, and fungi that live on fallen logs and leaf litter.

To a casual observer a forest may appear still and changeless, but in fact it is a dynamic place of gradual but constant change. As a forest matures, its plant and animal communities change with it. The process by which one community of plants and animals slowly replaces another over time is called **succession**. If left untouched by humans, for instance, a field will go through gradual changes: from grass to shrubs to sun-tolerant trees, and ultimately into a mature forest. Biological, geological, and chemical cycles are at work in this process. Whether a forest is natural or made by human hands, whether located in Georgia, Maine, or Oregon, these natural cycles are always in motion.

Our nation is fortunate to have vast expanses of forest land to use and enjoy. Forest diversity provides a wealth of natural, renewable resources that benefit everyone.

Cheaha Wilderness Area, Alabama
Photo: James H. Miller, USDA forest Service
www.forestryimages.org

Section D:

Environmental and Social Factors of Forest Management

DID YOU KNOW:

A windbreak is a row of trees or shrubs positioned to provide protection from the wind? Properly designed, located, and maintained windbreaks reduce wind speeds up to 30 times their height downwind; the height of the windbreak increases with tree age and depends on the tree species used.

Objective: The student will be able to recognize environmental and social factors affecting the management of forests.

1. Multiple-use conflicts with economic development

Multiple-use forestry refers to a concept of forest management that combines two or more objectives and manages the land or forest for more than one purpose. A multiple-use forest combines a balance of diverse resource uses that takes into account the long-term needs of future generations. Some of these uses include recreation, range, timber, minerals, watershed, and wildlife. Examples may include the production of wood or wood-derivative products, forage and browse for domestic livestock, proper environmental conditions for wildlife, landscape effects, protection against floods and erosion, recreation, and protection of water supplies.

Multiple-use forest management refers to the administration of forestland resources to determine optimum yields of products and services without impairing the site's productive capacity.

Forests, with their complex ecological processes, are essential to economic development and the maintenance of all forms of life. They are sources of wood, food, and medicine, and are rich storehouses of biological products. They act as reservoirs for water and other natural resources. Forests are home to many species of wildlife and, with their peaceful greenery and sense of history, fulfill human cultural and spiritual needs.

A society must manage forests to meet the social, economic, ecological, cultural, and spiritual needs of present and future generations. Such use should be based on policies consistent with **sustainable development**. The World Commission on Environment and Development defines "sustainable development" as making forestland more profitable, productive, or useful in ways that meet current needs, without compromising the ability of future generations to meet their own needs. A forestry plan should count both the economic and non-economic values of forests, and the environmental costs and benefits of harvesting or protecting forests.

2. Pollution

Pollution, especially of the air, affects the forest's economic, aesthetic, and ecological value. Ozone and acid rain impact the health and vigor of trees, leaving forests susceptible to drought, insects, and disease by weakening their natural defenses. To see meaningful change, society must decrease emissions of pollutants. Using alternative sources of energy such as solar and wind generated power can reduce the consumption of fossil fuels used to produce electricity.

Pollution
Photo: William M. Ciesla, Forest Health Management international. www.forestryimages.org

3. Watershed/Water quality

A **watershed** is a section of land that drains into a particular body of water (e.g., a river, lake, sea, or ocean). Rain falling onto a watershed will eventually drain into its corresponding body of water. Trees directly influence the yield to the watershed.by extracting water from the soil by **osmosis** and releasing it to the atmosphere through **transpiration**.

Watershed
Photo: Gerard D. Hertel, West Chester University. www.forestryimages.org

When in a condition of favorable flow, a forest watershed will prevent floods and will have sufficient openings to catch snow and promote runoff. Note, though, that an old or dense forest risks catastrophic stand mortality and watershed damage.

In the past forestlands were regularly picked clean and scorched, damaging forest watersheds. Water flow created damaging floods followed by periods of extremely low flow, interfering with agriculture and commerce. As a result the **Organic Administration Act** of 1897 specified dual purposes of national forests: furnishing timber for US citizens, and maintaining favorable water flows. The **Multiple-Use Sustained-Yield Act** of 1960 further expanded the US Forest Service's role to include management of range, recreation, wildlife, fishing, and other responsibilities.

Intelligent forest management and timber harvest activities can maintain favorable water yield without increasing flood risk, degrading water quality, affecting stream sedimentation, or causing environmental damage. Younger trees have a low transpiration rate and less **interception** loss (i.e., the collection of precipitation on tree leaves and branches). Sensible harvest procedures also reduce fire risks by maintaining fuel loads at manageable levels, creating healthy stands that are better able to tolerate disease and insect attacks.

Though a normal part of the forest management cycle, harvest creates the majority of risks to forest water quality. Improperly placed logging roads can misdirect water runoff, adding to erosion and sedimentation problems. Logging debris blocks streams and erodes channels and banks. When designing a logging road the forest engineer makes sure to direct water runoff into undisturbed vegetation rather than directly into a stream.

Another common method is the use of a **filter strip**, or an area of undisturbed vegetative cover. Vegetation growing in this strip removes sediment before it reaches the stream. How wide the strip should be depends upon the slope of land adjacent to the body of water: steeper slopes require wider strips. Use of heavy equipment in a filter strip should be avoided.

4. Windbreaks/Soil erosion

A **windbreak** is a row of trees or shrubs positioned to provide protection from the wind. Properly designed, located, and maintained windbreaks reduce wind speeds up to 30 times their height downwind; the height of the windbreak increases with tree age and depends on the tree species used. The effective height of a multi-row windbreak is that of the tallest row.

Windbreak

Photo: Minnesota DNR Archives. www.forestryimages.org

All tree or shrub windbreaks let some wind through; dense windbreaks stop more wind. Note though that as wind is deflected up and over a windbreak, low pressure on the downwind side draws wind back to the ground. This low pressure is stronger in more dense windbreaks and reduces the amount of area protected. Thus, letting some wind through reduces the low pressure and results in a larger protected area.

Windbreaks should be positioned at right angles to the prevailing wind direction to protect the greatest land area. Keep in mind that prevailing wind directions will often vary between summer and winter, and multiple-leg windbreaks should be used in areas with variable-direction winds. In hilly areas, locate windbreaks just upwind of the hillcrest for greatest benefit: placing a windbreak on the crest will reduce the protected area, because of extreme low pressure and turbulence created on the downwind and downhill side.

Longer windbreaks protect more area. Wind tends to curve around the ends of a windbreak because of the low-pressure effect mentioned above. Therefore, windbreaks should be long in relation to their height; a 10:1 ratio is recommended.

Trees and shrubs for windbreaks should be selected for hardiness, good form and foliage, fast growth, longevity, low maintenance needs, and pest resistance. Choose species that are suitable for your planting site and that fit your windbreak design. Native plant species in a windbreak will survive best.

Soil erosion
Photo: David J. Moorhead, University of Georgia. www.forestryimages.org

Windbreaks can be effective with even a few rows. Single-row windbreaks can be used where space is limited. Proper tree spacing and maintenance are important in single-row windbreaks: gaps should be avoided because there are no trees in adjacent rows to fill them. A twin-row, high-density windbreak uses two tree rows planted close together, with a tree in one row filling a gap in the next row. This effective design fills in very quickly after planting and takes little space.

Using several different tree and shrub species in a windbreak decreases the likelihood of serious disease or insect problems. For example: a row of low, dense shrubs, a row of medium-tall evergreens, and a row of tall deciduous or evergreen trees can provide reliable wind protection.

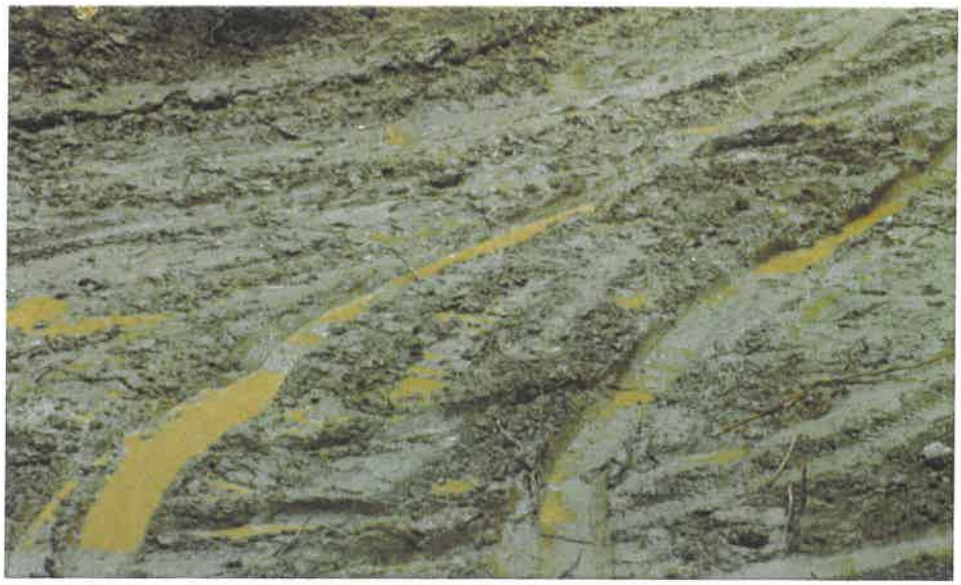
Establishing windbreaks and other vegetative cover prevents soil erosion and benefits wildlife. By slowing wind speeds, windbreaks help conserve soil moisture and prevent erosion. Windbreaks should be planted to block the prevailing winds during winter and early spring, the times of greatest soil exposure.

Some information in this discussion is from the publication "Windbreak Benefits and Design" from Utah State University Forestry Extension, and is used by permission.

5. Recreational impacts

For most people, forest recreation has been relatively un-commercial and non-motorized. Hunting, fishing, hiking, canoeing, and bird watching do not require heavy infrastructure or machinery, and usually have minor ecological impacts.

As high-impact, intrusive activities become more widespread on forestlands, however, a number of changes have occurred. Natural quiet and solitude are being lost, wildlife habitat is being destroyed, sensitive soils are being eroded, and millions who treasure the forest for its beauty are being denied.



Recreational impacts
Photo: Chris Schnepf, University of Idaho. www.forestryimages.org

Permanent habitat loss is perhaps the most ecologically damaging aspect of forest recreation. Forest managers must manage recreation to maintain quality wildlife habitat, clean water, quiet, and solitude. Recreation management decisions should ensure minimal land damage. To preserve ecological sustainability, forest managers need accurate, specific data on recreation impacts. The effect of motorized recreation on natural resources demands particular attention.

6. World populations

Forests, both here in our country and around the world, are affected by global changes in environment, economy, and society. Individual countries need to identify and implement policies and practices for sustainable forest management, and cooperative efforts must be forged among nations to promote sustainability. This means providing the values, services, and products people desire from forests to enhance their economic and social well being, while protecting environmental quality and respecting the sovereign status of all nations.

A key issue affecting forests around the world is how to sustain forest services, products, and values while population and consumption increase and forest area decreases. As population increases, sustainable forest management becomes more difficult and planning becomes more important. Land-use and industrial changes in one region of the world can have environmental repercussions in another region.

Expanding population places increasing demands on forests for a variety of values, services, and products. More than half of global wood consumption is for fuel, and pressures on forest resources seem likely to increase from population growth alone. Overall, the worldwide area of forests declined by 2.4 percent during the years from 1990 through 1999; in many countries, however, forest area is decreasing at much higher rates, particularly tropical forests.

Steady increases in world population create pressures to convert forest to infrastructure, agriculture, and single uses. Conflict among resource providers, environmentalists, and forest dependent communities is increasing and has global implications. Effectively balancing the decreasing area of forests with increasing demands for forest values, services, and products will depend on close cooperation among all stakeholders.

Knowledge and communication can help achieve sustainable solutions to global forestry problems. Plans must be based on sustainable development concepts as a way to help reduce deforestation, environmental degradation, and forest conversion now evident in many countries. Greater emphasis will be placed on intensive forest management in order to grow greater volumes of wood on smaller parcels of land, as demand increases for wood products.

Some information used in this discussion is from "World Forestry", a position paper of the Society of American Foresters, and is used by permission.

7. Habitat manipulation

Habitat manipulation
Photo: Dale Wade, USDA Forest Service
www.forestryimages org

All species need four essential elements to survive: food, water, shelter, and space. A species cannot survive unless these habitat needs are met: if one is absent the species will either migrate to another area, or will die. In areas that meet a species' habitat needs, a population's birth and survival rates will increase.

Habitat manipulation is an effective method for long-term species management. Habitat manipulation refers to a method of promoting a population by making conditions more favorable for it. For example, the adults of a species may require nectar as an energy source, and obtain nectar only from a small number of plant species; the deliberate planting of such plants is biological control by habitat manipulation.

The types, amounts, and forms of habitat attributes required by individual species differ. To effectively manage an individual species, one must consider its specific habitat requirements. Understanding its biology and ecology will increase the chances of either improving its conditions or deterring them from increasing their numbers.

Habitat manipulation is not only the best tool for reducing numbers of a particular species, but is also the most effective strategy for attracting wildlife to a particular environment. By determining which of a desired species' habitat requirements is absent, one can supply the missing element and provide a beneficial habitat.

Note too how habitat and species populations are affected by permanent land-use changes associated with human migration to rural areas. Greater numbers of people reside in the **urban/rural interface**: the zone between metropolitan and agricultural-based areas. Here, residents must remember that they live in a habitat for many wildlife species, and accept that these animals will continue to occupy the area as long as essential habitat needs are met. Some wildlife species may damage buildings and plants, and may be dangerous if encountered. For example, deer will browse on garden plants and rub their antlers on small trees, venomous snakes may inhabit residential and recreational areas, and rodents may damage items that are not stored properly.

Urban/rural interface
Photo: James Strawser.

8. Endangered species

Red-cockaded woodpecker
Photo: James Hanula, USDA Forest Service, Southern Research Station, Athens, GA

Many plant and animal species found in the forest are listed on state and Federal **endangered** and **threatened** lists. Most of the latest listings are concentrated in the invertebrate and plant categories. This increase is largely due to increased knowledge about a wider variety of species and their habitat needs.

Many species may be affected in part by forestry activities. Several reasons can lead to a species being listed. Some are "specialists" that are naturally restricted to uncommon habitats; some are scarce within abundant habitat because of life history factors; others because their populations have declined to low levels due to **habitat loss** or **degradation**, **exploitation** (e.g., overhunting or overfishing), or **persecution**.

Though extinction is a natural process, current and projected extinction rates around the world surpass what would be expected without effects of humans. Past human-caused extinctions were largely due to exploitation, but future extinctions are expected to be caused by continued loss, degradation, and fragmentation of habitats. Even a single species loss could affect such ecosystem functions as pollination and nutrient cycling.

Some species, such as rare plants, have direct economic value as a source of materials, food, and medicines. Those propagated for sale command high prices. Scarcity of certain wild plants and animals can encourage theft. In addition, some tourism is based on the observation and enjoyment of rare species. Protection and management of threatened and endangered species can sometimes be expensive, and may reduce other uses of resources.

Opinions differ about policies regarding endangered species. Many people are concerned about the potential consequences of extinction, concerned that without certain species ecological systems may fail to function properly. Others worry that extinction may cause a lack of materials, food, and medicines and a diminished quality of life for future generations. Still others hold ethical and spiritual beliefs about maintaining life on Earth, and believe that the effects of humans on endangered species violate those beliefs.

Others are less concerned. They reason that many endangered species are of little actual importance to humans, and that other species or ecological functions will develop to compensate for those lost. They also believe that protection measures are too expensive, and interfere with human resource use and economic development.

Some information in this discussion is from the "Statewide Forest Plan" from the Wisconsin Department of Natural Resources, and is used by permission.

Section E:

Tree Identification

Objective: *The student will be able to name the major forest types in the US and their geographical locations. He or she will learn tree characteristics and how to use them to identify trees by their common names.*

1. Economically important major trees of each region in the US

The US has a great variety of forests, divided into **Eastern** and **Western** types. The map below shows the large-scale forest regions, identified by their major **climax** and **pioneer** species. Climax species are those found in a mature forest; pioneer species are those that invade open areas and establish the early stages of succession.

To understand a forest, it is first necessary to understand its dominant inhabitants: the trees. In North America there are two types of forest trees, **hardwoods (deciduous)** and **softwoods (coniferous)**.

As their name implies, hardwood trees produce a dense, hard wood suitable for many uses. They are also known as **deciduous** trees, which means "to fall off or shed seasonally". Each fall most hardwood trees shed their leaves, though some (such as holly and magnolia) retain most of their leaves and remain green year-round.

Forest types map
Image: National Atlas of the United States, US Department of the Interior.

Softwood trees produce wood that is usually "softer" and less dense than that of hardwoods. They are also known as **coniferous** trees (or conifers), which means "cone-bearing". Not all conifers produce soft wood, however; several produce wood with a greater density and hardness than that from some hardwoods. Some examples of conifers are the pine, bald

DID YOU KNOW:

The bark of the Pacific Yew tree contains paclitaxel, a chemical compound that is an effective cancer-fighting drug? Currently, extracting the amount of paclitaxel required to treat an individual patient (about two grams) requires the bark from about three Pacific Yews. Since removing its bark kills the tree, researchers are developing procedures to isolate and synthesize paclitaxel from other yew species.

Alternate

cypress, cedar, and hemlock. Nearly all retain their leaves, scales, or needles throughout the year, and thus are also called "evergreens". As new leaves are produced, the tree gradually sheds the oldest ones and maintains its green appearance. Exceptions are the bald cypress and larch, which shed all their leaves each year.

Gymnosperms and Angiosperms

Two major classes of trees are **gymnosperms** and **angiosperms**. Both terms are based in Latin words: the prefix "gymno" is Latin for "naked" and "angio" for "vessel". The suffix "-sperm" means "seed". Therefore, "gymnosperm" means "naked seed" and "angiosperm" means "seed in vessel". Tree identification begins by identifying a tree as a gymnosperm or angiosperm.

Opposite

Whorled

Top two photos: Paul Wray, Iowa State. www.forestryimages.org
Bottom photo: Morgan Nolan, University of Georgia

Characteristics of Gymnosperms and Angiosperms

	Gymnosperms	Angiosperms
Examples	Pines, ginkgos, firs and cedars	Apple trees, oaks, elms, and pecans
Commonly called	Conifers, softwoods or evergreens	Broadleaf or hardwoods
Leaves	Persistent (3 to 5 years or more); needle, scale or awl-like	Generally deciduous; broad, expanded blades
Wood	No pores; resin ducts	Pores; no resin ducts
Fruit	Woody or fleshy cone	Dry or fleshy, encloses seed
Characteristic shape	Excurrent (dominant main stem with lateral side branching)	Dendritic (branching and rebranching of main stem)

2. Major tree species of each region

The process of identifying a tree begins by understanding the scientific terminology used to describe the characteristics of the various parts of a tree (e.g., leaves, bark, twigs, and fruit). Scientists use the characteristics to classify and assign a tree a scientific name.

Leaf Characteristics

Tree leaves vary in **arrangement**, **composition**, **margin**, **shape**, and **venation**. Understanding these terms is critical to tree identification. Note that conifers have needles and thus are not classified using these terms.

Leaf **arrangement** refers to the point the leaf is attached to the twig of a broadleaf tree. Common leaf arrangements include:

- ***Alternate*** — single leaf blades attached at different levels along the stem. Most trees' leaves are arranged in alternation. *Example*: oak.
- ***Opposite*** — two leaves are at exactly the same point on a stem, but on opposite sides. *Example*: maple.
- ***Whorled*** — a group of three or more leaves are at the same node on the stem. *Example*: ginko.

The number of leaves attached to the petiole determines the **composition** of the leaves on a broadleaf tree. Common compositions include:

- ***Simple*** — leaf with a single blade attached to the petiole. *Example*: elm.
- ***Compound*** — three or more blades (leaflets) are attached to a single stalk (rachis). *Example:* boxelder.
- ***Pinnately compound*** — leaflets are laterally attached along each side of the rachis. *Example*: hickory.
- ***Bipinnately compound*** — leaflets are pinnately compounded, and the leaf is compound (comprised of three or more leaflets). *Example*: black locust.
- ***Palmately compound*** — several leaflets are attached at the same point on a rachis. *Example*: buckeye.

Simple

Compound

Pinnately compound

Top photo: Patrick Breen, Oregon State.
Bottom two photos: Paul Wray, Iowa State.
www.forestryimages.com

Palmately compound

Photos left to right: Paul Wray, Iowa State; James H. Miller, USDA Forest Service.
www.forestryimages.org

Bipinnately compound

The leaf **margin** (edges of the leaf) identify different hardwood species. There are 14 different classifications of leaf margins. These include:

- ***Entire***—smooth.
  Example: willow oak.
- ***Toothed***—tiny to large coarse teeth.
  Example: red oak.
- ***Lobed***—blade is divided into lobes by shallow to deep notches.
  Example: white oak.
- ***Divided***—has rounded sinuses that extend to the midrib.
  Example: burr oak.
- ***Revolute***—rolled under.
  Example: rhododendron.
- ***Repand***—slightly wavy.
  Example: hazel alder.
- ***Sinuate***—more wavy than repand.
  Example: sycamore.
- ***Crenate***—has rounded to blunt teeth.
  Example: eastern cottonwood.
- ***Crenulate***—has finely rounded teeth.
  Example: honeylocust.
- ***Serrate***—has sharp teeth that are pointed upward.
  Example: red maple.
- ***Dentate***—has sharp teeth that are pointed outward.
  Example: swamp chestnut oak.
- ***Doubly Serrated***—has both course and fine teeth.
  Example: birch.

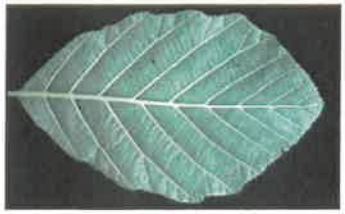
Entire

Toothed

Lobed

Divided

Revolute



Repand

Sinuate

Crenate

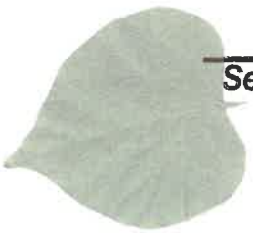
Crenulate

Serrate

Dentate

Doubly Serrated

Entire, repand, and dentate photos: Morgan Nolan, University of Georgia.
Revolute photo: Jerry A. Payne, USDA ARS.
Serrate photo: Paul Bolstad, University of Minnesota.
All other photos: Paul Wray, Iowa State. www.forestryimages.org



Elliptical

Obovate

Oblanceolate

Oblong

Acicular

Scale-like

Trees can often be identified by leaf shape alone. Common leaf shapes include:

- ***Elliptical***—broader in the middle, about twice as long as it is wide. *Example*: common persimmon.
- ***Ovate***—wide and broad at the base, shaped like an egg. *Example*: birch.
- ***Obovate***—wide and broad near the tip, with a narrow base; opposite of ovate. *Example*: swamp white oak.
- ***Lanceolate***—widest point about one-third the distance from the base. *Example*: black willow.
- ***Oblanceolate***—widest point at the tip; opposite of lanceolate. *Example*: wax myrtle.
- ***Linear***—long and narrow with parallel sides, longer than wide. *Example*: willow oak.
- ***Oblong***—two to three times longer than wide; sides are nearly parallel and ends are rounded. *Example*: live oak.
- ***Spatulate***—broad and round at the tip, tapering to a narrow base. *Example*: water oak.
- ***Acicular***—needle-like, slender, long, and pointed. *Example*: pine.
- ***Scale-like***—small and sharply pointed; leaves often overlap. *Example*: eastern red cedar.
- ***Oval***—broad ellipse, width is greater than one-half the length. *Example*: dogwood.
- ***Orbicular***–circular. *Example*: red maple.

Ovate

Lanceolate

Linear

Spatulate

Oval

Orbicular

Oblanceolate, linear and spatulate photos: Morgan Nolan, University of Georgia.
Elliptical photo: Richard Carter, Valdosta State.
Acicular photo: Erich G. Vallery, USDA Forest Service.
Scale-like photo: Connecticut Agricultural Experiment Station Archives.
Orbicular photo: Paul Bolstad, University of Minnesota.
All other photos: Paul Wray, Iowa State.
www.forestryimages.org

Cordate

- ***Cordate***—heart-shaped.
  Example: redbud.

- ***Deltoid***—triangular.
  Example: eastern cottonwood.

Deltoid

Bark

A tree's bark is a useful identifier. The bark of a tree grows from the inside out. Because the outer portion does not grow it cracks into plates, ridges, or scales, forming characteristic patterns. Bark varies in thickness, roughness, and color. It is useful for winter tree identification, particularly for deciduous trees that shed their leaves. Some bark types can be identified by color alone; some can also be identified by odor, though this method is not reliable. Examples of bark types are listed below.

- **Smooth** - American beech
- **Furrowed** - black oak
- **Scaly** - white pine
- **Blocky** - dogwood
- **Plated** - loblolly pine
- **Warty** - hackberry
- **Fibrous** - shagbark hickory
- **Papery** - birch

Smooth

Furrowed

Scaly

Blocky

Papery

Plated

Warty

Fibrous

Branches and Twigs

Twigs can be used for year-round tree identification except in the spring, when some buds are opening and newer buds have not yet formed. The twig's parts are the buds, leaf and bundle scars, and pith.

Fibrous photo: Morgan Nolan, University of Georgia.
Cordate photo: Chris Evans, University of Georgia.
Smooth and papery photos: Bill Cook, Michigan State.
Scaly photo: Dave Powell, USDA Forest Service.
Blocky photo: Robert L. Anderson, USDA Forest Service.
Deltoid and warty photos: Paul Wray,.Iiowa State.
Plated photo: Paul Bolstad, University of Minnesota.
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Sumar

Pome

Berry

Achene

Fruit and Flowers

Fruits and flower characteristics appear only part of the year, and thus have limited identification value. **Simple fruits** have a single, enlarged ovary; they may be dry or fleshy. Examples include:

- ***Samara***—a wing-shaped fruit.
  Example: maple or ash.
- ***Nut*** –a fruit with a hard outer husk.
  Example: oak, pecan, or walnut.
- ***Pome*** —a fruit whose outer part is fleshy and which contains many seeds.
  Example: apple.
- ***Drupe (stone fruit)*** —a fruit whose outer part is fleshy and which contains one seed.
  Example: dogwood.
- ***Berry*** —a fruit with fleshy inner and outer walls, containing one or more seeds.
  Example: cherry.
- ***Legume*** —consists of a pod or chamber containing many seeds.
  Example: black locust.
- ***Achene*** —consists of a single, hairy seed.
  Example: sycamore.
- ***Capsule*** —consists of two or more chambers that split open when ripe.
  Example: buckeye.

Pome photo: Jerry A. Payne: USDA ARS.
Berry photo: Gil Wojciech, Polish Forest Research Institute.
All other photos: Paul Wray, Iowa State.
www.forestryimages.org

Nut

Drupe

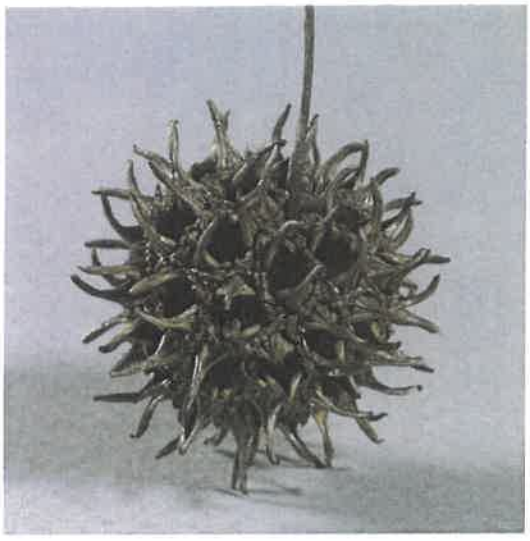
Legume

Capsule

Compound fruits are groups of simple fruits.

- An **aggregate** compound fruit is a cluster of simple fruits from the same flower. *Example*: yellow poplar (a cluster of samaras).
- A **multiple** compound fruit is a cluster of simple fruits from separate flowers. *Example*: sweetgum (a cluster of capsules).

Aggregate compound fruit
Photo: Paul Wray, Iowa State. www.forestryimages.org



Multiple compound fruit
Photo: James Strawser.

Tree Species

The following descriptions of tree species are based on the FFA National Event's current list.

Deciduous Trees

Alder

Alder (*Alnus*) is a genus of the birch family (*Betulaceae*). There are about 30 species of alder found throughout the world; eight are native to North America.

Leaf:	Alternate, simple; ovate, ovale, or obovate in shape; irregularly serrate or dentate margin.
Fruit/Seed:	small, leathery, almost woody, cone-like structure with scales; small winged seed.
Economic Importance:	Red alder is the only species that has commercial value for lumber; other species provide firewood. Alder has limited value to wildlife.
Unique Characteristic:	Alders extract nitrogen from the air and add it to the soil through a process called *nitrogen fixation.*

Alder foliage
Photos: Paul Wray, Iowa State. www.forestryimages.org

Alder fruit seed

Ash
Photos: Bill Cook, Michigan State; Dave Powell, USDA Forest Service.
www.forestryimages.org

Ash

Ash (*Fraxinus*) is a genus of the olive family (*Oleaceae*). Of 70 species of ash found throughout the world, 16 are native to North America.

Leaf: Opposite, odd-pinnately compound; lance shaped; leaflet margins are varied - entire to serrate.

Fruit/Seed: Samara with a single seed; seed has a dry, flat, terminal wing.

Ash leaf

Economic Importance: Wood from several species of ash are valuable and used to make furniture, tool handles, baseball bats and other wood products. Wildlife consume seeds and twigs. Green ash is planted as a shade and street tree.

Unique Characteristic: Green ash is the most widely distributed species of ash, but white ash is most common.

Aspen
Photo: Dave Powell, USDA Forestry Service.
www..forestryimages.org

Aspen

Aspens are a member of the genus Populus, which is part of the willow family (*Salicaceae*). This genus has three major groups: aspens, cottonwoods, and balsam poplars.

Leaf: Alternate; simple; round- to heart-shaped; toothed margin.

Fruit/Seed: Capsule; very small seed.

Economic Importance: Lightweight wood is used to make excelsior, crates, and boxes; also mixed with other species to make paper.

Unique Characteristic: Quaking aspen is important to hundreds of animal and plant species as a food source and habitat.

Aspen leaf

Aspen bark

All other photos: Paul Wray, Iowa State.
www.forestryimages.org

Beech

The American beech tree is a member of the genus *Fagus*, which is part of the beech family (*Fagaceae*). It is the only native beech in eastern North America.

Leaf: Alternate; simple; ovale to oblong, sharp pointed; coarsely-toothed margin.

Fruit/Seed: Husk is covered with curved spines and contains two nuts.

Economic Importance: Wood is strong and hard, but not durable. It is used to make tool handles, flooring, and some furniture. Oily seeds are valuable wildlife food.

Unique Characteristic: Winter buds are lance-shaped, narrow, tapered to a sharp point, and covered with dark brown scales. Because of its elasticity, beech wood is used to manufacture wood clothespins.

Beech

Beech bark

Birch photo: Morgan Nolan, University of Georgia. All other photos: Bill Cook, Michigan State. www.forestryimages.org

Birch

The birch is part of the genus *Betula*, and is a member of the birch family (*Betulaceae*). Eight of the 15 species are native to North America.

Birch bark

Leaf: Alternate; simple; oval to oblong, triangular to heart-shaped; toothed margin (some double-toothed).

Fruit/Seed: Upright cone with numerous scales; small winged seed.

Economic Importance: Yellow, sweet, and paper birch are used to produce plywood and interior wood finishes, log homes, and ships. Wildlife eat the seeds, branches, buds, and flowers.

Unique Characteristic: The paper birch is used to make birchbark canoes.

Birch

Black Walnut

Black walnut

The black walnut is part of the genus *Juglans*, a member of *Juglandaceae*, the walnut family. This family includes walnuts and hickories.

Leaf: Alternate; compound; 15-23 leaflets; long-pointed lance-shape; margin is finely-toothed above rounded uneven base.

Black walnut fruit and seed

Fruit/Seed: Thick green outer husk surrounding a hard nut.

Economic Importance: Walnut is heavy, strong, and very durable with a rich dark brown color. It is highly valued for use in making furniture, interior finishes, gun stocks, and caskets.

Unique Characteristic: The pith of the black walnut is chambered. The tree contains a substance called **juglone** that is thought to prevent germination of other trees and plants, therefore reducing competition for soil nutrients.

Cottonwood

Cottonwood

The cottonwood is part of the genus *Populus* (as is the aspen). The cottonwood is also a member of the willow family (*Salicaceae*). There are 13 species of cottonwood in North America.

Leaf: Alternate; simple; heart-shaped to triangular in shape; rounded teeth along margin.

Fruit/Seed: Capsule; releases downy seeds (hence the name).

Economic Importance: Several wood products are produced using cottonwood such as furniture frames, pallets, and pulp. Cottonwood trees are a food source for wildlife: branches provide browse for deer and moose, and game birds feed on buds and young flower clusters.

Unique Characteristic: Pioneers expanded the cottonwood's range by bringing the tree to the Great Plains as they moved west.

Cottonwood fruit and seed

Black walnut photos: Paul Wray, Iowa State.
Cottonwood photos: Dave Powell, USDA Forest Service.
www.forestryimages.org

Elm

The elm is part of the genus *Ulmus*, and belongs to the elm family (*Ulmaceae*). Six species of elm are native to Eastern North America.

Leaf: Alternate; simple; elliptical in shape; and with a single or double row of teeth along the margin.

Fruit/Seed: Circular, flat, papery, and hairy edges.

Economic Importance: Elm wood is used to make furniture, paneling, and ships.

Unique Characteristic: American elms are attacked by Dutch Elm Disease. Elm pollen is a major contributor to symptoms experienced by hay fever suffers.

Elm

Elm leaf

Hickory

The hickory is part of the genus *Carya*, and is a member of the *Juglandaceae*, or walnut, family.

Leaf: Alternate; pinnately compound; ovate-shaped; and with a toothed margin.

Fruit/Seed: Nut; outer husk splits into four sections when ripe, exposing the smooth-surfaced nut.

Economic Importance: Hickory nuts are an important food source for wildlife. Hickory wood is exceptionally hard and used for tool handles and implements.

Unique Characteristic: Hickory trees are heavy pollinators, and contribute to hay fever conditions in springtime.

Hickory fruit and seed

Hickory

All photos: Paul Wray, Iowa State. www.forestryimages.org

Maple
Photo: Dave Powell, USDA Forest Service.
www.forestryimages.org

Maple

The maple is part of the genus *Acer*, and is a member of the *Aceraceae* family. There are 13 different maple trees found in North America, and they are a component of the deciduous forests. About half of the species are economically important.

Maple leaf
Photo: David J. Moorhead, University of Georgia.
www.forestryimages.org

Leaf: Opposite; simple (palmately lobed) or compound (pinnate); and often have a toothed margin.

Fruit/Seed: Samara; always paired, seeds are joined at the base and each has a papery wing.

Economic Importance: Hard, strong wood is used for flooring, cabinets, and furniture.

Unique Characteristic: Syrup is made from the sap of the sugar maple.

Pecan fruit and seed
Pecan photos: Jerry A. Payne,
USDA ARS.
www.forestryimages.org

Pecan

The pecan is part of the genus *Carya*, and is a member of the walnut family (*Juglandaceae*). This is the same genus and family as the hickory, and the same family as the black walnut.

Leaf: Alternate; compound; lanceolate shape; and margin is coarsely toothed.

Fruit/Seed: Nut; shell covering the sweet kernel is thin.

Economic Importance: Pecan wood is highly valued; trees are grown primarily to produce nuts.

Unique Characteristic: A mature pecan tree can produce more than 500 pounds of nuts each year.

Pecan grove

Red Oak

The red oak is a member of the *Quercus* genus, and is part of the beech family (*Fagaceae*). Oaks are divided into two groups: red oak and white oak. Within the red oak group two species (Northern and Southern) bear the name "red oak".

Leaf: Alternate; simple; toothed or lobed with a bristle tip.

Fruit/Seed: Acorn; inner surface of the acorn shell is hairy; produced on previous year's growth.

Economic Importance: The red oaks possess a hard, course-grained wood used to make furniture, crates, flooring, and veneer. It is also important as wildlife food.

Unique Characteristic: Excellent tree for urban plantings.

Red oak

Red oak flower

Red oak fruit

Red oak photos: Paul Wray, Iowa State. www.forestryimages.org

Sweetgum

The sweetgum (*Liquidambar styraciflua)* is a member of the *Witch Hazel* family (*Hamamelidaceae*).

Leaf: Distinctly star-shaped, deeply lobed; finely toothed margin.

Fruit/Seed: Hard, round, spiny fruit; flat and angular with a small wing at the tip,

Economic Importance: Sweetgum is plentiful in the Southeastern US, and used to make furniture, pulp, plywood, and flake board.

Unique Characteristic: Gum extracted from bark is used to make adhesives and soaps.

Sweetgum

Sweetgum photos: James Strawser.

Sweetgum tree

Sycamore bark

Sycamore

Photo: Chris Evans, University of Georgia.
www. forestryimages.org

Sycamore

The sycamore tree is a member of the *Sycamore* family (*Platanaceae*). Ten species belong to the genus, but only three are found in the US.

Leaf:	Alternate; simple; lobed and irregularly toothed margin.
Fruit/Seed:	Solitary, round, and composed of many small, long, narrow seeds.
Economic Importance:	A fast-growing tree, one of the largest in the Eastern deciduous forest; used to make butcher blocks, furniture, and musical instruments. The California sycamore's growth characteristics are similar to those of the American sycamore; neither has much wildlife value.
Unique Characteristic:	The sycamore bears a distinctive round fruit.

Sycamore leaf

All other photos: Paul Wray, Iowa State.
www.forestryimages.org

White Oak

The white oak (*Quercus alba*) is a member of the *Beech* family (*Fagaceae*).

Leaf: Alternate; simple; leaves may be toothed or lobed with an entire margin, but not bristle-tipped like the members of the red/black oak group.

Fruit/Seed: Acorn; solitary or paired; edible; produced on current year's growth.

Economic Importance: One of the most important hardwood species, grown across Eastern North America. Wood is hard, tough, strong, and close grained. White oak is used for support timbers, furniture, flooring, and interior finishes. It is also an important wildlife food.

Unique Characteristic: Used to make wood barrels (staves) for production of whiskey.

White oak
Photo: Bill Cook, Michigan State.
www. forestryimages.org

White oak leaf

Yellow Poplar

The yellow poplar (*Lirodendron tulipifera*) is one of only two trees in the *Tulip Tree* genus, and is a member of the *Magnolia* family (*Magnoliaceae*).

Leaf: Alternate; simple; four lobes with a rounded base; smooth margin.

Fruit/Seed: Cone; contains numerous four-sided winged seeds.

Economic Importance: Fast-growing, used for furniture and plywood. Because it takes paint and stain well, it is often used for moldings.

Unique Characteristic: The leaf shape is easily recognized.

Yellow poplar
Photo: James Strawser.

Yellow poplar leaf, fruit, and seed
All other photos: Paul Wray, Iowa State.
www.forestryimages.org

Conifers

According to fossil records, ***conifers*** are older than deciduous hardwoods. The common characteristic of conifer trees is their production of a "naked seed" in a cone. Nearly all conifers are evergreen; all are resinous.

Bald cypress leaf

Bald cypress stand

Bald cypress fruit and seed

Bald Cypress

One of the world's two species of bald cypress is found in the US, and is called the bald cypress (*Taxodium distichum*). This tree is a member of the *Taxodium* family (*Taxodiaceae*).

Leaf: Alternate. Unlike most conifers that retain needles, the bald cypress is deciduous; small, linear, thin, flat, and pointed at the tip, appearing feather-like in shape.

Fruit/Seed: Cone; nearly round, wrinkled, hanging, usually in pairs. Leathery scales contain two three-sided seeds.

Economic Importance: Resistant to decay, this tree is used to make fence posts, exterior siding, poles, coffins, mulch, and shingles.

Unique Characteristic: The characteristic shape of the bald cypress' s trunk is named "buttressed".

Bald cypress stand photo: Gerald J. Lenhard, Louisiana State.
All other photos: Paul Wray, Iowa State.
www. forestryimages.org

Bald cypress bark

Cedar

Several species are commonly referred to as "cedar", such as *Incense* (*Calocedrus*), *Atlantic White* (*Chamaecyparis*), *Eastern White* (*Thuja*), and *Eastern Red* (*Juniperus*). All are from different genera of the *Cypress* family (*Cupressaceae*); descriptions apply to the family as a whole.

Cedar leaf

Cedar

Leaf: Scale-like; opposite or in threes; pressed against the branchlets.

Fruit/Seed: Cone; scales fused by their bracts; leathery to fleshy and hard when mature.

Economic Importance: Cedar wood is easy to work; many species are economically important. Others provide food and cover for wildlife.

Unique Characteristic: Cedars are also grown for their uniquely scented wood, most famously used in the construction of King Solomon's temple in Jerusalem.

Douglas Fir

A member of the *Pinaceae* family, the Douglas Fir (*Pseudotsuga menziesii*) is not a true species of fir, but has characteristics similar to those of hemlock.

Douglas fir

Leaf: Needle; rounded or blunt at the tip; crowded on the twig.

Fruit/Seed: Cone; cone scales nearly circular with a three-pronged bract protruding well past the scale.

Economic Importance: The most abundant and valuable tree in the Western US. Soft, light wood is used as structural beams for bridges and docks, railroad ties, interior finishes, and plywood. Excellent for windbreaks; provides cover and food for wildlife.

Unique Characteristic: The long, three-pronged bract on the cone is shaped in a way that is unique to this tree.

Douglas fir fruit and seed

Cedar leaf and Douglas fir fruit and seed photos: Paul Wray, Iowa State.
Cedar photo: Bill Cook, Michigan State.
Douglas fir photo: Dave Powell, USDA Forest Service.
www.forestryimages.org

Hemlock

Hemlock

Hemlock fruit and seed

Four species of hemlock are found in the US, and belong to the genus *Tsuga*. This genera are members of the *Pine* family (*Pinaceae*).

Leaf: Needles; small, flexible, flat, linear; arranged in one plane along the branchlet.

Fruit/Seed: Cone; small, leathery scales; winged seed.

Economic Importance: Western hemlock is the superior of these species. The hard, tough lightwood is used for construction and pulp. Seed is important food source for wildlife.

Unique Characteristic: The bark of the Eastern hemlock was once used for tanning leather.

Loblolly pine leaf

Loblolly Pine

Loblolly pine fruit and seed

The loblolly pine (*Pinus taeda*) is a member of the *Pine* family (*Pinaceae*)

Leaf: Needle; three needles per bundle, six to nine inches long, and slightly twisted.

Fruit/Seed: Cone; cone grows flat against the twig and is often curved.

Economic Importance: This fast-growing pine tree is found in the Southeastern US and represents a majority of commercial pine forest land. It is used to make lumber and pulp, and provides wildlife with food and cover.

Unique Characteristic: This tree is killed or damaged by the Southern pine beetle and fusiform rust disease.

Hemlock photo: Chris Schnepf, University of Idaho.
Hemlock fruit and seed photo: Bill Cook, Michigan State.
Loblolly pine leaf photo: William M. Ciesla, Forest Health Management International.
Loblolly pine fruit and seed photo: Erich G. Vallery, USDA Forest Service.
Loblolly pine photo: Paul Bolstad, University of Minnesota.
www.forestryimages.org

Loblolly pine

Lodgepole Pine

Lodgepole pine

The lodgepole pine (*Pinus contorta*) is a member of the *Pine* family (*Pinaceae*).

Leaf: Needle; two needles per bundle; one to three inches long; stiff and twisted.

Fruit/Seed: Cone; each thin scale has a curved, short spine.

Economic Importance: Valuable for timber products and pulp, it also provides wildlife with food and shelter.

Unique Characteristic: Serotinus cones require high temperatures to open, such as a fire or the sun's heat.

Lodgepole Pine Fruit/Seed/Leaf
Photo: Ed Jensen, Oregon State University

Longleaf pine

Longleaf pine leaf

Longleaf Pine

The longleaf pine (*Pinus palustris*) is a member of the *Pine* family (*Pinaceae*).

Leaf: Needle; three per bundle; flexible and 10 to 18 inches long.

Fruit/Seed: Cone; six to ten inches when mature; slightly curved.

Economic Importance: More longleaf pine is being planted each year along the Southeastern coastal plain. The tree supports wildlife and is used for lumber and poles.

Unique Characteristic: Longleaf pine is resistant to many diseases that affect other species.

Lodgepole pine photo: USDA Forest Service - Rocky Mt. Region Archives.
Longleaf pine photo: David J. Moorhead, University of Georgia.
Longleaf pine leaf photo: University of Georgia Archives.
www.forestryimages.org

Ponderosa Pine

Ponderosa pine
Photo: Doug Maguire, Oregon State. www.forestryimages.org

The ponderosa pine (*Pinus ponderosa*) is a member of the *Pine* family (*Pinaceae*).

Leaf: Needle; bundles of twos, threes, or both mixed; four to eleven inches long and stout.

Fruit/Seed: Cone; thin, narrow, flexible scales armed with small spine,

Ponderosa pine fruit and seed
Photos: Dave Powell, USDA Forest Service. www.forestryimages.org

Economic Importance: The ponderosa pine is used to make multiple wood products, from construction lumber to toys; it is also an excellent food source for wildlife.

Unique Characteristic: Ponderosa pine is the dominant pine species in Western North America.

Red pine
Photo: Scott Roberts, Mississippi State,www.forestryimages.org

Red Pine

The red pine (*Pinus resinosa*) is a member of the *Pine* family (*Pinaceae*).

Leaf: Needle; two needles per bundle; straight, slender, and brittle; four to six inches long.

Fruit/Seed: Cone; thin, concave scales with no spine.

Economic Importance: Found in the Northeast, this tree provides wood for pulp, pilings, bridges, and other construction projects.

Unique Characteristic: Red pine bear a serotinus cone.

Red pine fruit and seed
Photos L to R: Paul Wray, Iowa State; Bill Cook, Michigan State. www.forestryimages.org

Shortleaf Pine

The shortleaf pine (*Pinus echinata*) is a member of the *Pine* family (*Pinaceae*).

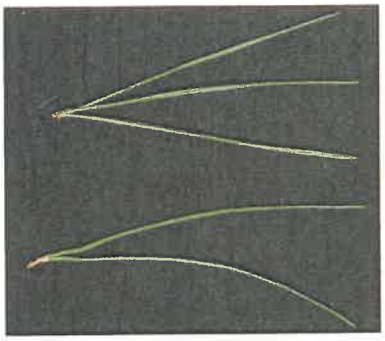
Leaf: Needle; two or three needles per bundle; soft and flexible; three to five inches long with a sharp point

Fruit/Seed: Cone; thin, flat scales with a small sharp spine.

Economic Importance: This tree provides food for wildlife and wood products such as lumber, pulp, and turpentine.

Unique Characteristic: Trees less than eight to ten years old are able to sprout even if the main stem is damaged by fire or cutting.

Shortleaf pine
Photo: Robert F. Wittwer, Oklahoma State. www.forestryimages.org



Shortleaf leaf
Photo: Morgan Nolan, University of Georgia.

Spruce

There are seven species of spruce in North America, found mostly in cooler regions. Spruce wood is primarily used in production of paper or pulp.

Leaf: Needle-like; spirally arranged; mostly angled with four sides; few are flat, most have pointed or rounded tips.

Fruit/Seed: Cone; dry and papery or woody when ripe; two winged seeds per scale.

Economic Importance: Valuable species for wildlife; harvested for pulp; used for windbreaks and ornamentals.

Unique Characteristic: Many species of wildlife consume parts of the spruce. Deer eat leaves and twigs, and small mammals and birds eat the seeds. The spruce grouse depends almost entirely on the spruce for food and shelter.

Spruce

Spruce leaf
Spruce photos: Bill Cook, Michigan State. www.forestryimages.org

White pine
Photo: Dave Powell, USDA Forest Service.
www.forestryimages.org

White Pine

There are two species of white pine trees, the *Western white pine* (*Pinus monticola*) and the *white pine* (*Pinus strobus*). Both belong to the *Pine* family (*Pinaceae*).

Leaf: Needle; five per bundle; soft and flexible.

Fruit/Seed: Cone; narrow, oblong in shape and often slightly curved.

Economic Importance: Both species are economically valuable for timber, and a source of food and cover for wildlife.

Unique Characteristic: In the Northeast, white pine was highly prized by the settlers as ship masts for its light weight and straight form.

White pine leaf
Photo: Chris Schnepf, University of Idaho.
www.forestryimages.org

The forest types of the United States are as diverse as the landscapes on which they grow: from the flat, sandy sites of the Southern Pine Forests of Georgia to the mountainous Northwestern Coniferous Forest in Oregon. Our forests are a renewable, natural resource important to our nation's economy, environment, and culture. Forests provide jobs, protect water quality, provide habitat for wildlife and offer a place to observe and enjoy nature.

Similarly, the types of trees growing in forests are as diverse as the forests themselves. It is important to know the names and characteristics of the trees found in each forest type in order to understand the forest for what it is. Tree identification is a learnable skill that can be useful wherever you go; it requires observation and classification skills, as well as the ability to apply them correctly.

Section F:

Tools and Equipment

DID YOU KNOW:

Technological advances in forestry continue to improve the accuracy, safety, efficiency, and utility of new tools and equipment? For example, a GPS unit sold at your neighborhood store can now pinpoint your global location within six to twelve feet!

Objective: *The student will learn to identify common forestry tools and equipment, and be able to explain their uses.*

Foresters use many different tools in their profession. Some are as simple as a tally book used to record cruise data. Some, such as GPS navigational tools, are so complex they utilize satellites 12,000 miles above the earth. A forestry tool can be as small as a wedge prism or as large as a logging truck. Commonly-used forestry tools are described in this section.

While in the woods a forester may be away from his or her vehicle for hours, so often must carry many pieces of equipment. A **cruising vest** is designed for utility and durability. It is made of heavyweight material and has several pockets of various sizes that can hold multiple items such as a notebook, GPS unit, handheld radio, water bottle, or small hand tools.

Cruising vest

1. Forestry measurement and scaling equipment

A **bark gauge** is used to determine the thickness of bark on a tree. The gauge resembles a narrow curved blade chisel with a guard that slides along the blade. To use the tool, a forester pushes or drives the cutting edge through the bark until it reaches the wood, then pushes the guard against the tree or log. The thickness of the bark can then be read from the scale.

A **clinometer** is a pocket-sized instrument used to measure tree height. When the clinometer is held to the eye, a value is recorded on the scale for both the top and base of the tree. These two measurements are used to determine total height. This versatile tool can also be used to determine land slope and measure angles.

Clinometer

Bark gauges

Diameter tape, or d-tape

Diameter tape, or **d-tape,** is used to measure the diameter of a tree. Measurements are made in inches and tenths of inches. Tree diameter is part of the equation to determine volume in board feet of wood in a tree.

An **increment borer** is designed to remove a core of wood from a tree or treated pole. The tool is made up of three parts: the handle, bit, and extractor. The wood core is used to assess the tree's growth rate, age, and wood quality. The core is also used on treated poles to determine the depth of penetration of the chemicals used to protect the wood.

Increment borer

A **log scale stick**, or **Biltmore stick**, is a lightweight, sturdy piece of wood with graduated marks used to measure tree diameter, height, and total volume. Holding the stick 25 inches from the eye, the forester determines a tree's diameter to the nearest inch and height to the nearest 16 foot log. From these measurements, the tree's board foot volume is calculated using the volume tables printed on the stick. There are three log scaling rules used in the US: Doyle, Scribner, and International 1/4 inch.

Log scale stick, or Biltmore stick

Tree caliper

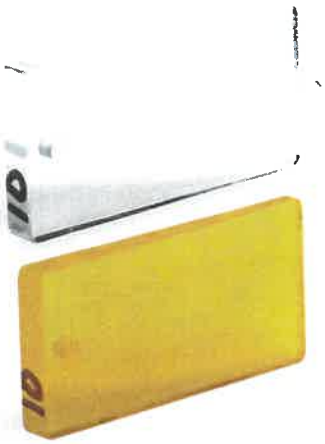
A **relaskop** contains precision optics housed in cast aluminum. It is used to measure a tree's basal area, diameter and height, vertical angles, slope, and distance. The instrument can be held by hand, or mounted on a Jacob staff or tripod.

A **tree caliper** is used to measure tree diameter. The jaws, made from wood or aluminum, slide apart until they fit around the tree. The diameter is read from the graduated marks in inches and tenths of inches. For multiple measurements, more precise calipers are equipped with a small computers that record the data.

Tree-marking gun

A **tree-marking gun** looks like an oil can, but can accurately squirt a stream of specially-formulated tree paint up to ten feet. Trees are marked for several reasons: to indicate if the tree is to be cut or left standing; to delineate property boundaries; or to signify den trees for wildlife. Different colors of paint represent different purposes.

Relaskop

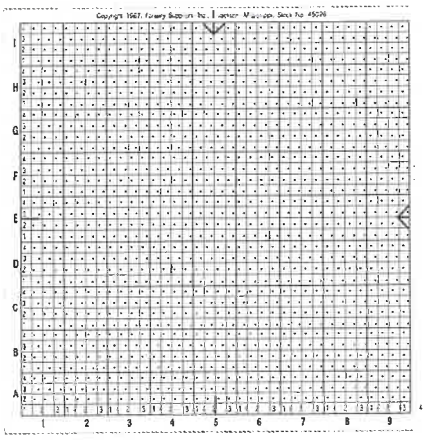


Wedge prism

A **wedge prism** is a wedge-shaped piece of glass ground to specific optical characteristics. The prism is used to determine a tree's basal area (BA).

Data recorder

A **data recorder** is a hand-held programmable computer that looks like a pocket calculator, and is used to record, retrieve, and process field data. Most are used with their own companion software, but are compatible with other software packages for processing on a personal computer.



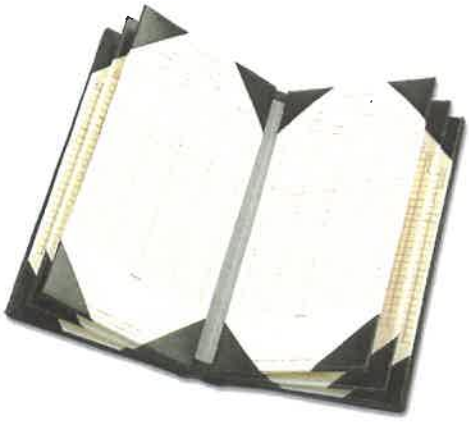
Dot grid

A **dot grid** is a small, flexible piece of plastic printed with dots spaced at equal distances. The dot grid is used to estimate area; by placing the grid on a map or aerial photo, the user counts the number of dots that lie within the area of interest. Each dot represents a designated area (e.g., acres or square feet).

Flagging
Photo: James Strawser

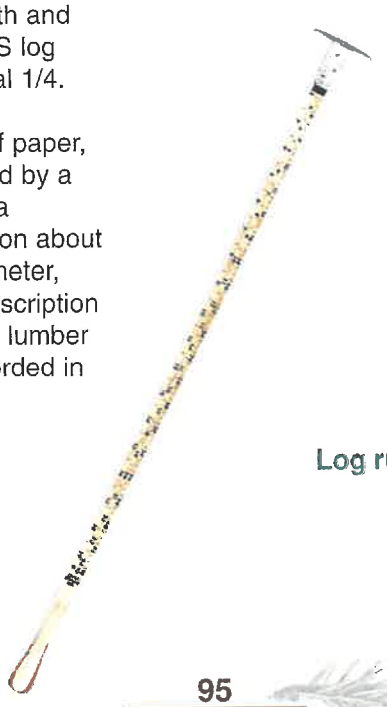
Flagging is made of vinyl, wood fiber, or photodegradable materials. It is used to mark objects temporarily (e.g., hazard trees, property boundaries, restricted areas, or trees not to be cut). Flagging is available in many different highly-visible colors.

A **log rule** is a table that shows the estimated or calculated amount of lumber, in board feet, that can be sawn from a log of given length and top diameter inside the bark. Common US log rules are Doyle, Scribner, and International 1/4.



Tally book

A **tally book** is a 4" x 8" sheet of paper, marked in columns and protected by a weather-resistant cover. When a forester cruises timber, information about tree species, product class, diameter, height, number of plots, legal description of the land, and notes or tallying lumber (e.g., species and grade) is recorded in the tally book.



Log rule

Tally meter

A **tally meter** is a small hand-held counting tool, slightly larger than a golf ball. Depressing a button advances the meter's counter in increments of one. Typically, tally meters count from 0 to 9,999. A knob resets the meter to zero.

An **altimeter** is an instrument used to measure elevation. The instrument detects and displays the change in atmospheric pressure on a dial gauge.

Altimeter

Fiberglass measuring tape is flexible and will not stretch or shrink. Lightweight and waterproof, the tape is graduated in English (feet and inches) or metric units. The tape is stored on a reel.

Fiberglass measuring tape

A **Global Positioning System (GPS) receiver** is a hand-held navigational tool that uses computer technology to receive and process signals from 24 US government satellites orbiting 12,000 miles above the earth. An inexpensive palm-sized unit can show departure location, current location, and a route to a final destination with accuracy to within 300 feet. More expensive units are even more accurate (within three feet) and perform such additional tasks as bearing calculations, trip planning, and point-to-point navigation.

Global Positioning System (GPS) receiver

A **hand compass** is a liquid-filled capsule with a steel needle mounted on top of a jeweled bearing. The capsule has a ring around it that is graduated from 0 - 360° (Azimuth) in 2° units. A compass is an essential forestry tool; by orienting compass bearings with a map or aerial photograph, a forester can survey property boundaries.

Hand compass

A **staff compass** is much larger than a hand compass, usually 4-5" in diameter. This compass has ideal features for such forest survey work as surveying property boundaries or establishing a forest road, including sights and leveling vials for more accurate measurements. The needle can be locked in place for transport, and a ball-and-socket joint on the bottom is used for mounting on a Jacob staff. Similar to a hand compass, the staff compass is graduated from 0-360° (Azimuth).

Staff compass

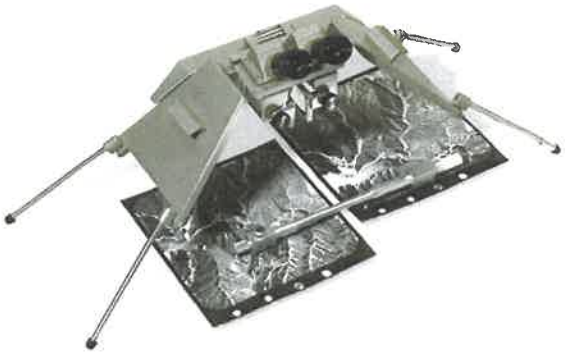
Hip chain

A **hip chain** is a simple tool used to measure distance traveled when walking over rough terrain or in thick forest cover. The chain contains a spool of thin string and a counter, held in a plastic case attached to the forester's belt. The string is pulled through the counter as the forester walks.

A **planimeter** is a mechanical instrument used to measure the area of a map or aerial photo. It consists of a pole and tracer arm, and is calibrated to a selected unit of measure.

Planimeter

A **stereoscope** is a binocular optical instrument used to view two aerial photos simultaneously. A combination of magnifying lenses and mirrors allows three-dimensional viewing, useful in estimating tree heights, identifying timber types, and planning locations for forest roads.



Stereoscope

Level
Photo: Used by permission

The **transit**, **theodolite**, **level**, **transit level**, and **dumpy level** are surveying instruments that allow the forester to sight in and read a leveling or measuring rod from a distance. Each instrument is designed for a specific use, and are used together to measure and lay out the necessary distances and angles for construction of forest roads, log decks, temporary bridges, and buildings. Survey instruments are mounted on tripods, leveled, and plumbed before use.

Transit
Photo: Used by permission

A **Wheeler caliper** is used to measure the diameter of a tree at any height. The forester views the tree through a slot and slides a movable prism until the reflection of the right and left edges of the tree are aligned. The diameter of the tree is then read from a scale.

Wheeler caliper
Photo: Morgan Nolan, University of Georgia

2. Forest harvesting equipment

Cant hook

A **cant hook** is a forged tool steel hook attached to a stout wood handle. It is used to roll and position logs.

Chainsaw

A **chainsaw** is a gas-powered tool used for felling trees along the fire line, but it is also used to fell trees and delimb and buck logs. A forester should receive training and wear proper safety equipment at all times when operating this dangerous tool.

Chainsaw chaps

Chainsaw chaps are important items of personal protective equipment when using a chainsaw. Chaps protect the forester's legs from the waist down. They are designed to stop the chain (which moves at about 3,000 feet per minute) by pushing it against the bar of the saw.

Heavy-duty equipment is required to perform many of the operations associated with the timber industry. Constructing roads, plowing fire breaks, planting trees, and harvesting timber demand tough powerful machinery. Heavy machinery is very expensive; a new feller-buncher can cost as much as $250,000. Harvesting equipment is specialized machinery designed to perform specific tasks. The following are some of the more commonly-used machines in the woods.

A **chipper** reduces logs into small pieces and blows them into a semi trailer at a harvesting site. The trailer is then hauled to a mill where the chips are used to manufacture such wood products as paper and bathroom tissues.

Chipper
Photo: David J. Moorhead, University of Georgia. www.forestryimages.org

A **delimber** is used to remove limbs from harvested trees on site. This piece of equipment is faster and safer than a chainsaw. A **stroke-boom delimber** works by securing the cut tree and running a circular knife along the stem. A **chain-flail delimber/debarker** uses short chains attached to rotating drums; as the tree passes through, the chains' impact removes both limbs and bark.

Delimber
Photo: Deere and Company/New Horizons Productions.

Feller-buncher

A **feller-buncher** cuts one tree at a time using a hydraulic shear, circular saw, or chainsaw head. Several trees are cut and accumulated; a **skidder** then picks up the pile of trees and hauls them to a landing. In areas that allow safe operation of heavy equipment, the feller-buncher has replaced manual (hand) felling, dramatically decreasing the hazards of harvesting timber.

Feller-director

A **feller-director** is similar to a feller-buncher, but does not hold on to the tree. The feller-director cuts the tree and controls the direction it falls using a hydraulic mechanism.

Forwarder

A **feller-forwarder** accumulates trees like a feller-buncher does. Instead of dropping the load to the ground for the skidder to pick up, however, it pivots and deposits the load on a bunk trailer.

A **forwarder** is designed to carry short wood, but not tree length logs, from the harvesting site to the loading deck.

Knuckle-boom loader

A **knuckle-boom loader** has a hydraulic grappling head at the end of a jointed boom. It can pick up and load several logs at a time.

A **log truck** is a diesel vehicle rigged with a trailer specially designed to carry logs. The trailer has "bunks" on the sides to prevent the logs from rolling off, and are designed to allow easy loading and unloading. Log trucks haul harvested timber from the woods to the mill, and is usually the only visual connection most people have with timber harvesting.

Multi-function harvester

Log truck

A **multi-function harvester** fells a tree, delimbs it, cuts the top off, and cuts the log to desired lengths, all within seconds.

A **skidder** carries logs from the felling machine pile to the loading deck, either with a **grapple** (clamping device) or a cable with **chokers** (for attaching one or more logs) mounted to the back of the skidder.

Grapple

Photo: Used by permission
Multi-function harvester and Grapple photos: Caterpillar Inc.
All other photos on this page: Deere and Company/New Horizons Productions.

3. Planting equipment

Tree planting bar

A **tree planting bar** is made of steel, and has a T-shaped handle and a flat blade. It is used to plant tree seedlings by hand. A tapered blade is best in rocky soil, and a wedge-shaped blade in soft soil.

A **dibble bar** is a hand implement with a hollow tip, used to prepare soil to plant seedlings. A similar apparatus is a hoedad, which is a hoe used for planting seedlings.

A **planting shovel** is a spade with a long flat blade, step-plates, and foot pads.

A **mechanical tree planter** can be towed behind a tractor or skidder: it plows a narrow trench in which the operator plants seedlings, followed by packing wheels that firm the soil.

A **hypo-hatchet** connects to a plastic container of herbicide. The container attaches to the forester's belt and a hose runs to the bottom of the hatchet handle. When struck against the trunk of a tree, a small preset volume of herbicide is injected. The hypo-hatchet is used for selective removal of unwanted trees without harming the surroundings.

Planting equipment is discussed in further detail in **Section G**.

Dibble bar

Planting shovel
Photo: Morgan Nolan, University of Georgia

Hypo-hatchet

Tree spade

Mechanical tree planter
Photos L to R: Jerry A. Payne, USDA ARS; David J. Moorehead, University of Georgia. www.forestryimages.org

4. Safety equipment

Specific hand tools are used to control and extinguish forest fires; each fire is different and requires unique tools. Fighting forest fires is hot, dangerous, and hard work; a person on the fire line may work for 12 to 18 hours without a break. Operating these tools for extended periods in smoke and heat requires strength and endurance.

An **adze hoe** has a cutting blade perpendicular to its handle, much like a garden hoe. It is used for grubbing out vegetation or trenching along a fire line.

Adze hoe

A **backpack sprayer** is a water-filled tank or rubber bladder, used in areas where hoses cannot reach. Fitted with shoulder straps and a piston-type pump nozzle, it is worn on the firefighter's back and used to extinguish small spot fires, douse smoldering logs, and assist in the cleanup operation. Firefighters must ensure that all possible ignition points are extinguished and will not reignite after the crew leaves the area.

Backpack sprayer

A **drip torch** is constructed of a steel tank, a fuel spout, and a nozzle-igniter assembly. The tank and nozzle assembly are held in a downward position allowing a mixture of diesel fuel and kerosene to dribble out. The fuel is ignited as it exits the nozzle; the burning fuel then falls to the ground and starts a fire. Uses for the drip torch include prescribed burns, brush and slash disposal, roadside burning, agricultural clearing, and back-firing.

Drip torch

Hard hats and safety goggles are personal protection devices engineered to OSHA standards. The firefighter's hard hat resists high heat conditions and offers superior protection against flying objects. Safety goggles keep smoke and debris out of the eyes.

Pulaski, or foresters' axe

Hard hat and safety goggles

A **pulaski**, or **foresters' axe**, is a hybrid hand tool. The steel head has an axe blade on one end and a modified hoe blade on the other, and is attached to an axe handler. This sturdy tool is used for chopping, grubbing, and digging fire lines in bushy and rocky terrain.

A **fire plow** is a specially designed heavy-duty implement pulled behind a bulldozer. The plow has a V-shaped blade that turns up the soil in a four-to-six-foot swath. This cleared path exposes the bare soil and creates an effective fire break.

Fire plow

Fire rake

A **fire rake** is specially designed for fire fighting, and constructed with V-shaped metal blades. The sharp blades remove leaves and twigs, and dig up the soil to create an effective fire line.

Fire swatter

Fire-resistant clothing must be worn by all firefighters when working on the fire line. Pants, shirts, and coveralls made of NomexIIIA® material protect the firefighter from heat and flames.

A **fire shelter** (also known as a "shake-and-bake") is designed and manufactured to US Forest Service standards. It is constructed of special aluminum foil that is laminated to glass cloth, and provides a barrier against a fire's intense radiant heat. If a firefighter is caught without a means of escape, the shelter provides an option for protection: the ground is cleared of combustible materials, then the firefighter lies down and covers himself or herself with the shelter.

A **fire swatter** is a hand tool designed to fight grass fires. It consists of a large flap of rubber-treated webbing, attached to a long stout handle. The tool is "batted" in an up-and-down motion, smothering the fire.

Interpreting the weather and forecasting what it will do tomorrow is very important when battling forest fires. The **fire weather kit** contains instruments to measure climatic conditions. A simple kit may contain a wind speed meter, a hand compass to determine wind direction, a sling psychrometer and slide rule to determine relative humidity, and a note book in which to record data. All items are contained in a canvas bag that can be worn on a belt.

Fire-resistant clothing

Fire shelter

5. Environmental protective and enhancement tools

Densiometer

A **densiometer** is used to estimate percentage of canopy cover, a measurement of the density of foliage in the overstory. The densiometer is a dome-shaped mirror marked with a grid pattern and mounted in a wooden box.

Hand lens

Photo: Morgan Nolan, University of Georgia

A **hand lens** is a single glass or plastic lens, mounted in a plastic or metal case, with a specific magnification power. Magnification levels are increased when the forester uses multiple, stacked lens units. The hand lens is used most often to view objects that require modest magnification (e.g., maps, insects, and wood samples).

Field microscope

Similar in size to the hand lens, the **field microscope** has greater magnification capabilities. While a hand lens may provide 10x or 14x magnification power, the field microscope provides 25x or 30x power.

A **flow/current meter** is used to measure the velocity (speed) of flowing water in a river, stream, irrigation canal, or storm water runoff ditch. The meter consists of an impeller mounted on the end of a sampling rod connected to an electronic data recorder. Water velocity is calculated based on the speed at which the impeller turns when inserted in flowing water. Velocity is recorded in feet per second (fps) or meters per second (mps).

Flow/current meter

A **pH meter** is an electronic device with a sensor that indicates if a solution is alkaline or acidic. The pH is an expression of the negative logarithm, to base 10, of the hydrogen ion concentration. A pH of seven indicates the substance is neutral (neither acid or alkaline). A pH reading less than seven indicates acidity, and greater than seven indicates alkalinity.

pH meter

Soil auger (or sampler)

A **plant press** is a wooden frame with straps, used to press leaf samples. Leaves are placed between two sheets of blotter paper, stacked, and secured in the frame. The straps are tightened, compressing the leaf material. The plant material dries in a few days and can be mounted in protective cases.

Plant press

Soil can be sampled using a shovel, but if exact amounts must be taken a **soil auger** (or **sampler**) is used. Soils are sampled to assess such characteristics as nutrient levels (to know if fertilizer is needed), bulk density (whether soil is compacted), and moisture level.

Soil test kits are available for single and multiple tests, and are equipped with all necessary materials. The kit may include plastic tubes, solutions, reagents, sample bags, instructions, and color charts for comparing results. Foresters may use test kits in the field, but for best results samples should be submitted to a lab for complete analysis.

Soil test kits

A **water sampler** is a plastic chamber with spring-loaded ends that can be closed remotely. The sampler is attached to a rope and lowered to the desired depth. Triggering the device seals in a water sample. The sample provides information about the temperature and other characteristics of the water at the tested depth.

Water sampler

Like soil test kits, **water test kits** may be designed for single or multiple tests. For example, a multiple test contains all the materials to analyze for nitrate, phosphorus, pH, carbon dioxide, chlorides, ammonia, sulfide, silica, hardness, and alkalinity.

Water test kits

Tools and equipment come in many shapes and sizes, each with a specific purpose. A field forester may require basic hand-held equipment, while a timber harvesting contractor may invest hundreds of thousands of dollars in heavy equipment. Regardless of cost, all tools must be used safely and correctly, and kept clean and in good repair.

The forester must ensure that all operation instructions are understood, asking all necessary questions about maintenance while the tool is in his or her possession. The moments spent cleaning and storing a tool after use are less costly than replacement or repair after misuse or damage.

Section G:

Silviculture:
The Art and Science of Forestry

DID YOU KNOW:

One cord of wood (a stack 4' wide by 4' high by 8' long) will yield either:

- More than 7 1/2 million toothpicks
- One to two tons of paper
- More than 61,000 standard envelopes
- Or nearly 4 1/2 million commemorative-size postage stamps?

Objective: *The student will be able to identify and explain the technical components of silviculture in the United States.*

Silviculture is the art and science of controlling the establishment, growth, composition, health, and quality of forests. Silviculture practices seek to meet the needs and values of forest landowners and society on a sustainable basis, based on knowledge of species characteristics and their environmental requirements. The root word of silviculture is **silvics**, which refers to the growth and development of single trees, and the forest as a biological unit.

. . many ways, silviculture is to forestry as agronomy is to agriculture. Good silviculture practices seek to:

- Produce a marketable and profitable crop of trees.
- Influence natural conditions to improve growing conditions.
- Control composition and density of the forest stand.
- Regenerate and reclaim unproductive areas.
- Protect the environmental quality of the forest site.
- Meet the forest landowner's objectives.

Whether a forest supports wildlife, recreation, or commerce, it must be managed and kept in good condition. The forester must determine which management activities are best suited for a given forest type. Silviculture is not a "cookbook" approach to forest management: rather, it requires knowledge and application of forest ecology, tree physiology, soils, hydrology, wildlife biology, forest engineering, and other disciplines.

The management procedures used in silviculture include:

- Site preparation.
- Regeneration (establishment of new forest stand).
- Pruning.
- Thinning.
- Harvest planning.
- Fire (as a management tool).
- Fertilization.
- Control of insects, disease, and herbaceous weeds.

A well-stocked stand of healthy trees is essential to producing high-quality timber products. The professional forester develops a **management plan** to ensure that the integrity of forestland is protected, including soil, wildlife, water, trees, and social concerns. The forester follows the plan as a traveler follows a road map.

A forest management plan includes detailed descriptions of activities to be carried out, a timeline when particular activities must take place, and a budget showing costs and income. Activities described in a plan include **site preparation, intermediate treatments, harvesting**, and **regeneration**: the stands that will be regenerated artificially or naturally.

Site preparation refers to the treatment of soil and ground vegetation. The soil surface or seedbed is prepared for either **natural** or **artificial** means of regeneration. Site preparation creates favorable environmental conditions for establishment and growth of the desired tree species.

The ability of a site to respond to preparation activities depends upon a number of factors, including:

- The type and magnitude of the activities.
- The size of the impacted area and elapsed time since previous disturbances.
- The species and density of **residual vegetation** (e.g., grass, shrubs, and trees).
- The productivity of the site, as related to site quality or site index.
- The weather and time of year in which the disturbance occurs.

ɔed and seedlings must make direct contact with soil to germinate and grow. Survival depends on receiving adequate sunlight, moisture, nutrients, and physical space.

Surrounding vegetation and residue decreases the availability of these elements, and thus the seed and seedlings' survival rate. It is important, therefore, to control competing vegetation and reduce residue. Site preparation methods used for this purpose include **mechanical**, **chemical**, and **prescribed burning** techniques.

- **Mechanical** site preparation uses heavy equipment for raking, piling (creating windrows), crushing, or disking. The goal is to reduce the **vertical dimension** (height) and **volume** (depth) of residual vegetation, and expose the soil as much as possible.

- **Chemical** site preparation uses herbicides to control unwanted vegetation. A site is usually sprayed during the spring and early summer months when target species to be removed are actively growing. Large-scale application may use helicopters, or skidders and tractors equipped with holding tanks and boom sprayers.

- **Prescribed burning** effectively clears a site of unwanted vegetation and woody debris with minimal soil disturbance. Sites are often first treated with herbicide: after vegetation is dry, the site is then burned. Note that prescribed burns are most often used in pine stands; their usefulness in hardwood stands is still a matter of debate.

Mechanical

Chemical

1. Harvesting techniques

Harvesting is an essential part of management activities for all silviculture prescriptions. Harvesting removes mature trees of merchantable size.

Selection of a harvest method depends on the regeneration and growth requirements of the tree species in the stand, and plans for maintenance of an **even-** or **uneven-aged stand**.

To maintain an **even-aged** stand (i.e., all trees are the same age class) as found on a pine plantation, **clearcutting** and **seedtree** methods are used.

Prescribed burning to clear the land

Clearcutting

- **Clearcutting** methods remove all merchantable timber in the stand during a specified time period, usually over several months. A cost-effective method, it applies well to **pure** stands (those regenerated with one species).

Mechanical and prescribed burn photos: USDA Forest Service - Rocky Mt. Region Archives
Chemical photo: James H. Miller, USDA Forest Service
Clearcutting photo: David J. Moorhead, University of Georgia
www.forestryimages.org

- **Seedtree** methods leave a set number of trees per acre to reseed the area. Note that loss of seed trees to fire, insects, disease, storm damage, a poor seed crop, or other factors can result in loss of the seed source.

Seedtree

To maintain an **uneven-aged** stand (i.e., all trees are of different age classes) as found in a natural stand of hardwoods, **shelterwood** and **selection cutting** methods are used.

- **Shelterwood** involves a three-stage removal of crop trees over a period of years. The preparatory cut creates conditions for regeneration, and is similar to thinning. The **establishment** cutting opens areas in the stand and allows new seedlings to grow. Note that undesirable species will appear if the stand too large or small; openings must only be large enough for the target species to regenerate. The **removal** cutting takes out mature, merchantable trees and allows established seedlings to grow.

- **Selection** cutting is commonly applied as either single-tree or group systems. **Single-tree** systems harvest individual trees over short, equal time intervals. This can be expensive if large tree-removal equipment is needed. **Group** systems best manage uneven-aged stands. They remove small groups of trees and create openings no larger than twice the height of those removed, allowing sunlight to reach the remaining trees.

Shelterwood

Selection

Seedtree photo: Thomas C. Croker, USDA Forest Service
Shelterwood photo: Philip McDonald, USDA Forest Service
Selection photo: John D. Hodges, Mississippi State
www.forestryimages.org

Thinning and pruning schedules

Pre-commercial thinning

Thinning benefits a forest stand by removing some trees to favor those selected for superior growth, form, and vigor. Thinning maximizes tree growth, also known as **annual increment** (e.g., the amount of wood produced over one year period).

- **Pre-commercial** thinning removes small, poorly formed, diseased, or defective trees to reduce the density per acre and regulate the stocking level of the stand. Trees removed are not merchantable and of no commercial value: the landowner pays for the work without receiving income from the trees removed.

- **Commercial** thinning is usually performed in a timber stand in the middle to latter stages to redistribute the allocation of available water, light, growing space, and nutrient resources, and stimulate growth of remaining trees. Trees removed have commercial value (e.g., **chips**, **pulp**, or **chip'n'saw**), can generate enough income to fund the operation, and may even provide some income.

Low thinning

- The **vertical area** of the tree canopy in which thinning occurs can also help categorize the procedure. **Low thinning** (or "thinning from below") removes trees with small crowns. This technique simulates natural forest processes where smaller trees are overgrown by larger ones, and subsequently die from lack of sunlight. **Crown thinning** (or "thinning from above") removes trees within the middle to upper portion of the crown. This opens up the canopy and creates room for healthier trees to grow. Crown thinning provides greater economic return than low thinning, because larger trees are removed.

Crown thinning

- **Geometric** thinning removes trees from a crowded or unthinned stand according to a predetermined pattern or spacing plan without regard to **crown class** (i.e., dominant, co-dominant, intermediate, or suppressed). This method is useful in plantations because of their geometric planting layout: trees are in rows and spaced within the row.

ow thinning

- **Row** thinning is common in Southeastern pine plantations. Every third or fifth row of trees is removed completely, and trees in between rows are removed selectively.

Pre-commercial and low photos: Chris Schnepf, University of Idaho.
Crown photo: David J. Moorhead, University of Georgia.
Row photo: James H. Miller, USDA Forest Service.
www.forestryimages.org

Thinning also affects **stocking levels** (e.g., the number of trees per acre). Awareness of stocking levels helps the forest manager control rotation length, maximize wood quality and quantity, and produce desired timber products. An under-stocked stand produces trees with irregular form (e.g., too many branches), excessive taper of the bole, and elevated **live-crown ratios** (e.g., the ratio between the heights of the live crown to total height of the tree). An over-stocked stand can decrease tree growth and live-crown ratios, and increase tree mortality.

Thinning does not conform to a strict schedule but rather is based on the forest landowner's objective for the timber, taking place when the stand has grown sufficiently to warrant the activity. Saw timber, for example, requires a different thinning regime than pulpwood. **Stocking tables** help the forest manager estimate stocking levels for a given species and establish timetables for thinning.

Pruning
Photo: Scott Roberts, Mississippi State.
www. forestryimages.org

Pruning refers to the removal of branches (live or dead) from standing trees to improve wood quality. Though labor- intensive and costly, pruning provides many benefits. It promotes growth of knot-free lumber, improves air movement through the stand, improves accessibility within the stand, reduces the risk of wildfire reaching the crowns, and improves the appearance both of individual trees and the entire stand. Pruning simulates natural forest processes: many tree species (such as pine) naturally prune themselves after crown closure.

Pruning should take place periodically throughout early stages of growth to eliminate branches on the first log (generally at a height of 16 feet). At least two-thirds of the live crown should be retained: this ensures sufficient leaf surface to maintain tree health.

A forest managed for timber production will require **intermediate treatment** at some time between planting and final harvest. Primary objectives are to remove undesirable trees and vegetation, improve wood quality, and maintain tree health and forest productivity. Thinning and pruning are two examples of intermediate treatment: others include application of **fertilizer** and **herbicide**.

- **Fertilization** improves tree growth, just as when a gardener fertilizes flowers and vegetables. For timber production fertilizer is applied to increase the volume of wood produced; for pine straw production fertilizer is applied to increase the number and quality of needles. Fertilization typically uses a mixture of nitrogen and phosphorous, and amounts of each depend on soil type. As mentioned above, application may use helicopters, or skidders and tractors equipped with holding tanks and boom sprayers. Trees may not show a response for one to two years, but eventual effects may last five to seven years. Note that trees require a longer

Fertilization
Photo: Dave Powell, USDA Forest Service.
www.forestryimages.org

period of time to mature, and react differently to fertilization, than do other plants. Thus the timing and methods of application and expected responses are different than for other crops. Not all forest stands require fertilization, and costs can approach $100 per acre depending on materials, application rate, and method.

- **Herbicides** effectively control undesirable vegetation that competes with crop trees for light, water, nutrients, and space. Pre- or post- planting application allows seedlings to establish root systems to compete for nutrients and water,and application during forest stand rotation eliminates unwanted woody vegetation. Many different herbicides are approved for forest use. Cost per acre varies depending upon species to be controlled and their density, application method (ground or air), and the chemical to be applied.

Herbicides
Photo: David McComb, USDA Forest Service.
www.forestryimages.org

3. Regeneration methods

Regeneration is the renewal of a tree crop, whether by natural or artificial means. **Natural regeneration** uses seed or vegetative growth (i.e., sprouts from stumps and suckers from roots). **Artificial regeneration** involves human activity (i.e., seedlings planted by hand or by machines). Hand planting can use a **dibble bar**, a **hoedad**, or a **planting shovel**. A mechanical tree planter can be towed behind a tractor or skidder: it plows a narrow trench in which the operator plants seedlings, followed by packing wheels that firm the soil. Note that natural regeneration is usually used with hardwood stands, and artificial regeneration with pine.

Regeneration
Photo: Tom Landis, USDA Forest Service.
www.forestryimages.org

Selecting a regeneration technique involves several factors: the species to be planted, the site conditions, the cost, and the landowner's objectives. Natural regeneration is less costly and helps create landscape diversity; but stand density, composition, and genetics are harder to control. Many species of hardwood and conifer are regenerated naturally. Artificial regeneration allows better control of species and spacing. Genetically improved seedlings produce stands with higher yields and better resistance to insects and diseases. Artificial regeneration usually involves high initial costs, however, and risks to survival rates if seedlings are damaged or improperly planted.

In either method, spacing is controlled both within and between the rows. Spacing is expressed by two distances: for example, a spacing of 8' x 10' indicates eight feet of spacing between seedlings within each row, and ten feet of spacing between rows. To determine the number of seedlings per acre that can be planted using this spacing, first multiply the spacing factors, and then divide the result into the number of square feet in one acre. (One acre equals 43,560 square feet.) In our example 8 x 10 = 80, and 43,560/80 = 544.5. Thus, approximately 545 seedlings per acre can be planted at an 8' x 10' spacing.

4. Timber stand improvement (TSI)

Timber stand improvement (TSI) refers to the actions prescribed by the forest manager to improve the composition, structure, condition, health, and growth of even- or uneven-aged stands. Undesirable species are removed or deadened to achieve a desired stocking level and species composition. This is accomplished by herbicide application, controlled burning, girdling to prevent transportation of water and nutrients (e.g., making two cuts one-half to one inch deep around the tree) or felling undesirable trees.

Prescribed burn

Photo: USDA Forest Service - Southern Research Station Archives
www.forestryimages.org

TSI activities can be labor-intensive and costly depending on the number and size of trees to be removed, the size of the stand, and the methods used. TSI activities do not follow a strict schedule, but rather are initiated when undesirable trees impact the growth of crop trees.

5. Fire as a management tool

Professional foresters use **fire** as a tool to create favorable changes in the forest. **Prescribed burning** effectively clears a site of unwanted vegetation and woody debris with minimal soil disturbance. Prescribed burning is scheduled depending upon the desired outcome for a particular forest. Outcomes may include:

- Controlling populations of harmful insects and diseases.
- Reduction of **slash**, or logging debris.
- Preparation of a seedbed for species that require exposed soil.
- Reducing accumulation of litter to lessen the risk of major loss from wildfire.

- Controlling the composition of the understory plants: specifically, to improve wildlife habitat and promote habitat diversity.
- Opening pitch-sealed cones and breaking dormancy of buried seeds.
- Directing succession over large areas at low cost.
- Controlling the amount of vertical diversity.

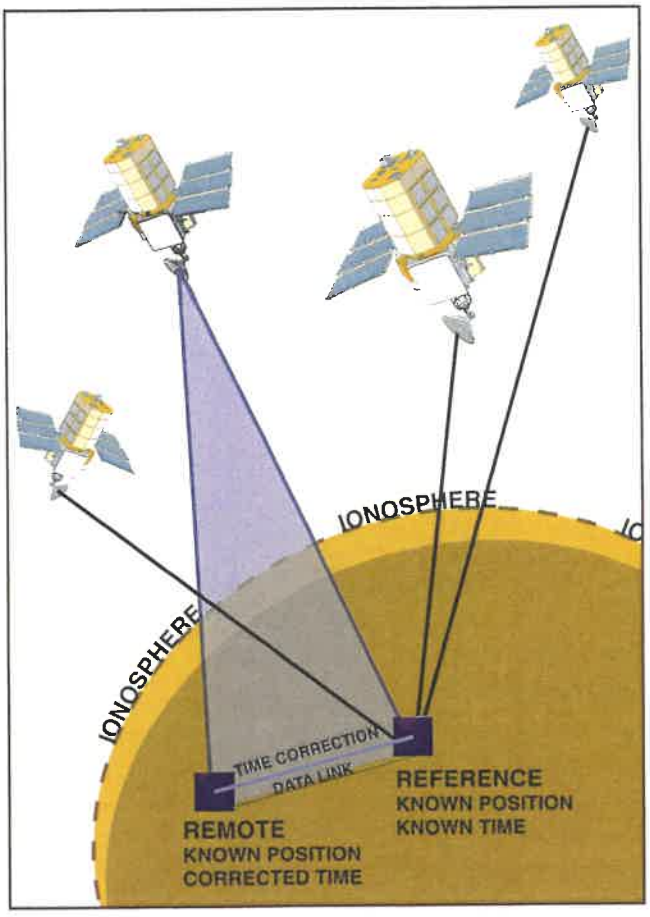
Fire can be a practical management tool both for naturalists and forest planners. Properly prescribed burning offers many positive benefits. Fire destroys diseased trees and allows more sunlight to reach the forest floor. Some tree species require introduction of fire in order to reproduce. Fire can create and renew desirable habitat for many types of wildlife (e.g., deer and wild turkey): understory growth becomes succulent and makes excellent forage and protective cover.

Note that a trained professional should conduct all prescribed burning.

6. Technological advances

As our knowledge about forest ecology, tree physiology, and silvics has increased, the art and science of silviculture has also improved. Applying silviculture techniques to a forest stand requires the participation of a professional forester, one whose knowledge and experience can help match an appropriate prescription with the landowner's objectives and the site conditions.

The **Global Positioning System (GPS)** is a navigational tool developed by the US Department of Defense. A GPS unit receives radio signals sent from satellites circling the globe in precise orbits more than 12,000 miles away. Just as a forester determines his or her position on the ground using a compass, the GPS unit calculates the travel time of signals transmitted from the satellites and determines its distance from each satellite. The GPS unit must receive signals from at least four satellites; more signals determine a more accurate reading. The unit calculates longitude, latitude, altitude, and travel direction and speed. Data are collected digitally, making storage and retrieval easier. A commercial hand-held unit can determine positions to within ten feet. GPS technology has improved the speed, accuracy, and quality of timber mapping and cruising.



Global Positioning System (GPS)

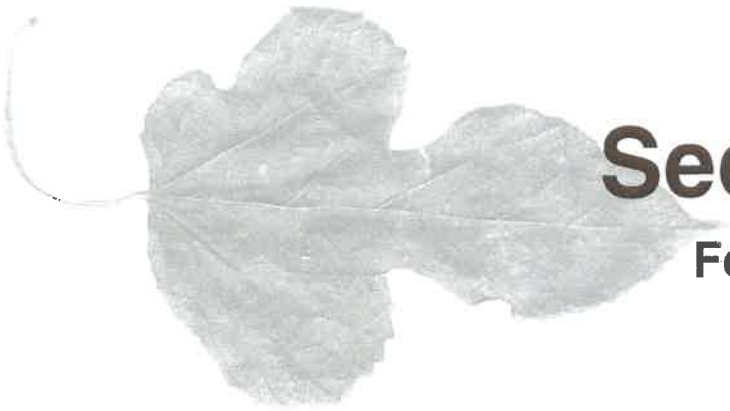
7. Habitat manipulation

Silviculture activities directly affect wildlife **habitat**: the extent of the impact depends on the size of the area and the activity. For example, a forest's canopy and understory are removed after thinning, prescribed burning, or TSI activities. This allows more sunlight to reach the ground. This change in the microclimate provides favorable conditions for **browse plants** to grow (e.g., small shrubs, **forbs**, and grasses.) These provide a food source to grazing wildlife species (e.g., wild turkey, deer, and rabbits.)

Changes created after harvesting and regeneration activities can be more dramatic. A large area once covered in trees is opened; when this open area is adjacent to a residual forest stand, an "edge" is created. Wildlife is often attracted to this transition between the cover provided by the forest and the food source provided by the emerging succulent plants in the open area.

A forest manager's job includes making sure that forestry operations do not negatively impact water quality. **Best management practices (BMPs)** are followed to protect water quality by keeping sediment out. Buffer strips of uncut timber beside streams filter surface runoff and provide shade to keep water temperatures from increasing. Stream crossings are engineered to withstand heavy equipment traffic and allow unrestricted water flow. Forestry operations are monitored to minimize soil disturbance.

Habitat manipulation
Photo: Chuck Bargeron, University of Georgia
www.forestryimages.org



Section H:

Forest Disorders

DID YOU KNOW:

There are more than 290,000 known species of beetle in the world, including more than 300 wood borers - and nearly 29,000 of them exist in the US?

Objective: *The student will learn to examine and investigate in order to identify damage sustained by forest trees. He or she will be able to describe basic characteristics of damage caused by animals, insects, disease, chemicals, machinery, and environmental causes.*

This chapter describes the characteristics of some of the more common insects and diseases that attack trees in the forest, as well as the damage these forest pests can cause and the economic impact they can create.

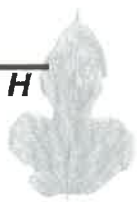
Locating and identifying outbreaks of insect damage and disease requires the forester to take immediate action. Uncontrolled, pests and diseases can kill acres of trees and create severe economic hardship. Whether the forest is used for recreation, wildlife, or to produce wood products, control of insects and disease is essential.

A forest manager needs to be especially concerned with insect and disease control when forests are managed to produce wood products. Significant amounts of money, time, and energy are required to monitor and control pests. Healthy, vigorous growth can reduces the likelihood of attack. For example, during dry hot summer months, trees often are unable to absorb sufficient water to maintain their physical defenses. This environmental stress makes trees less able to fight off a pest attack.

Keeping the forest healthy can be accomplished by:

- Planting genetically superior seedlings.
- Properly preparing the planting site.
- Using fire as a management tool.
- Keeping the stand at a proper stocking level to promote vigorous tree growth.

An attack on trees by insects or disease is referred to as an **infestation**. No simple method exists to control an attack on a stand of trees. When insects or disease attack a tree, its defenses are weakened and it is less able to defend itself against attack from secondary pests (e.g., bark beetles, borers, and fungi). Nor is it capable of surviving an



environmental stress, such as drought. Unfortunately, a tree attacked by insects or pathogens is not likely to survive; a forester must maintain a healthy stand of trees that will withstand attack by secondary pest problems.

Forest entomologists and **forest pathologists** study the pests found in the forest. An entomologist studies insects, investigates the damage they cause to trees, and determines the best management strategy to control the insect. A pathologist studies tree diseases and performs research to find ways to control the spread of a disease or fungus.

1. Insects and insect-like pests

Beetles

Beetles belong to the Coleoptera order, the largest of all insect orders. There are more than 290,000 known species of beetle in the world, of which 28,600 exist in North America. Adult beetles are identified by their leathery elytra, the hard covering over the wings. Other characteristics used to identify adult beetles include the number of antennae segments and form, mouth parts, and abdomen and leg segments.

Beetles feed on plant and animal matter. Some species defoliate a tree (eat its leaves), making the tree unable to produce sugar during photosynthesis. Other beetles bore into the tree and damage living tissue. This damage affects the tree's health and reduces wood quality.

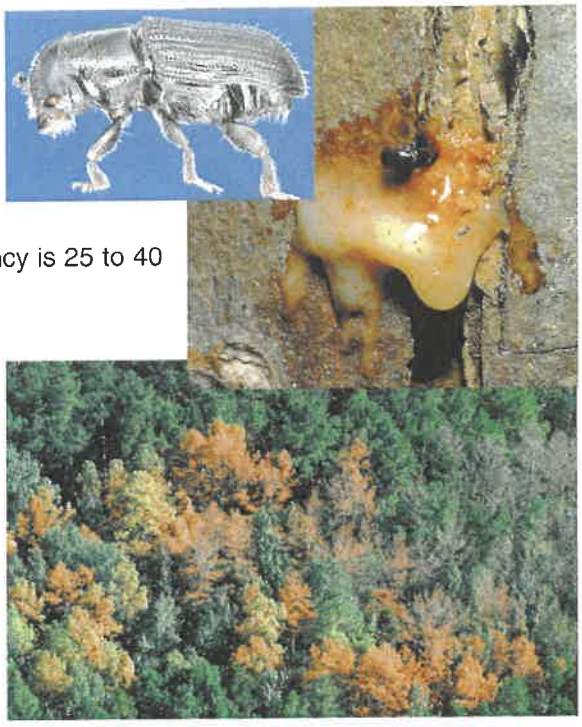
Bark beetles make their home just under the bark, eating their way into the wood where they construct their home, called a **gallery**. The gallery pattern created by each species is different. Bark beetles of the genus *Dendroctonus* cause the greatest damage to living trees. Species of this genus usually attack certain pine trees; when populations reach epidemic numbers, however, any tree greater than six inches (150 mm) in diameter may be attacked. Seven species from this genus attack forest trees: a brief description of each follows.

Bark beetle gallery
Photo: Dave Powell, USDA Forest Service
www.forestryimages.org

Southern Pine Beetle

Identification: The adult Southern pine beetle (*D. frontalis*) is brown to black in color. Its abdomenis rounded at the end, and its eggs are white and visible; fully-grown larvae are about an eighth of an inch (2 to 3 mm) long and are white with a reddish-brown head; and pupae are white. Its life expectancy is 25 to 40 days.

Damage: The Southern pine beetle is the most destructive of Southern US forest insects. It attacks trees that are under such environmental stress as drought, flooding, or competition for nutrients and light. Adult beetles bore through the bark and chew long S-shaped "galleries"; female beetles lay eggs in notches along the gallery. In four to nine days the eggs hatch; the larvae feed on the tree's cambium tissue, and then bore through to the outer bark to pupate.

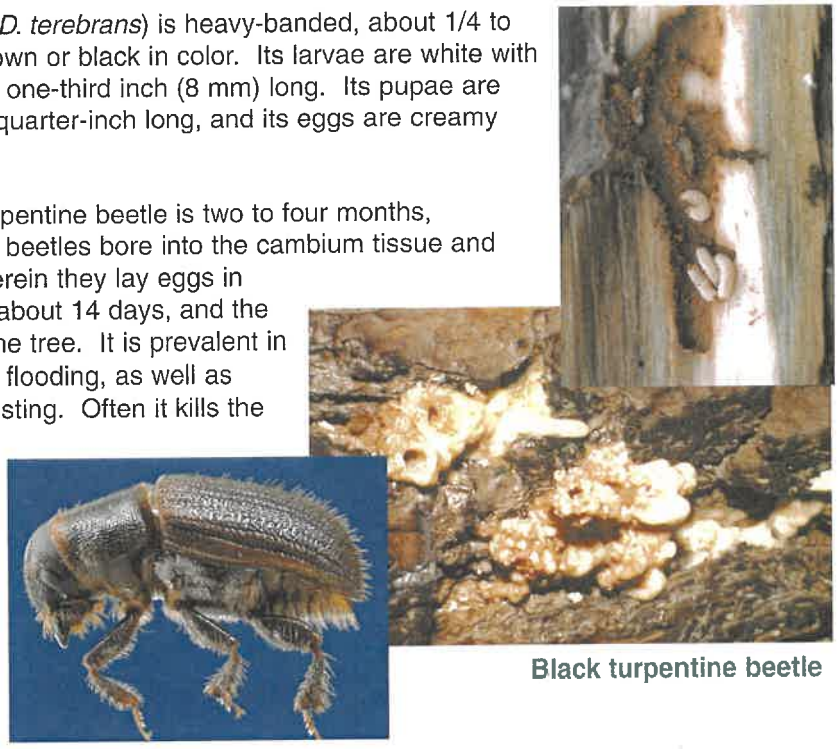


Southern pine beetle

Black Turpentine Beetle

Identification: The black turpentine beetle (*D. terebrans*) is heavy-banded, about 1/4 to 3/8 inches long, and dark brown or black in color. Its larvae are white with a reddish-brown head, about one-third inch (8 mm) long. Its pupae are yellowish-white and about a quarter-inch long, and its eggs are creamy white and very small.

Damage: The life cycle of the black turpentine beetle is two to four months, depending on season. Adult beetles bore into the cambium tissue and create vertical passages wherein they lay eggs in clusters. The eggs hatch in about 14 days, and the larvae feed on the wood of the tree. It is prevalent in times of serious drought and flooding, as well as after fires, storms, and harvesting. Often it kills the healthiest trees in a stand, but is also attracted to injured and weakened trees and fresh stumps. Walnut-sized white-to-reddish pitch tubes on the lower tree trunk and stumps are a sign of this beetle's presence.



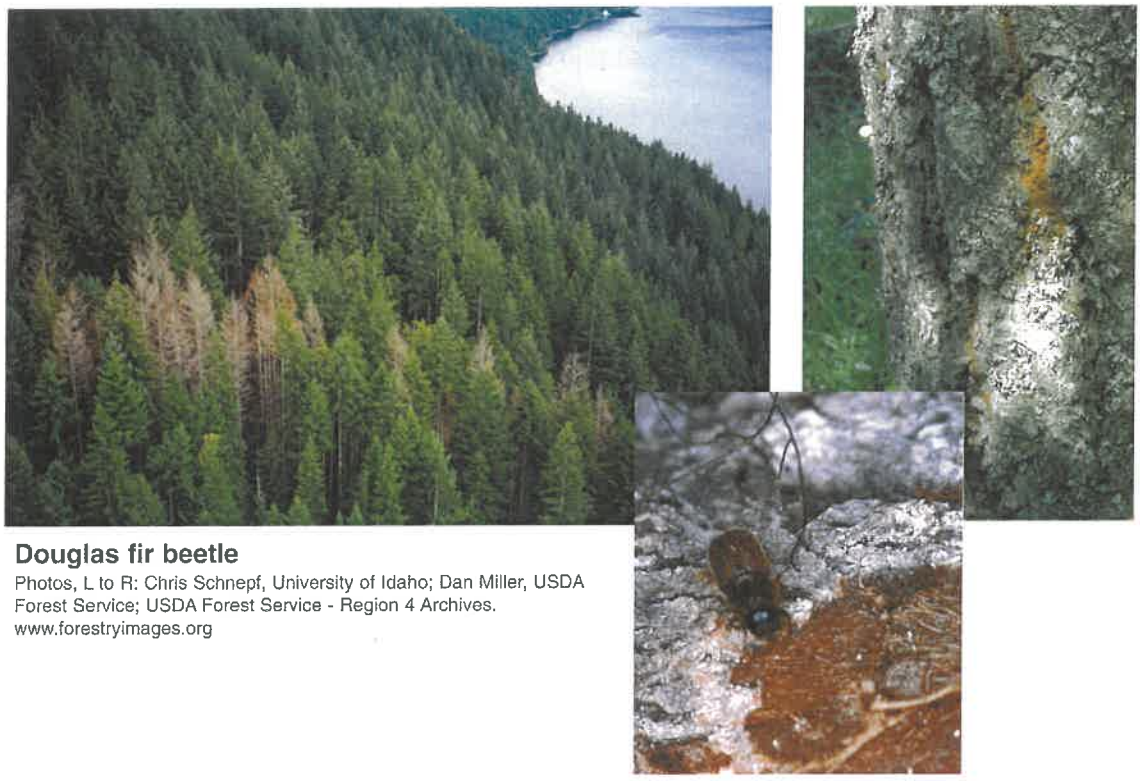
Black turpentine beetle

Beetle closeup photos: David T. Almquist, University of Florida.
Other photos, top to bottom: Ronald F. Billings, Texas Forest Service; Gerald J. Lenhard, Louisiana State; James R. Meeker, USDA Forest Service; James McGraw, North Carolina State.
www.forestryimages.org

Douglas-Fir Beetle

Identification: The Douglas-fir beetle (*D. pseudotsugae Hopk.*) is approximately a quarter-inch (4 to 6 mm) long. This beetle is stout and cylindrical in shape; the head and thorax are black, and wing covers are reddish brown. The larvae are white and shiny with a light brown head. This beetle produces one generation per year. The female beetle forms distinctive egg galleries: after passing through the bark, she excavates the phloem material in an upward direction, running parallel to the wood grain for about 8 to 10 inches.

Damage: This beetle infests and kills Douglas-fir trees throughout its natural range, which extends from British Columbia through the western US and into Mexico. The first sign of attack is the presence of reddish-orange "frass" along the trunk of the tree: frass is the tree's inner bark or phloem which is ingested by the beetle and excreted as it burrows. After beetles enter, the tree's foliage changes color from yellow to reddish brown. Needles fall from the tree during the year following initial infestation, becoming more evident the second year. The Douglas-fir beetle can cause great losses during periodic infestations every two to four years. Under normal conditions, however, this beetle attacks scattered trees. Most susceptible to infestation are trees that have been blown over by the wind,scorched by fire, or suffer from root disease.



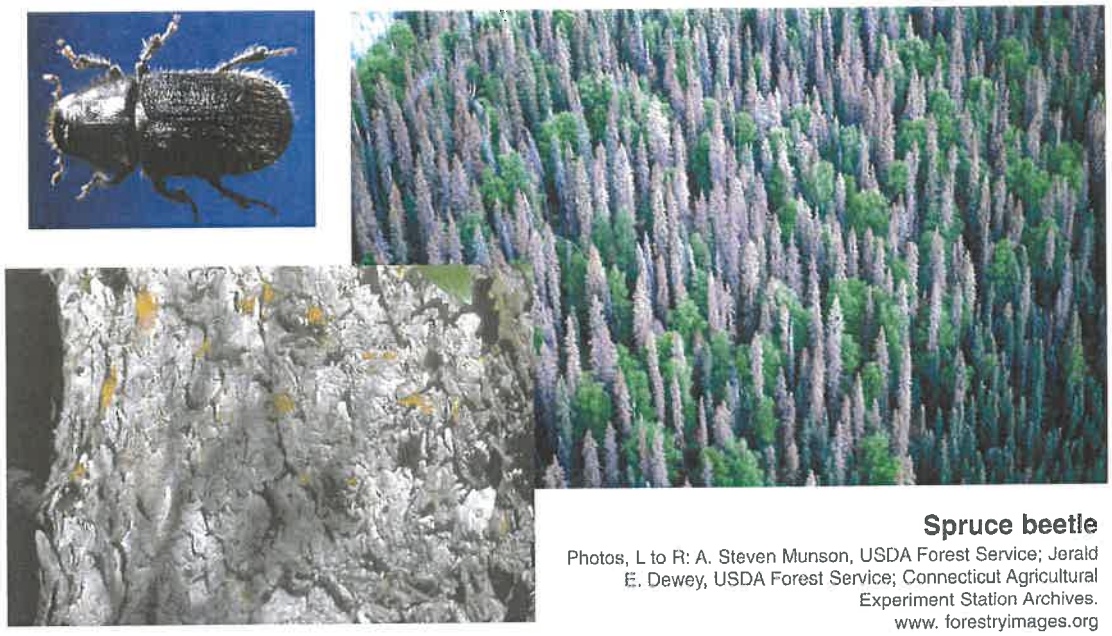
Douglas fir beetle

Photos, L to R: Chris Schnepf, University of Idaho; Dan Miller, USDA Forest Service; USDA Forest Service - Region 4 Archives. www.forestryimages.org

Spruce Beetle

Identification: The spruce beetle (*D. rufipennis* (Kirby)) is about a quarter-inch (4 to 6mm) long and cylindrical in shape. The body of the adult beetle is dark brown to black in color, and the wing covers are reddish-brown or black. The life cycle of the spruce beetle is usually two years in most areas in which it is found, but may be as short as one year in warm climates and up to three in cooler, shady climates. The female beetle creates the egg gallery just under the bark and lays eggs in the phloem tissue of the tree. The gallery varies in length from two to four inches (6 to 13 cm).

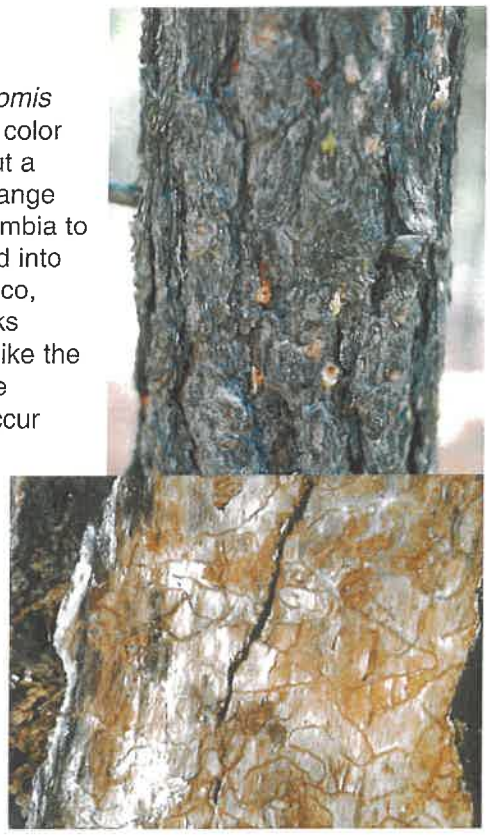
Damage: The spruce beetle damages mature spruce trees. Extensive losses can occur anywhere spruce forest stands grow, from Arizona to Alaska and across most of Canada. The first sign of attack is the buildup of reddish-brown dust created by the beetle boring into the tree. Dust can be found at the entrance holes, in crevices of the bark, and around the base of infested trees. A build-up of "pitch" or resin around the entrance hole may also be visible during the summer after initial infestation. Woodpeckers will feed on the beetles and debark trees, causing significant damage. Needles of infested trees usually turn yellowish-green during the second summer after initial attack, though not all needles change color at the same time.



Spruce beetle

Photos, L to R: A. Steven Munson, USDA Forest Service; Jerald E. Dewey, USDA Forest Service; Connecticut Agricultural Experiment Station Archives. www. forestryimages.org

Western Pine Beetle



Identification: The western pine beetle (*D. brevicomis LeConte*) is dark brown to black in color with a stout cylindrical shape, about a quarter-inch(4 to 6 mm) long. Its range extends from southern British Columbia to northwestern Mexico, and eastward into Montana, Utah, Arizona, New Mexico, and west Texas. This beetle attacks ponderosa and coulter pine trees; like the mountain pine beetle, all four of the western pine beetle's life stages occur under the bark of a host tree. Egg galleries crisscross within the inner bark and on the surface of the sapwood.

Damage: The western pine beetle infests declining mature trees scattered within a stand and clumps of overstocked second-growth ponderosa pine, attacking the main trunk. Indications of attack include changes in foliage from pale green to yellow to brownish-orange, and the presence of woodpeckers removing bark as they forage for larvae. Like the mountain pine beetle, the western pine beetle carries spores of blue-stain fungus.

Western pine beetle

Roundheaded Pine Beetle

Identification: The mature roundheaded pine beetle (dendroctonus adjunctus) is shiny dark brown to black in color, about a quarter-inch (4 to 6 mm) long and an eighth-inch (2 to 4 mm) wide. The female is slightly larger than the male. Found primarily in the southwestern US and Mexico, it attacks ponderosa and other pine species. Adults emerge and fly from infested trees from September through November, with a life span of about one year.

Damage: The roundheaded pine beetle infests immature trees. The female bores through the phloem to the xylem tissue where she constructs an egg gallery above the bored entry hole. Eggs are deposited in niches on either side of the gallery. Larvae feed on phloem tissue, essentially girdling the tree.

Roundheaded pine beetle

Photos, top to bottom: Kenneth E. Gibson, USDA Forest Service; Mark McGregor, USDA Forest Service; USDA Forest Service Archives. www.forestryimages.org

Wood Borer

Identification: There are more than 300 different kinds of wood borers, most belonging to the moth (Lepidoptera) or beetle (Coleoptera) family. Each different species (including long-horned beetles, flat-headed borers, and round-headed borers) has different identification characteristics. All bore into the bark of living or freshly-cut trees.

Damage: The damage caused by these insects varies. Many species attack and decimate live trees, while others can cause structural damage to log buildings.

Wood borer
Photo: Stanislaw Kinelski, Polish Forest Research Institute
www.forestryimages.org

Defoliators

Gypsy Moth

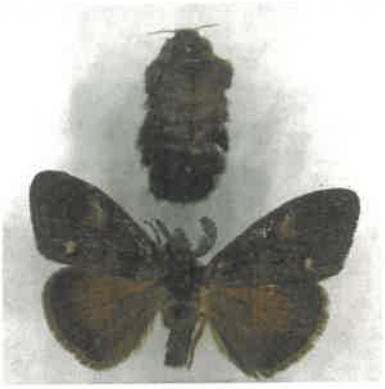
Identification: The gypsy moth (*Liparidae*) migrated to the US from France. and now infests white and red oak trees in the Northeast. The mature gypsy moth larvae measures one-and-a-half to two-and-a-half inches (35 to 65 mm) long, and is brownish-gray with tufts of hair on each segment. Along its back is a double row of five pairs of blue spots, followed by six pairs of red spots. The male is dark brown with wavy bands across the forewings. The female is white and cannot fly. Females deposit eggs on rocks, tree trunks, houses, campers, and cars. Egg masses may contain from 100 to 800 eggs.

Damage: In its larval stage, the gypsy moth causes damage to trees. Young larvae chew small holes in leaves, while more mature larvae eat the entire leaf except for the midrib and large veins. Large numbers can defoliate an entire tree.

Gypsy moth
Photos: Tim Tigner, Virginia Department of Forestry. www.forestryimages.org

Gypsy moth damage

Douglas Fir Tussock Moth



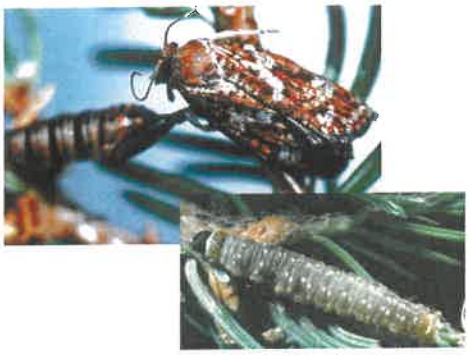
Identification: The larvae of the Douglas-fir tussock moth (*Liparidae*) is identified by red spots and tufts of cream-colored hair along its back, and narrow broken orange stripes along its sides. Behind its head are two pencil-like tufts of hair, with a similar tuft near its back. The female lays her eggs in a mass in the fall and winter. Larvae emerge in the spring and feed heavily through June and July, then spin cocoons and emerge as adults sometime at the end of August or early September.

Damage: Larvae are very destructive, defoliating Douglas-fir and true fir tree species in such areas as the Northern Rocky Mountains. More than 400,000 acres were nearly destroyed in eastern Oregon and Idaho in the late 1940s; and in 1973 nearly 800,000 acres were killed by the moths two years after their detection.

Douglas fir tussock moth

Photos, top to bottom: Jerald E. Dewey, A. Steven Munson, USDA Forest Service. www.forestryimages.org

Spruce Budworm



Identification: The female spruce budworm (*Tortricidae*) deposits a green-colored egg mass late in the summer on the needles of host trees. Each mass contains 10 to 30 eggs, and overlap one another in a manner similar to roof shingles. Small larvae hatch and seek places on the tree to hide, then cover themselves with silk, shed their skin, and hibernate over winter. In spring, the larvae emerge from hibernation and begin to feed. As they grow they switch from eating dead needles and unopened buds to new foliage, forming a web of needles around themselves for shelter. Larvae grow to full size in about three weeks. Young larvae are pale yellowish green in color with black heads; as they grow, they become dark brown with black markings. They grow to adulthood beneath the needle shelter, and emerge in late July and early August to begin a new cycle.

Damage: The spruce budworm threatens balsam fir and spruce trees in Northern forests, primarily through defoliation; outbreaks have killed many acres of forest.

Spruce budworm

Photos , L to R: Jerald E. Dewey, USDA Forest Service; Connecticut Agricultural Experiment Station Archives; Minnesota Department of Natural Resource Arhchives www.forestryimages.org

Red-Headed Pine Sawfly

Identification: The red-headed pine sawfly is a small, heavy-bodied, four-winged, fly-like creature. Larvae are yellowish-white or light green; the mature insect is red.

Damage: Adults lay rows of eggs in pockets sawed into pine needles. Eggs hatch in about two to four weeks. Larvae drop to the ground and spin cocoons. Adults emerge in the spring and females lay eggs in pine needles, cutting a slit in the needle for each egg and laying up to 30 eggs at a time. Larvae hatch and eat the needles. They mature in three to six weeks, then drop to the ground where they spin cocoons in the soil. Sawflies attack most species of Southern pines. Attacks are often unnoticed until the tree needles are almost gone, or until larvae are present in large numbers. Cocoons attached to the needles are indicators of infestation, as are large amounts of cocoons and waste beneath the tree.

Red-headed pine sawfly

Tent Caterpillar

Identification: There are three important species of tent caterpillar: forest, eastern, and western.

- The forest tent caterpillar (*Malacosoma disstria Hubner*) is found in eastern North America. The larva has a brownish body, about two inches (50 mm) long, with pale bluish lines along the sides and a row of keyhole-shaped white dots down the middle of the back. Despite the name, members of this species do not make a "tent", but will cluster on the lower portion of a tree's trunk.

- The eastern tent caterpillar (*M. americanum* (F.)) is found east of the Rocky Mountains. It constructs a white web in the crotch of small branches. At full growth the larva is two to two-and-a-half inches (50 to 65 mm) long. The caterpillar has a black head, is covered with light brown hairs, has a light stripe on its back with yellowish-brown and black lines, and has blue and black spots on its sides.

Photos, top to bottom: James McGraw, North Carolina State; G. Keith Douce, University of Georgia; Herbert A. "Joe" Pase III, Texas Forest Service; Lacy L. Hyche, Auburn University; John A. Weidhass, Virginia Tech. www.forestryimages.org

Eastern tent caterpillar

- The western tent caterpillar (*M. californicum*) is found from the Rocky Mountains west to the Cascade Mountains. It has a pale blue stripe down the back, bordered by black stripes interlaced with traces of orange. The mature larva is around two inches (50 mm) long.

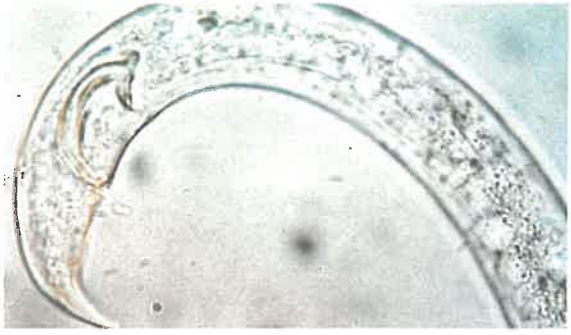
Damage: Larvae defoliate the host tree, eating its leaves. The forest tent caterpillar infests oaks, birch, sugar maple, tupelo gum, and other hardwood trees, but never red maple. The eastern tent caterpillar prefers tree species of the genus Prunus, specifically wild cherry, apple, and black cherry. The western tent caterpillar favors quaking aspen, cottonwoods, and willows.

Western tent caterpillar
Photos, L to R: Jerald E. Dewey, USDA Forest Service; William M. Ciesla, Forest Health Management International. www.forestryimages.org

Nematode

Identification: Nematodes are among the most abundant creatures on our planet. Nematodes are not insects, but are very small worms that range up to a quarter-inch (4 to 6 mm) in length; most often they must be observed with a microscope. Most nematodes feed on fungi, soil organisms, and bacteria, while some are parasites and feed on other animals, humans, and plants.

Damage: The nematode has a sharp, hard mouthpart called a stylet, used to puncture plant cells and remove their contents. This causes a reduction of nutrients and water, and puts the plant under stress. The nematode's attack makes the plant more susceptible to attack from insects, fungi, viruses, and disease, and reduces the yield of agricultural plants.



Pine wood nematode
Photos, L to R: L.D. Dwinell, USDA Forest Service; William M. Ciesla, Forest Health Management International. www.forestryimages.org

Sucking insects

Aphids, cicadas, spider mites, and scales are members of the order Homoptera, and are classified as plant feeders. Their feeding results in plant discoloration, distortion, wilting, and stunting; heavy infestation can kill the plant.

Aphids

Identification: Aphids (Aphididae) are small, soft-bodied insects, usually green and pear-shaped. A tube-like structure protrudes from the insect's abdomen, from which it excretes a sweet sticky liquid called honeydew. When dry and hardened, honeydew is difficult to remove. Ants will often protect a colony of aphids and, in return, feed on the honeydew. This is referred to as a symbiotic relationship: each member receives a benefit from the other.

Damage: When aphids appear in small numbers, the risk of serious damage is slight. When their population increases, however, they can reduce the trees' growth rate and cause death. Aphids feed on plant roots, stems, leaves, flowers, and seedlings. The aphid inserts its beak into the soft tissue and sucks out the sap of the plant. This causes the plant to wilt and curl. Trees injured by aphids are also susceptible to attack by other insects or diseases.

Aphids

Cicadas

Identification: Cicadas (Cicadidae) are large insects, one to two inches (25 to 50 mm) long, typically black with green markings. Males produce a loud, pulsating, almost buzzing sound from the base of their abdomens. When they reach the adult stage, the nymph crawls out of the ground and onto vertical structures (e.g., trees and houses).

Damage: The nymph lives in the ground and feeds on roots.

Cicadas

Aphid photos: James Solomon, USDA Forest Service.
Cicada photos, L to R: Robert L. Anderson, USDA Forest Service; Kenneth M. Gale. www.forestryimages.org

Spider Mite

Identification: Spider mites are in the same class as spiders (*Arachnida*) in the order Acarina, the largest order in the class. The mites are "free-living" and populous in debris and soil; the soil and leaf litter on one square acre of forest would uncover several million.

Damage: Spider mites are serious pests. They are commonly found on house plants, but also attack orchard trees.

Spider mite

Scales

Identification: Scales (Coccoidae) are small insects that often require the use of a microscope to identify them correctly. As the insect matures it becomes less active; its legs and antennae are lost at first molt and are replaced with a scale-like covering.

Damage: Scales attack cultivated orchard trees, shrubs, and greenhouse plants.

Scale

Spider mite photos, L to R: Mississippi State University Archives; John A. Weidhass, Virginia Tech.
Scale photos, L to R: USDA Forest Service Archives; John A. Weidhass, Virginia Tech.
www.forestryimages.org

2. Diseases

Trees are susceptible to many diseases that impair their structure and function. Tree diseases can be categorized as biotic (living) and abiotic (non-living).

In order to treat a tree disease, it is imperative to understand its cause. Note that poor tree health conditions are often caused by human activity. Prevention is the best defense against tree disease. While difficult to maintain in the forest, trees in community settings can benefit from preventive measures.

Leaf Spot

Identification: Leaf spot is caused by fungi that reside in leaf tissue, and whose spores disperse in rain and wind. As its name implies, leaf spot causes small round-to-angular spots on the leaf. Spots range in color from red to rusty-brown to brown, and vary in size.

Damage: Severe infections may cause defoliation and impact the tree's overall health.

Leaf spot
Photo: Clemson University - USDA Cooperative Extension Slide Series. www.forestryimages.org

Needle Cast

Identification: Needle cast fungi is a disease caused by Lophodermium sp. and Hypoderma sp., attacking many species of conifers. In the Southern US, more than 25 needle-cast fungi are known to exist.

Damage: The first indication of needle cast fungi attack is the brown or yellowish appearance of the tree's needles. The fruiting bodies on infected needles split open during wet weather in late spring or early summer. Spores are released and transported by the wind and rain to receptive needles. From late fall to early spring, before new needle growth starts, infected needles turn brown. The spores of the needle cast fungi are one-celled, colorless or nearly transparent, spindle-like in shape, and appear shiny black and elliptical on the infected needle.

Needle cast
Photo: Erich G. Vallery, USDA Forest Service.
www.forestryimages.org

Nectria Canker

Nectria canker

Identification: Several species of canker attack both coniferous and deciduous trees. Nectria canker is the most common to infect deciduous trees; though it usually does not kill the tree, it severely reduces the quality and quantity of wood.

Damage: Nectria canker kills wood, cambium, and bark in a localized area of the tree. Concentric ridges of callous material form each year, and as the canker expands the bark of the older material falls off.

Pitch Canker

Pitch canker

Identification: Pitch canker attacks Southern pines. Infection occurs through small broken branches, insect wounds, or other injuries to branch tips or stems. The fungus causes sunken cankers on the main stems, usually soaked with pitch that flows down the bole of the tree.

Damage: Sunken cankers secreting pitch are the main sign of an infection. Cankers girdle the main stem and can kill all or part of the tree. Wood beneath the canker develops a light to dark reddish-brown discoloration.

Damping-Off Disease

Damping-off disease

Identification: Damping-off disease is a significant problem in nurseries that grow coniferous tree seedlings. Several fungi are responsible for the disease, which can also attack hardwoods.

Damage: Newly-germinated seedlings are susceptible to infection, and may die before they break the soil surface. Infection of emerged seedlings occurs at or just below the ground line. Seedlings will fall over in nursery beds when stem tissue cells are destroyed.

Top and bottom photos: Edward L. Barnard, Florida Department of Agriculture and Consumer Science.
Middle photo: Robert L. Anderson, USDA Forest Service.
www.forestryimages.org

Slime Flux

Identification: Slime flux affects hardwood trees after being wounded by boring insects, mechanical damage, or such natural causes as splitting and cracking. Slime flux is caused by bacterial growth in the sap that flows from the tree wound; as the bacteria population grows, the area darkens and a foul odor is produced.

Damage: The persistent, oozing wound on the stems or bases of hardwood trees results in loss of quality wood. After the area is infected, the fluid surrounding the area is toxic to the bark. Over time, the bark separates from the tree and the wound grows.

Slime flux
Photo: Edward L. Barnard, Florida Department of Agriculture and Consumer Science.
www.forestryimages.org

Rust

Identification: **Rust is a fungus, and** several species attack trees. Often, but not always, two hosts are required for the life cycle of the rust. Common rust diseases include:

- White Pine Blister Rust, which affects "five-needle" pines.
- Fusiform Rust, which affects loblolly and slash pines.
- Eastern Gall Rust, which affects shortleaf, Virginia pines, jack pines, and red oaks.
- Western Gall Rust, which affects ponderosa and lodgepole pines in the west, and jack and Scot's pines in the east.
- Apple Rust, which affects apples and hawthorns.
- Ash Rust, which affects ash species east of the Rocky Mountains.

Species of rust are identified by the color, shape, and location of spores. The host species is also a good indicator.

Damage: Rust is an obligate parasite, and needs a living host to survive. While trees usually do not die from rust infection, their growth is restricted. The damage is often secondary to this growth regulation.

Rust
Photo: John W. Schwandt, USDA Forest Service.
www.forestryimages.org

Heart Rot

Identification: Many different species of fungi produce heart rot in hardwood trees. One of the most prominent symptoms of heart rot is the appearance of a conk, or a hard shell- or shelf-shaped structure, on the outside of the trunk or a major limb. Four species of fungi cause nearly half of all cases of heart rot; these are Hericium erinaceus, Pleurotus sapidus, Polyporus fissilis, and Laetiporus sulphureus.

Heart rot damage

Photos, L to R: Ladd Livingston, Idaho Department of Lands; Theodore D. Leninger, USDA Forest Service.
www.forestryimages.org

Damage: Heart rot enters the tree through large, deep wounds such as those caused during logging operations or fire. Fungal colonization cannot be controlled once it begins, and the decay process may continue for many years.

Brown Spot Needle Blight

Identification: Infected needles in the early stages of blight are encircled with irregular brown spots. Needles die, leaving green buds; large numbers of fallen needles around a seedling is evidence of an attack.

Damage: Brown spot needle blight is the most serious disease affecting longleaf pine seedlings. It increases the time seedlings need to grow beyond the grass stage; tree death is often the result.

Brown spot needle blight

Photos: Edward L. Barnard, Florida Department of Agriculture and Consumer Science.
www.forestryimages.org

Littleleaf

Identification: Littleleaf is a disease of shortleaf and loblolly pine in the Piedmont region of the Southeast US. Trees with littleleaf disease appear malnourished, decline slowly, and die prematurely. In early stages, foliage appears slightly yellow and needles appear shorter than normal.

Damage: Littleleaf leads to high mortality and growth reduction, destroying the growing root tips by soil fungus. It often occurs in heavy, wet soil with poor aeration and low fertility.

Littleleaf
Photo: Clemson University - USDA Cooperative Extension Slide Series. www.forestryimages.org

Annosus Root Rot

Identification: Annosus root rot is caused by a fungus infection that enters pines from airborne spores landing and germinating on freshly-cut stump surfaces. The fungus spreads to the roots and then to adjoining healthy trees. An infected area may be composed of dead trees without needles, trees with chlorotic foliage, and trees with healthy appearing needles.

Damage: Annosus root rot attacks and kills all species and ages of Southern pines. Fungus grows in the wounds or stumps and travels into the root system. The disease usually spreads to healthy trees by root contact. The fruiting bodies are greyish-brown to reddish-brown, bracket-shaped, and vary in size.

Annous root rot
Photos: Robert L. James, USDA Forest Service; USDA Forest Service Archives. www.forestryimages.org

3. Chemical applications

Chemical damage effects
Photo: Susan K. Hagle, USDA Forest Service.
www.forestryimages.org

Trees experiencing chemical damage display different symptoms. The level of damage depends on the type and amount of chemical exposure; for example, a tree accidentally sprayed with herbicide shows different symptoms from one that has been over-fertilized.

The effective compound contained in a chemical is referred to as its **active ingredient** (AI). The amount of AI applied to a tree will affect its level of damage and how quickly it shows signs of injury.

Symptoms vary for trees damaged by **herbicides**. These depend upon the mode of action of the chemical, the dosage received, the length of exposure, tree species, and weather conditions (e.g., temperatures, wind speed, amount of sunlight, and humidity). The herbicide may cause leaves to twist or cup, become yellow or brown, or fall off completely. Visible symptoms, however, should not be the only variables used to determine the cause of herbicide damage.

Herbicides, like all pesticides, are regulated under Federal and state law. There are two types of pesticides: restricted use (RUP) and non-restricted use. RUP products are clearly identified as such on their labels; non-restricted use products are those sold "over the counter" in garden centers and farm supply stores.

In order to purchase, transport, or apply RUP products, a person must complete a training course and possess a pesticide applicator's license Each state's Department of Agriculture can provide a copy of applicable regulations and requirements. It is very important to read and follow label directions when using any pesticide. It is unlawful to use a pesticide in a manner inconsistent with its labeling.

Improper **fertilization** can damage trees. Several problems are associated with over-fertilization. For example, excess nitrogen can stimulate succulent growth and cause poor fruit set. High levels of ammonia can induce a calcium deficiency. Excess phosphorus can cause micronutrient deficiency (e.g., zinc, iron, and copper). Too much potassium can cause a nitrogen deficiency and affect the uptake of magnesium and calcium.

Visible symptoms include curled or spotted leaves and tips, and scorched edges. As with pesticides, professional assistance is needed to monitor fertilizer use and application, and to identify problems.

Over-fertilization can also affect water quality. Read the label and apply only as recommended.

Air pollution (e.g., acid rain and high levels of ozone) also causes damage to trees, usually evidenced by reduced growth. Most trees are affected by pollution in some way, but more research is still needed to determine exactly how each species responds to each contaminate. It is often a challenge to determine which chemicals causes a tree's damage. Most are identified by analyzing leaf tissue; others by an air sample.

The USEPA regulates industries that pollute our air. The Clean Air Act, first passed in 1970, sets the allowable levels of pollutants that can be emitted into the atmosphere. Other pollutants, such as carbon monoxide produced from combustion of fossil fuels, contribute to the buildup of greenhouse gases in our atmosphere. Pollutants such as auto exhaust are not easily controlled, as it is nearly impossible to limit how much people drive.

Air pollution effects
Photo: Robert L. Anderson, USDA Forest Service
www.forestryimages.org

4. Mechanical damage

Humans are primarily responsible when a tree experiences mechanical damage (i.e., careless and improper use of equipment and machines). Damage may be caused by a motor vehicle, bicycle, lawn mower, excavator, or string trimmer. Injuries from mechanical damage often lead to the decline of the tree's health, a decrease in growth rate and vigor, and eventually death.

When a tree's bark, wood, limbs, or roots are smashed, gouged, cut, or removed, its ability to transport water, sugars, nutrients, and other chemical compounds through the tree is interrupted. In particular, the bark provides its defense against environmental extremes, insect attack, and infection.

Small, newly-planted trees have thin, easily-gouged bark and are very susceptible to damage. Damage can occur when a lawn mower is pushed against the tree, removing large sections of bark and denting the wood. This may be prevented by putting wood mulch around the tree's base. Apply a three-to-five-inch layer around the tree; the depth will determine the effectiveness of grass control. The width of the mulch ring depends on one's overall landscape plan, mowing equipment and pattern, and aesthetic preferences. Do not put plastic down under the mulch: this keeps water, oxygen, and nutrients from the soil. Instead, carefully remove the grass with a shovel, or spray with herbicide.

Mechanical damage effects
Photo: Morgan Nolan, University of Georgia.

Construction causes injury to both the above- and below-ground tree structures. For example, digging a home's foundation can sever tree roots and make the tree unable to absorb water and nutrients from the soil. Larger construction equipment can scuff the bark and break branches from the crown.

Young trees can easily be damaged by string trimmers (commonly known as "weed eaters"). When cutting grass next to the trunk of a young tree, their high-speed whipping action can cut and rip thin bark, or crush cells inside the bark that transport water and nutrients to the rest of the tree.

5. Animals

Animal damage effects
Photo: Randy Cyr, Greentree Technologies.
www.forestryimages.org

Trees are also damaged by wildlife. Deer may eat the fresh tips of young trees, and rub their antlers on the trunk to establish their territory. Beavers cut down trees with sharp, powerful teeth, and gnaw through the trunk; the felled tree is then stripped of its branches, which are used for food and construction of their dams and lodges. Squirrels and porcupines eat bark and branch tips. Wild hogs dig in soil around the tree looking for edible roots; this causes problems with tree root systems, and creates poor soil quality conditions.

Livestock also cause problems for trees. For that reason, grazing by domestic livestock (particularly cattle) is not advisable or recommended in hardwood stands. When confined to a corral, cattle seek shade provided by any tree within or adjacent to the confinement area. They gather underneath the tree and compact the soil with their hooves. When soil is compacted the ability of water to infiltrate is restricted, oxygen and carbon dioxide exchange is severely diminished, and bulk density (gm/cm3) of the soil is increased. Tree growth and health are reduced under such conditions. In addition, cattle, horses, pigs, and goats chew on leaves and branch tips.

It is more difficult to prevent tree damage from wildlife than from livestock, as the former are not confined and do not impact the resources of a single area. Livestock damage can be minimized by constructing fences around trees inside corrals, and pruning branches back away from fence rows. Shelters protect trees, and also protect animals from sun, rain, and wind.

6. Environmental factors

a. Air pollution

Trees are nature's air conditioners. An acre of forest removes three tons of carbon dioxide and produces two tons of oxygen per year. A person uses less than one pound of oxygen per day, or about 278 pounds per year. Thus, each acre of forest produces enough oxygen to support 18 people for a year. At the same time, an acre of forest removes 13 tons of dust from the surrounding environment, and releases 8,000 gallons of water into the air. This makes forest areas cooler and cleaner than surrounding areas.

b. Fire

Fire is a leading cause of tree damage. The National Interagency Fire Center reports that nearly 85,000 fires consumed more than three-and-

Fire damage
Photo: David J. Moorhead, University of Georgia.
www.forestryimages.org

a-half-million acres in 2001, and an average of more than four million acres each year between 1991 and 2000. Wildfire suppression is costly: $542 million was spent in 2001 alone. Some trees survive fire better than others. Conifers have thicker bark than deciduous trees do, for example; this insulates living tissue and provides better fire resistance.

c. Other natural disasters

Nature can damage trees in an instant. Millions of acres of forest land are destroyed by hurricanes, tornados, wind storms, and fires caused by lightning strikes.

- **Lightning:** Lightning damage is hard to diagnose visually. Some indicators include a strip of missing or burnt bark from near the top of the tree to the ground; or branches, limbs, and trunk areas that appear as if they were torn off, splintered, or "burst out".

  Exterior tree damage is not as severe as that inside the tree. Intense heat generated by a lightning bolt can kill vascular tissue in the tree and roots. A tree suffering from internal tissue damage cannot transport water or nutrients. Damaged tree areas are more susceptible to attack from insects and disease. Lightning protection devices for trees generally include copper cables installed near the top of each major branch, with ends connected to a ten-foot grounding rod buried in the soil beyond the tree's drip line.

Lightning damage

Mistletoe

Photos, top to bottom: Randy Cyr, Greentree Technologies; USDA Forest Service - Rocky Mt. Region Archives. www.forestryimages.org

- **Mistletoe:** Mistletoe is a perennial, evergreen plant parasite that grows in the crown of a tree. While normal populations will not kill the tree, mistletoe reduces the vigor of the branches to which it attaches. An overabundance of mistletoe in a single tree causes significant decline, making the tree unable to defend itself from insects or disease. Hardwoods, particularly hickories and oaks, are primary hosts for mistletoe.

- **Girdling roots:** Tree roots that grow around one other or the tree stem constrict the flow of water and nutrients, and are called "girdling" roots. When the stem is girdled the tree is weakened structurally, and may break under the stress of wind, snow, or ice. Girdling roots develop when the tree is improperly planted. This may

occur when the planting hole is too small, the tree is planted too deep, or a root-bound tree in a container is out-planted without removal of circling roots (which continue to grow in a spiral pattern).

Symptoms of girdling roots vary, based upon such factors as tree age, size, growing conditions, and climate. If girdling is extensive, leaves may show fall colors or drop early in the season. Branches in the tree crown may show signs of dieback, and the stem at the tree's base may show a lack of taper.

Snow damage
Photo: USDA Forest Service Archives.
www.forestryimages.org

Wind damage
Photo: Randy Cyr, Greentree Technologies;.www.forestryimages.org

- **Snow:** Snow sticks to limbs, particularly if wet and heavy, and can create structural failure.

- **Wind:** Wind will damage both large and small trees. For large mature trees, dead branches are dislodged. The swaying action of the crown will snap hollow or weak branches, and can lift the entire tree out of the ground; this is referred to as wind throw. Small trees, particularly newly-planted ones, can be lashed about to a point where the soil around the base no longer contacts with stem.

- **Frost:** Frost is not a factor for most trees, but can be detrimental to fruit growers if it occurs when fruit is set. Early spring frosts also damage a fruit tree's flowers, thus reducing yield at harvest time.

Frost damage
Frost photo: Andrew J. Boone, South Carolina Forestry Commission.
www.forestryimages.org

- **Flooding:** Flooding damages trees in several ways. Debris carried in floodwaters can rip off tree bark. In areas covered by floodwater for long periods, some tree species may be unable to breathe and will drown. In addition, receding floodwaters deposit large amounts of soil over roots, and may suffocate the tree.

- **Hail:** Hail can rip leaves and twigs from a tree, or can shred leaves. The tree sustains damage because photosynthesis cannot take place without leaves. The degree of damage depends upon hailstone size and the intensity of the storm.

Flood damage

- **Sunscald:** Trees with thin, dark-colored bark are susceptible to sunscald damage in summer or winter; young trees are more susceptible than older trees. Damage occurs when extreme temperature stresses kill cambium tissue. Summer injury results when bark is exposed to extremely high temperatures; winter injury from rapid temperature changes in the bark and conductive tissues due to a temperature drop at sunset.

  Sunscald damage is usually found on the south and southwest sides of the tree. Damage is identified by dead, cracked bark over sunken, elongated areas along the trunk.

Hail damage

Though natural phenomena cannot be prevented, tree care is very important after damage has occurred. A professional, certified arborist can prune broken limbs, or remove the entire tree if necessary. The best way to minimize tree damage is to keep it healthy; a tree needs sunlight, water, nutrients, and space to grow.

Sunscald damage

d. Water quality

Forests act as living sponges. They catch rainwater, clean it, and slowly release it into rivers and streams. The layer of leaves and twigs on the forest floor cushions the force of raindrops and prevents soil erosion. Forest soils can absorb up to 18 inches of water from rain or snow; roots hold the soil and prevent it from washing away. The cleaning value of forests has been known for decades, and has been actively used to protect water quality near reservoirs and lakes.

Flood photo: Randy Cyr, Greentree Technologies.
Hail photo: David J. Moorhead, University of Georgia.
Sunscald photo: Susan K. Hagle, USDA Forest Service.
www.forestryimages.org

e. Soil/site relationships

Trees survive and reproduce in natural settings that favor growth and survival, where site characteristics such as moisture, light, nutrients, and temperature are within satisfactory limits. Soil is a major determinant of site quality, and exerts significant influence in moisture and nutrients in the site. Soil changes from site to site within a forest stand: from the bottom of a hill to the top, from one side of a valley to the other. Knowing the type of soil in an area makes it possible to predict which tree species will be found.

Soil is comprised of three primary components: listed from largest to smallest, these are sand, silt, and clay. Each distinct soil type has these in a different proportion, along with rock, gravel, and other aggregates.

A soil's nutrient- and moisture-holding capacities are determined by the amounts of these components, and whether they are formed in layers. Sand does not directly contribute to a soil's nutrient level, but rather to its ability to hold moisture. Silt and clay particles have the greatest influence on nutrient level. Clay content significantly influences water-holding capacity. Clay particles are the smallest of the primary components: when they are bound together, water cannot fill the gaps between particles. Thus a layer of clay is almost impervious to water.

Each tree species' needs have upper and lower limits. The bald cypress, for example, is normally associated with swamps and other areas that are covered with water. It can, however, be planted outside its normal range in soils that are not covered in water but have high clay. This creates a low-oxygen environment for the root system, similar to that in a swamp.

The composition of a forest's species changes between the rich, moist bottomland to the rocky, dry upland. All species adapt and grow in their particular environments, and species in the bottomland exhibit different growth rates than those in the upland. Thus bottomland species will not be found in the upland and vice versa, though both may grow in the areas between the two.

f. Drought

A drought is an extended period wherein water availability falls below an area's requirements. Drought in a forest stand can decrease growth rates, diminish resistance to environmental stresses, disrupt food production and distribution, and change a tree's physiological processes.

Generally, three types of conditions are referred to as drought.

- Meteorological drought occurs when there is insufficient moisture for average crop or range production.
- Agricultural drought occurs when there is insufficient moisture for average crop or range production. This may happen even in times of average precipitation, due to soil conditions or agricultural techniques.

- Hydrologic drought occurs when available water reserves (e.g., aquifers, lakes, and reservoirs) fall below a statistical average. This may happen even in times of average or above-average precipitation when increased water usage diminishes the reserves.

Drought periods can create significant economic and social consequences. A famous example was in the dustbowl of the 1920s and 1930s, when vast areas of the US Great Plains were depopulated by a combination of drought and economic factors.

Drought damage

Photo: Andrew J. Boone, South Carolina Forestry Commission.
www.forestryimages.org

Section I:

Taking a Forest Inventory

DID YOU KNOW:

Measurement of trees at breast height (four and one-half from the ground, on the high side of the tree) became the accepted standard out of consideration for the back health of the foresters taking the measurements?

Objective: *The student will be able to design and implement forest inventory procedures.*

Good forest management decisions are based on sound knowledge. A forester must know the resources that are available, and how much is out there. To gather this information a forester conducts a **forest inventory** or **timber cruise**. A timber cruise is a systematic survey to gather the information necessary for forest management planning.

Vital information must be collected and determined before management activities are applied to a forest stand. This information helps select the best management approach and techniques. The forester first locates the property using maps, aerial photos, or **Global Positioning System (GPS)** data; then designs an inventory to uncover valuable information such as the number and species of trees, wildlife populations, and water resources present on the land.

1. Reading maps (land descriptors)

Every forest resource manager must master the ability to read a map. Maps are available in many forms, each presenting different types of information.

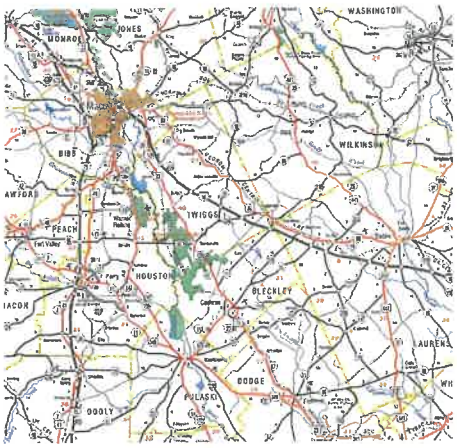
- **Orthophoto** maps are color-enhanced photographic images that show land features. They are particularly useful at delineating large areas covered by sand, marsh, and flat agricultural land.
- **Physical** maps show the earth's landforms and bodies of water. Shading and different colors indicate changes in elevation.

Orthophoto map
Image: US Geological Survey

- **Relief** maps also indicate elevation difference. **Shaded relief** maps use different tones to represent sunlight and shadows. **Raised-relief** maps are three-dimensional charts with sculptured forms projecting from a flat surface. They are produced in vinyl or plastic, with as much as two to three inches of projection.

Relief map
Image: US Geological Survey.

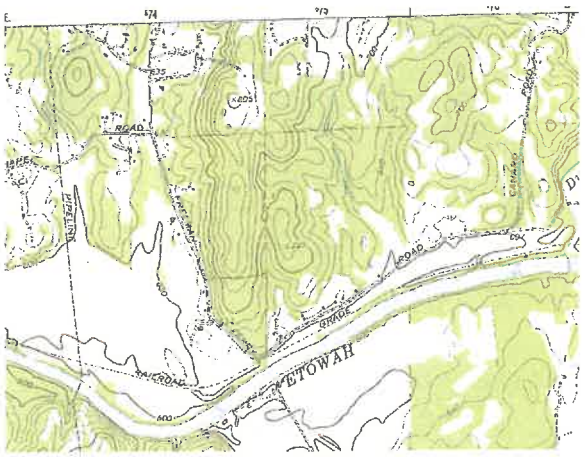
- **Road** maps, most commonly used by travelers, show interstate highways and state, county, and city roadways. They indicate distances between cities and roadway exits, and designate features such as colleges and universities, airports, museums, historical sights, rest stops, and state and national parks.



Road map
Image: Georgia DOT.

- **Topographic quadrangle** maps represent the land's shape and elevation. "**Topo maps**" convert three-dimensional features into a two-dimensional representation. **Contour lines** are plotlines of equal elevation typically representing 20-foot elevation differences, though the specific representation is noted on the legend. Lines that are close together indicate steep terrain, and those that are far apart indicate flat terrain. Topo maps show natural and artificial features including mountains, valleys, lakes, rivers and streams, vegetation type, roads, property boundaries, electrical transmission lines, railway beds, water wells, and buildings. Standard-issue topo maps produced by the US Geological Survey are referred to as **"7.5 minute" topographic quadrangles**. These maps cover an area that is 7.5 minutes of latitude by 7.5 minutes of longitude.

Maps come in many different forms and are used for different applications. Therefore, it is important to learn how to interpret map information. An example can be found by examining a topo map to locate these pieces of information.



Topographic map
Image: US Geological Survey.

Map scale

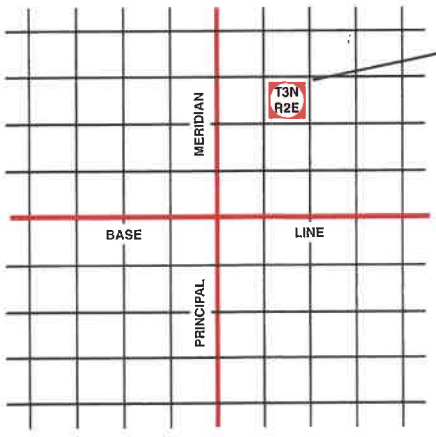
The **map scale** is the relationship between the distance on the map and the distance on the ground. The standard scale for a 7.5 minute topo map is 1:24,000, but scales can be as much as 1:250,000. The scale is a representative ratio wherein the first number is the map distance and the second is the ground distance. For example, a scale of 1:63,360 indicate that every inch on the map represents 63,360 inches (or one mile) of distance on the ground. The larger the second number, the smaller the scale of the map.

Topo maps indicate **land features** using points, lines, symbols, labels, and colored areas. Lines indicating vegetation are shown in green; water in blue; built-up areas in gray; major roads and land boundaries in red; and other roads, trails and railroads in black. Symbols indicate the location of churches, buildings, campgrounds, schools, and other structures and features. Contour lines are shown in brown. Because contour lines are of equal elevation, they never cross. **Index contours** are shown every fourth or fifth line to display the elevation.

Legal land descriptions (such as town names) are also represented on a topo map. Note that a common 7.5 minute topo map represents a limited ground distance, and the relationship between the townships and ranges may be difficult to read. For this reason, it is important to understand the **Public Land Survey System (PLSS).**

PLSS, first enacted by Congress in 1785, established survey guidelines for all public lands in the US. Previously, land had been surveyed using **metes and bounds**: a method that used physical descriptions to divide land (e.g., "starting at the blazed oak tree, follow the fencerow to the bank of the Wild River"). As land features changed this system created many ownership disputes. PLSS uses the **rectangular survey system**, a survey method that divides the land by reference lines parallel to the north-south meridians of longitude and the east-west parallels of latitude. This method outlines pieces of land shaped like rectangles. All states west of the Mississippi River (except Texas and the panhandle of Oklahoma), plus Alabama, Mississippi, and Florida have been mapped using PLSS.

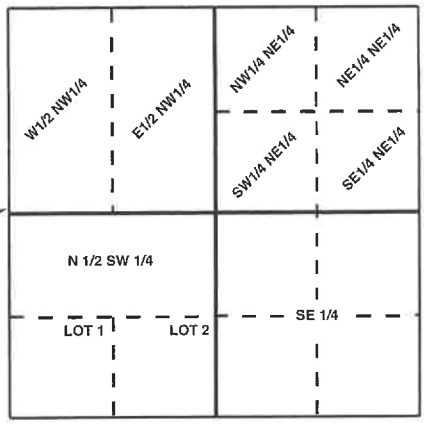
PLSS divides land into **townships**: areas six miles wide by six miles long, thus containing 36 square miles. A location is said to be a number of township units (T) either north or south of a map's base line, and a number of units east or west, referred to as **range** (R), from its **meridian**. For example, the notation "T3N, R2E" is read as "township three north, range two east". Applying this to a map, the location is twelve miles north of the base line and six miles east of the principal meridian.



TOWNSHIP GRID

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

T3N R23



SECTION 10

Each of the 36 square miles within a township is numbered as a **section.** The section in the upper right corner is number 1: numbering in this row proceeds right to left, so that the section in the upper left corner is number 6. Section number 7 is below number 6, and numbering proceeds in this row left to right to number 12, which is below number 1. Number 13 is below number 12, and the pattern continues in this way through number 36 in the lower right corner.

Each section contains 640 **acres**, and is subdivided into **quarter sections**, each with 160 acres. Quarter sections are divided into **forties**, or 40-acre areas.
Note that, due to the Earth's curvature, all townships may not be perfectly square and may not contain 36 sections: further, some sections do not contain 640 acres. This situation occurs more often the farther North one travels.

2. Aerial photographs

Aerial photographs provide useful information to the forester: changes in forest stand types, roadways, streams, boundary lines, home sites, and other important features. Aerial photos provide valuable mapping information when designing and conducting a timber cruise.

Aerial photo
Photo: Airborne Data.

Aerial photos used by forest resource managers are taken with the camera pointed straight down at the surface of the earth. These are considered to be **vertical photos** as long as the exposures are not tilted more than three degrees. As an airplane travels along a flight line a special camera takes multiple overlapping exposures; these allow a viewer using a **stereoscope** to view the area in three dimensions. Photos are taken depending on the specific application: e.g., a vegetation survey would need to be "flown" during the growing season.

Aerial photography is expensive, and flights must occur on sunny, clear days. Identifying cover type and plant species from an aerial photo depends on such factors as the scale and quality of the image, and the time of year photos were taken. The knowledge and ability of the person interpreting the photos is also a critical factor.

3. Using a compass

Compass use is an essential forestry skill. This simple tool is used to navigate from point to point, and is indispensable when conducting a timber cruise. The user must know the different parts and how they function together. The customary parts of a hand-held compass are listed below.

- The **baseplate**, also known as the **compass card**, is the section of printed information that forms the compass's foundation. It is usually marked with a grid or a ruler to measure map distance.
- The **travel arrow** is an arrow on the base plate. The compass user points the travel arrow in the direction he or she wants to travel.
- The **capsule** is the housing that contains the compass needle, orienting arrow, and bezel. Also referred to as the **compass housing.**
- The **compass needle** is the most important part of the tool. One end, usually painted red, is magnetized and always points to **magnetic North.**
- The **bezel** is a rotating ring graduated from 0to 360 degrees, and labeled with **cardinal directions** (N, S, E, and W) and **quadrants** (NE, NW, SE, SW). Also referred to as the **direction ring, degree dial,** or **Azimuth ring.**
- The **orienting arrow** is used to align the red compass needle to the **true North** direction. Note that magnetic North and true North are not the same.
- The **index mark** is the letter "N" printed on the bezel, usually in red.

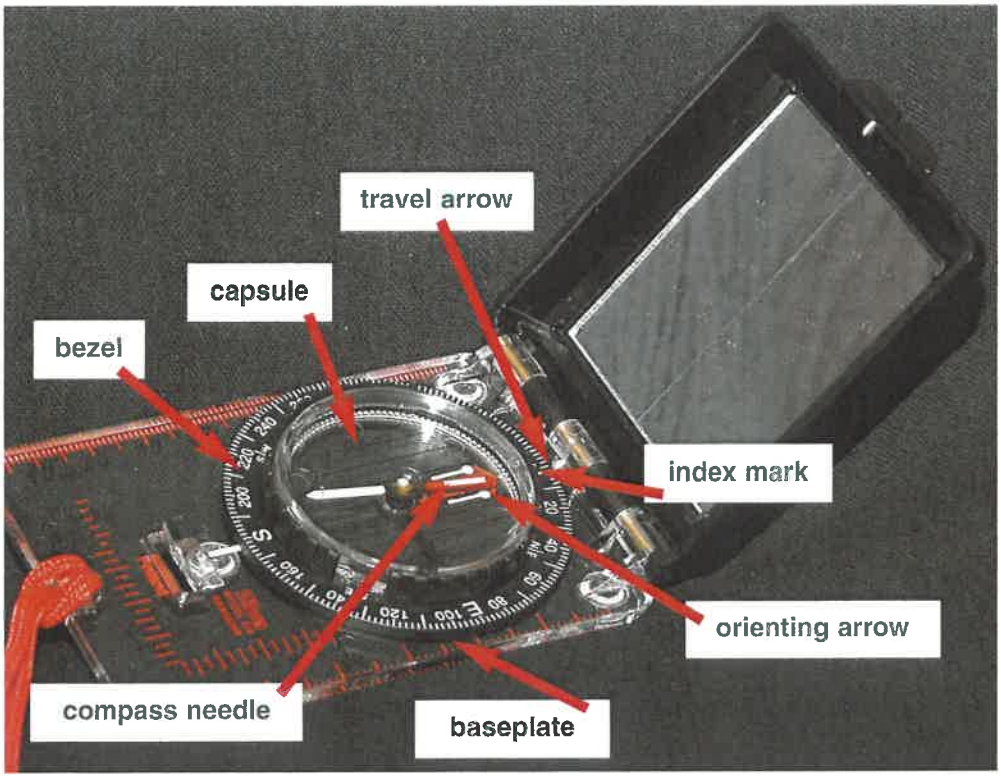


Photo: Morgan Nolan, University of Georgia.

Using a compass can seem complicated at first, but becomes easier with practice. A compass reading uses either **azimuths** (i.e., degrees only) or **bearings** (i.e., cardinal direction plus degrees). To find the directions for an object or particular direction of travel:

1. Hold the compass level at all times to allow the needle to rotate freely.
2. Face the object or the desired direction of travel.
3. Hold the compass at chest level one arm's length away so that the travel arrow (printed on the base plate) points toward the object or desired direction of travel. The compass needle will pivot and settle down, and the red end will point to magnetic North.
4. Turn the bezel until the travel arrow (in the capsule) is directly below the compass needle.
5. Carefully lower the compass, keeping it level. Note the index mark on the bezel that is aligned with the travel arrow. Read the bearing (e.g., north 43 degrees west) or azimuth (e.g., 226 degrees).

Note that **magnetic North** and **true North** are not the same. Magnetic North is continually shifting, so a compass must be adjusted using East or West **declination**, a factor indicating the difference between true North and magnetic North. In the Eastern US the declination is westerly; in the Western US, it is easterly. **Isogonic** charts show the number of degrees, East or West, of this shift. From this chart, the declination can be set on a compass for any region in North America.

4. Cruising standing timber

As mentioned above, a timber cruise is a systematic survey to gather the information necessary for forest management planning (e.g., merchantable volumes by species, growth rate, and site conditions). Other information that can be collected includes:

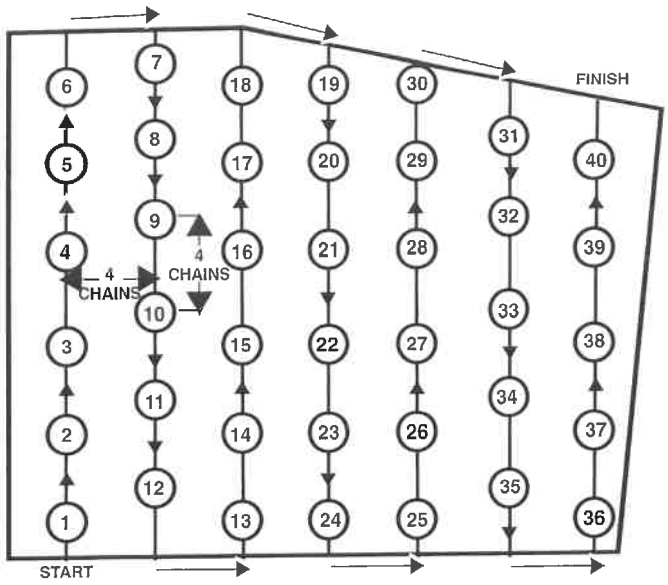
- Wildlife habitat.
- Special land features (e.g., future home sites, streams, and access points).
- Evidence of disease or insect problems.
- Presence or absence of advanced regeneration.
- Stand assessment (e.g., use of prescribed fire for control of competition).

The goal of a timber cruise is to acquire accurate information at the lowest cost possible. It is not often possible to measure every tree in a timber stand. Thus, foresters developed statistical **sampling** methods to evaluate a characteristic portion of the entire stand.

Sampling reduces time and costs by providing accurate estimates of timber volume and value. Select sampling areas that are **representative** of the stand; that is, the portion sampled should be similar to the surrounding area.

The most common sampling methods are **plot sampling** and **point sampling**. Both methods use compass lines at predetermined distances and widths throughout the stand. The forester takes plots or points at specific intervals along each compass line, which create a **sampling grid.**

Plot sampling is a method whereby the forester establishes circular plots at specific distances along the compass line. Plot sizes, distances between plots, and distances between compass lines are set based upon the desired **cruise percentage**, or the proportion of the stand that will be evaluated.



Point and plot sampling

Point sampling is a method whereby the forester marks **sample points**, or narrowly localized places, along the cruise line. At each point, a **prism** or **angle gauge** (refer to **Section F**) is used to determine if the tree is "in", "out", or "borderline". Smaller prism factors result in a larger number of trees being sampled. The type of glass (clear or amber) used to make the prism can help alleviate problems caused by glare, or shadows caused by underbrush.

The number and size of sample points depends upon:

- The desired degree of accuracy.
- The size and shape of the stand.
- The variability of the characteristics to be measured.

The size of a sample plot will vary from 1/4 acre (plot radius = 58.9 feet) and 1/5 acre (plot radius = 52.7 feet) for large sawtimber and poles, to 1/10 acre (plot radius = 37.25 feet) for pulpwood and small sawtimber. The number of plots measured depends on the total size of the forest stand and the value of the timber products therein. In general, the sum of the plot area sampled should represent 20 percent of the total area for tracts under 300 acres, and 10 percent for tracts larger than 300 acres. For a stand of high-value timber (such as black walnut), however, a 100 percent cruise may be necessary.

An aerial photo can be used to set up the cruise. After determining the number of plots, draw lines on the photo to set the plots in a grid pattern. Plots should cover timbered areas and not open pastures, roads, streams, or other areas not representative of the stand.

Before setting up the cruise, determine what information will be collected. Most cruises collect tree **diameter**, merchantable **height**, **species**, and **grade**; some include **volume** and **site index (SI)**.

Diameter
Photo: James Strawser

a. Diameter

A tree's **diameter,** or the distance running through its center from one side to the opposite side, is measured at four and one-half feet (4 1/2 ') above the ground on the high side of the tree. This measurement is known as **diameter at breast height** or **DBH.** A standardized method makes the task of measuring easier, and standardized diameter measurements are used to develop **volume tables.**

When cruising, tree diameters are recorded in two-inch classes: e.g., the 10-inch class contains trees with DBH of 9.1 to 11.0 inches, and the 12-inch class contains those with DBH of 11.1 to 13.0 inches. This reduces the time spent cruising, and facilitates the process of determining total tree volume.

Tools used to measure DBH include **diameter tape**, a **Biltmore stick**, and **tree calipers** (refer to **Section F**). A diameter tape is small and fits in the pocket of a cruising vest. Experienced foresters may master the skill of "ocular estimation" or "eyeballing", however, and be able to tell a tree's diameter class just by looking at it.

Height
Photo: James Strawser

b. Height

After determining the DBH, the tree's **height** must be measured. **Merchantable height** is the usable, marketable portion of the tree. It is measured from **stump height**, generally six inches from the ground, to the **cut-off point**, where the tree reaches its recommended **small-end diameter**. Cut-off points vary with tree species, the application for which it is cut, and the local market. Recommended small-end diameters for common products are two to three inches for **pulpwood**, four to six inches for **chip'n'saw**, and eight to ten inches for **sawtimber** and **veneer logs**. Tools used to measure tree height include the **clinometer**, **Biltmore stick**, and **relaskop** (refer to **Section F**).

c. Volume

A tree's **volume**, typically expressed in **cords** or **board feet**, is determined by DBH and height measurements. **Volume tables** for different species allow the forest landowner to quickly estimate the amount of wood in a tree. To use a volume table, find the tree' s DBH on the left axis and the corresponding height of the tree across the top, and then locate the corresponding value. Volume tables are based on research data that takes into account a tree's **taper,** or gradual decrease of diameter from base to top.

Each table is also referenced to a species' specific **form class**. Form class is an expression of a tree's taper, used to select the appropriate local volume table for a stand. For example, Form Class 78 is acceptable for most pines in Georgia.

d. Site index (SI)

Site index (SI) is a relative measure of forest site quality, based on the combined effects of soil and climate on tree height growth. SI is based on the height in feet of one or more species in a given area, at ages of 25 to 100 years. A particular species may correspond with several SIs, which are then grouped into **site classes**.

Forest managers use SI to estimate future forest productivity, and as a guide when developing silviculture prescriptions. In many states, SI is used to assign values to the forestland. It is also used in land-use planning and zoning to identify areas best suited for growing timber. Professional foresters have calculated SI curves for most US timber species; this requires knowledge of forests, tree growth, soils and hydrology, and ecology

e. Species

Tree **species** in a given land area vary as site conditions change (e.g., soil type and available moisture). Not all tree species are valuable for timber. And though pine, oak, black walnut, cherry, and tulip poplar are timber species, they will not grow in the same area: each has specific site conditions that favor maximum growth. When setting up a cruise, be aware of site differences and anticipate tree species in those areas. Learn to identify local species and to recognize them throughout the year (e.g., hardwoods do not bear leaves in winter).

f. Grade

A tree's **grade**, or classification of its product characteristics, is part of the cruise data. High-value hardwood used for specialty products is evaluated based on wood size and quality. Defective limbs or scarring decrease their value. For pine timber, trees are classified into one of five grades: **pulpwood**, **chip'n'saw**, **veneer** or **peeler**, **sawtimber**, or **pole timber**. Tree value per unit of volume increases through these five grades from pulpwood to poles. Larger trees carry higher value, and tree quality is important as well. A large, tall, straight tree is more valuable than a shorter tree with a curved stem.

Section J:

Forest Business

DID YOU KNOW:

Annual sales in the US forest and paper products industry exceed $200 billion?

Objective: *The student will be able to describe the business aspects of forestry.*

The goal of growing and selling any crop is to make a profit: timber is no exception. To make a profit, a forest landowner must understand and apply sound forest business principles. Growing trees from seedlings to marketable size requires significant financial investment: important management decisions must be made early on and at many points along the way. Sound decisions early in the process are easier and less costly to implement than they would be later on, when missteps must be unmade.

Like gold or oil, timber is a **commodity**. Management activities applied during the rotation of a timber stand determine the net profit or loss on investment. This section offers a brief glimpse at these activities in the world of forest business.

A **contract** is a legally binding document that identifies the parties involved in a business transaction, and defines each party's expectations, responsibilities, and benefits. In a sales transaction, a contract protects the seller and buyer of goods or services. Note that all contracts should be prepared and reviewed by an attorney.

1. Sales contracts

A **timber sale contract** is an agreement between the owner of the timber and a person who wants to buy it. Timber is typically sold on either a lump-sum or a pay-as-cut basis. Under the **lump-sum** method, the timber is sold for a specified amount that is agreed to and paid for in advance. Under the **pay-as-cut** method, the price is negotiated on a per unit basis (e.g., cord, ton, or board foot) after the harvest volume is determined; payment is due after the logger delivers the timber to the mill. The method a seller selects depends on his or her financial situation; thus he or she should consult a financial advisor before entering into a contract.

Note too that all timber tracts are different: the terms and conditions of each timber sale contract must be customized to match the specific characteristics of the tract. Sample timber sale contracts are available from state forestry agencies and on the Internet. These should serve only as a guide.

In most cases a timber sale contract consists of five sections: a preamble; a description of the sale area; a designation of the trees to be sold; the conditions of sale; and the signatures and witnesses.

The **preamble** legally defines who the seller and buyer are. It lists names and addresses of all individuals and businesses involved in the transaction. It specifies the exact dollar amount to be paid for timber designated for harvest at a specific location, and the method and time of payment. The preamble also specifies whether the seller or buyer employs the persons harvesting the timber.

The **description of the sale area** is a legal explanation of the land to be harvested, and should reference a survey map to be included with the contract. It describes how the boundaries of the sale area will be marked (e.g., using paint or flagging), and guarantees that the parties have clear title to the land and the right to harvest timber.

The **designation of the trees to be sold** depends on the harvesting objective. If a final harvest is to be done where all marketable trees are removed, then only the boundaries need to be marked. If only a portion of the stand is to be harvested, however, then only those trees are marked. A specific description (e.g., "trees are spot painted on the stump and at breast height') eliminates confusion and helps loggers identify trees to be harvested.

Conditions of sale must be agreed upon by both seller and buyer. This contract section describes both parties' responsibilities, and lists penalties for any contract violations. It can include:

- A description of logging methods, utilization standards, and merchantability.
- Locations of log landings, roads, and skid trails; and requirements that affected areas be stabilized and revegetated after harvest.
- Specifications of how soil, water, and recreational values will be protected, and requirements that Best Management Practices be used where appropriate.
- Requirements to abide by all local, state, and Federal laws and regulations.
- Language that allows the agreement to be assigned to another agent only with the seller's written consent.
- Assignment of liability for losses, protecting the seller from workers' compensation claims, liability lawsuits, and property damage claims.

All contracts must bear the **signature** of both seller and buyer, and the date of signing. Two people who can verify the signatures must also **witness** them. Both seller and buyer should receive file copies of the signed documents.

2. Logging contracts

Note that the buyer is not always the person who will harvest the timber: in many parts of the country, a buyer often draws up a separate **logging contract** with a logging company for this purpose. A seller should work closely with a professional forester who can guide them through the selling process and ensure that the harvest is carried out according to the contract's terms.

3. Taxes

For many years, tax rules in the US have encouraged non-industrial private forest owners to manage their timber. Tax incentives and timber investment opportunities provide significant advantages, but the process of securing these can be confusing and frustrating. Note that US tax laws change yearly and require careful attention.

The following is an overview of tax information and timber management, not a complete guide. It discusses different types of forest ownership, how timber is taxed, common deductions and costs associated with managing timber, and how casualty loss is determined. Forest landowners should consult a tax attorney to consider all options.

In general, how a forest landowner treats his or her taxable income from the sale of timber depends upon how long and in what way the timber is held. Timberland is held or owned for one or more of three purposes: personal, investment, or business.

- A **personal** timber holding is not used to produce income. Many people own timberland that includes a home and serves as their place of residence. The property may provide such recreational opportunities as hunting, fishing, and bird watching.

- **Investment** timberland is managed to generate a profit, but is not the owner's primary income source. This category includes timber-related activities undertaken for the purpose of generating income.

- **Business** property is part of an activity entered into and carried out for profit on a regular basis. The timber resource is "for sale" to customers. Often a decision must be made about the business structure (e.g., whether it is a sole proprietorship or a partnership). The structure of ownership and tax strategy is based on such factors as financial goals, quantity and quality of the resource, and level of timber-related activity.

The provision of capital gains for cutting or other uses significantly affects how timber is taxed, and is covered in Section 631 (a and b) of the Internal Revenue Code.

Capital is an expenditure that creates or establishes an asset. **Capital gains income** comes from the sale of assets that have increased in market value. For example, consider a tract of timber. Over time, trees grow and gain value as a wood product. What began as a stand of trees grows into saw timber, and increases in market value. Sale of the timber creates capital gains income.

Section 631(a) applies to a timber owner who decides to harvest it by him or herself, or hires someone to accomplish the task. It allows the timber harvest to be considered either a **sale** or an **exchange**. To be eligible the person must either own the timber, or hold a contract right to cut it, for more than six months prior to harvest and on the first day of the taxable year. He or she must also cut the timber for sale or for use in trade or business.

Section 631(b) applies to owners who dispose of their timber under a harvest contract, but retain an economic **interest**. To be eligible, the person must be either an owner, a sub-lessor, or a contract holder for more than one year prior to harvest. There is no precise definition of an economic interest, but it can be compared to a pay-as-cut contract as described above. The timber owner is paid a stipulated price per board foot or cord volume; the amount he or she receives depends on the amount of timber cut.

Note that Section 631(a) is an **elective** provision: the timber owner must choose to exercise it. Section 631(b), on the other hand, applies **automatically**. The owner determines how to treat the income generated from his or her interest in a timber harvest.

There are **costs** associated with owning timber: it is important to determine which should be **capitalized** (e.g., claimed as a capital expenditure) and which should be **expensed** (e.g., claimed as a tax-deduction). As mentioned above, expenditures that create or establish an asset are considered capital. Those used to manage, maintain, or improve the asset are considered expenses: these can include pest and fire control; insurance; interest paid on loans and mortgages; taxes; labor and consulting fees related to managing, cutting, and harvesting; and tools, materials, and supplies.

The US tax code categorizes an improvement with a useful life of more than one year as a **capital expenditure**. An example would be the costs associated with planting trees for timber production. These costs may include site preparation (e.g., herbicide applications and removal of brush), seed or seedling costs, and tool and labor costs (including depreciation of planting and seeding equipment).

The cost of cruising timber (i.e., walking a forest to measure the trees and collect other information) can be either capital or an expense, depending on when and why the cruise was performed. A cruise of a tract of timber in connection with a potential purchase is a capital expenditure; after the purchase, it is a deductible business expense.
Other capital expenditures include the purchase cost of land and timber (including associated legal costs); permanent improvements to the land; construction of fire brakes; and equipment having a useful life of more than one year (including repair costs).

Section 165(c)(3) of the US tax code defines **casualty loss** as a deficit resulting from a fire, storm, or other natural catastrophe. The loss must be sudden, unexpected, or unusual (e.g., not caused by gradual deterioration through steady operating force). For example, consider a timber stand that is damaged by fire, and later killed by opportunistic insects or disease. The fire damage is viewed as the casualty, not the insect or disease infestation.

Casualty loss not compensated by insurance is deductible from ordinary income during the year it is sustained. The loss must be a casualty incurred in a trade or business, or in a transaction entered into for profit (even if not connected with a trade or business).

4. Profit and loss

Just like any businessperson, a forest landowner's objective is to show a profit at the end of the year: a profit is earned when income is greater than expenses. The landowner's **profit and loss statement** (also referred to as an earning or income statement) shows a tabulation of the land's income compared with expenses incurred.

Categories showing revenues and expenses in a profit and loss statement follow a prescribed order regardless of the nature of the business. Recording expenses consistently under the same headings allows year-to-year profit analysis to be computed easily.

5. Record keeping

Good forest management, tax benefits, and fiscal responsibility all require careful **record keeping.** Records keep track of production costs and assist in estimating taxable income or expenses from timber sales. Accurate tax records help to:

- Establish accounts and allocate costs for land and timber purchases.
- Track expenses associated with forest management.
- Record income from timber sales and adjust timber accounts.

It is very important to establish a framework for recording forest management income and expenses. At minimum, accounts should be established to record capital assets, management and operating expenses, and income.
Examples include the following:

- Land, timber, equipment, and buildings that are purchased, inherited, or gifted are **capital assets**. These are not deductible from income taxes in the year they were acquired: a deduction can only be taken when the asset has been disposed of through sale, depletion, or depreciation.
- **Management and operating expenses** are those considered ordinary and necessary to manage, maintain, and improve the profitability of forest land. The type and amount of deduction allowed depends upon the ownership status (e.g., business, investment, or hobby). Expenses can be categorized as **fixed** or **variable**. Common management and operating expenses include fees for consultants; property taxes; equipment repair; insurance premiums; and business-related travel and meetings. Specific expenses are allowed if land is used for forestry-related tours and demonstrations.
- **Timber sales income** is that from sale of land, timber, and equipment. Depending on the type of sale, and the length and classification of ownership, the landowner may claim a capital gains treatment of the income. Note that revenue from firewood and pinestraw permits, hunting leases, and some forms of cost-share payments are treated as ordinary income.

Section K:

Safety in the Forest

DID YOU KNOW:

Ticks are not insects? They instead are classified under the order of acarina and are related to spiders and scorpions. Lyme disease is a common tick-borne illness caused by the bacteria known as spirochete.

Objective: *The student will understand how accidents can be prevented, and learn about ways to prevent personal injury while in the forest.*

Many occupational hazards are associated with forestry work, including the risks involved with operation of heavy equipment, falling trees, extreme environmental conditions, and negligent coworkers. Working in the forest is not the only source of injury, however. While walking along a trail, for example, a person may twist an ankle, suffer heat exhaustion, or get stung by an insect.

This section provides information to help prevent an accident or injury while in the forest. It also offers suggestions for first aid if an accident or injury happens.

Maintain personal safety when working in the forest: this is the most important element for preventing personal injury and property damage. Industrial safety experts H.W. Heinrich and Alfred Lateiner developed an accident analysis system to explain how injuries occur. They identified five components that create an injury sequence:

- *Background:* The observable historical elements that lead to the occurrence.
- *Personal characteristics:* A person's skill or knowledge level, attitude on the job, and physical or mental condition.
- *Unsafe acts or conditions:* A person's risky behavior and the conditions he or she allows to exist.
- *Accident:* An unplanned event that results from unsafe acts or conditions. An accident may result in an injury.
- *Injury:* A person is physically hurt.

Frequency of injury can be controlled if one or more components of the sequence are removed. It is unlikely to negate the background and personal characteristics components, but it is possible to remove the unsafe acts or conditions. Removal of these components is the responsibility of all employees: laborers, supervisors, and management. This requires proper job training and supervision, routine equipment maintenance, and common sense. Consider the following example:

CASE STUDY: Falling Limbs Injure Logger

Background: In the morning of a mid-summer day in the Lake States, a logger was about to fell a tree in an area that was being clear-cut.

Personal Characteristics: The 41-year-old logger had worked in the woods all his life. He received formal safety training but did not use the techniques he learned on the job. It is unknown if he was wearing personal protective equipment at the time of the accident. The logger started his day by operating the forwarder. Around 10 am, he caught up with the cutters and decided to cut some trees by hand in order to finish his load. He could hear the trucks coming to pick up the wood, and wanted to hurry and fell a tree before they arrived.

Logger
Photo: Chris Schnepf, University of Idaho.
www.forestryimages.org

Unsafe Act or Condition: Only four trees remained where the logger was working. One was a dead tree within a tree-length of the tree the logger planned to cut. The logger decided not to bother with directional felling of the tree because the area around him was almost clear.

Accident: When the tree started to fall, it fell through the dead tree, causing it to snap back and throw broken limbs toward the logger, hitting him in the shoulder.

Injury: His injuries were enough to immobilize him, so that he was not found for two hours, in spite of his calling out for help. He spent two days in the hospital and was out of work for six weeks. The logger suffered no broken bones, but was severely bruised.

Recommendations for Correction:

- Before felling trees, always conduct an appraisal of surrounding trees for potential hazards, and either fell, remove, or avoid these trees before felling adjacent trees.
- Determine a safe direction of fall. Before beginning to fell any tree, plan and clear an escape path.
- Use proper directional felling techniques: cut a notch, then go to the backcut, being sure to leave sufficient hinge wood to guide the tree to the ground.
- Always wear personal protective equipment when felling trees: hard hat, eye and hearing protection, and chainsaw-resistant leg and foot protection.
- Always work within visible or audible contact of a co-worker.

1. Wearing apparel

Protective clothing suggested for forest use include.

- Long pants to protect legs from scratches and insects. Light-colored fabric will show ticks and ants.
- A long-sleeved shirt is best for forest work; short sleeves can be worn in open-field or high-heat conditions. Tucking the shirt into the pant top will keep insects from under the clothing. A light-colored shirt is cooler, and will show ticks and other insects.
- Sturdy foot wear is a must whether working or walking in the forest. Work boots or shoes (or other appropriate footwear with a closed top, hard sole, and hard upper) will protect feet from piercing objects and provide support in uneven terrain. Lightweight hiking boots are adequate for use on moderate to level ground without sharp rocks and wood debris. Laced leather boots with cleated soles provide the greatest support, and protect feet and ankles against injury from sharp objects like rocks and jagged branch ends.
- Light-colored socks to show ticks. Tucking the pant legs into socks will prevent ticks, ants, chiggers, or spiders from entering.

2. Environmental awareness

Pay attention and recognize outdoors situations that pose a threat to personal safety. A forester spends a great amount of time working outdoors, and must be prepared for all conditions. Consider this scenario:

It's late afternoon; you've been cruising timber all day and your vehicle is on the other end of a large tract of timber. The forecast predicted a chance of severe weather. You left your hand-held radio and rain gear in the truck because you didn't want to carry them all day. Suddenly, the wind begins to blow, lighting streaks the sky, and rain falls in sheets. You start running in the direction of the truck, but unfortunately you step in a stump hole, severely twisting your ankle, and you are unable to walk. What should have been done differently?

Solution: A prepared forester would heed the forecast and pack a hand-held radio and rain gear in his or her cruising jacket. More importantly, he or she would have noted the changing weather conditions and started back to the safety of the vehicle before getting caught in the middle of the severe thunderstorm, injured, and without a way to call for help.

Look, listen, think, and react when in in the woods. Personal protection is every forester's job.

3. Equipment use

When working in the forest it is important to wear personal protection apparel to protect the feet, hands, head, and eyes. Boots, gloves, hard hats, and eye and ear protection are essential, and additional items such as Kevlar chaps are required when operating power equipment such as a chainsaw. Most forest work is accomplished using simple hand tools that require no special safety equipment. Refer to **Section F** for a description of common hand tools used by foresters.

4. Health hazards

Terrain: When walking through an unfamiliar forest, pay special attention to changes in terrain. Go slow: trails may be steep, rough, rocky, and slippery. Stump holes are often hidden by leaves and brush. A slip or fall in the forest can cause a cut, scrape, bruise, sprain, or broken bone.

Heat: Overheating is common when one performs strenuous activities outdoors, and weather conditions are hot and humid. Heat-related illnesses include **heat cramps**, **heat exhaustion**, and **heat stroke**. Cramps are the least severe and require simple first-aid treatment. Exhaustion and stroke may be life-threatening: a person suffering from either condition must receive medical attention immediately. Recognizing these medical conditions could save a life.

When working outside in hot weather, it is important to wear clothing to keep cool. Lightweight and light-colored clothing should be worn when working in hot weather. Lightweight material allows ventilation. Light-colored clothing reflects more of the sun's rays, effectively reducing solar heating.

A well ventilated hat with a brim will protect the head and eyes from the sun. It is critical to keep the head cool! Much like the radiator of an automobile cools the engine, blood vessels in the head are close to the skin and function to dissipate heat, cooling the body.

Work should be performed at a slower pace in higher temperatures. Take breaks often and drink plenty of water to replace what is lost through perspiration. Doing so allows one to work longer and reduces the chance of heat-related illness.

Cold: Cold-weather conditions require a different approach. Exposure to freezing temperatures may result in **frostbite** and **hypothermia**.

Frostbite occurs when parts of the body are frozen; most at risk are the fingers, hands, toes, feet, ears, nose, and cheeks. Under extreme cold conditions, the body reduces blood flow to extremities and diverts it to vital organs. Blood keeps tissue warm, and without adequate blood flow tissue will quickly freeze. There is no treatment to reverse the affects of frostbite. The affected body area may be saved, but surgery is often required.

Hypothermia occurs when a person is exposed to cold temperatures (water or air) for a long period of time. The body expends all its energy trying to stay warm. When the

body's core temperature drops to 90-93ºF (34-35ºC), the brain begins to shut down and does not function normally. A person suffering from hypothermia is unable to make reasoned judgements and may not even realize what is happening: without proper medical attention, severe injury or even death is possible.

Cold-related injury can be prevented by dressing properly. Body heat warms the air space trapped between the layers; thus several layers of light clothing are better than one heavy layer. Textile technology and manufacturing advancements have led to the development of lightweight materials that keep a person warm and dry. There are three components to layering: **base**, **insulation**, and **outer**.

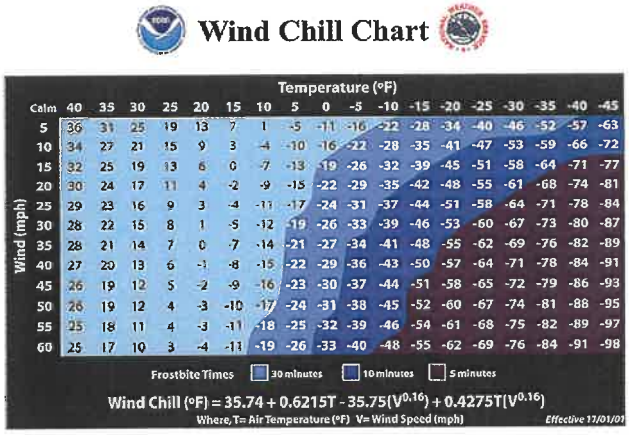
- Keeping skin dry is the first level of defense against cold. Worn next to the skin, the **base layer** functions to wick moisture away. Instead of absorbing water, materials such as "Polypropylene" and "Coolmax" transfer it from the skin and create a dry layer of air between the material and the body.

- Put on over the base layer, the **insulation layer** maintains a comfortable body temperature. Depending on the level of physical activity, this layer can be light or heavy, thick or thin, tight or loose. Goose down is an effective lightweight insulator, but loses its insulating ability when wet. Wool and "Polartec", however, retain insulating qualities under these conditions.

- The **outer layer** is most important because it provides protection from rain, snow, and wind. Many different materials are available that offer varying degrees of protection. Some, like "Gore-Tex", are waterproof; others, such as "Supplex", are designed to block the wind. The outer layer protects the insulation and base layers. If these inner layers become wet or are penetrated by the wind, they will not provide warmth or comfort.

Layering also allows easier regulation of body temperature. Clothing layers can be removed as one warms up and put back on as the physical activity level decreases. Protecting the extremities (i.e., hands, feet, and head) from the cold is also important; wearing insulated footwear and gloves, socks, and a hat made of thermal-regulating material will help protect the extremities from cold-related injury.

Wind is also a major cold-weather factor, contributing to a dangerous condition known as **wind chill**. This term describes the rate of heat loss from the human body from the combined effect of freezing temperatures and wind.



Wind chill chart
Source: National Weather Service, National Oceanic and Atmospheric Administration, US Department of Commerce.

Wildlife: Many different species live in and around the forest. Some are large, like bears and elk; some are very small, like ticks and mosquitoes; and many are in-between like squirrels, birds, wolves, and of course humans. Some are airborne, but most live their lives on the ground. Just as each animal's size is different, so too is the level of threat each poses to a forester's safety.

Blister beetle
Photos; Clemson University - USDA Cooperative Extension Slide Series. www.forestryimages.org

Most animals are not dangerous. Even though hundreds of thousands of people spend countless hours in the forest each year, the ocurrence of animal injury is rare. The likelihood of being injured by a wild animal is very low. More likely are bites or stings, which cause minor irritation and usually require no medical attention. Be aware, but unafraid, when observing in the forest.

Most forest-dwelling animals, large or small, are **non-venomous**. They can inflict injury, however, by biting or scratching if disturbed or threatened. One is more likely to encounter annoying insects like ants, mosquitoes, and flies. These pests can bite, leaving a welt on the skin that may itch or burn.

Found in the Eastern US, the blister beetle can inflict injury without biting, stinging, or scratching. When disturbed, the beetle releases an oily substance called "cantharidin" from around the joints of its legs, which causes human skin to blister.

Ticks inhabit the forest, but are not insects; they are classified under the order of **acarina** and are close relatives of spiders and scorpions. A person residing in an area where ticks are found will often find one on his or her body after spending time outdoors. Ticks are capable of transmitting diseases to humans. As the area wheren ticks are found increases, so does the incidence of tick-borne illness.

A common tick-borne illness is **Lyme disease**, spread by the ticks found on field mice and deer. Three types of tick are known to carry the disease: the black-legged tick (*Ixodes scapularis*), the Western black-legged tick (*Ixodes pacificus*), and the lone star tick (*Ixodes neotomae*). These ticks are usually small, about the size of a pin's head, but have been found as large as a orange seed. Lyme disease is caused by the bacteria known as **spirochete**, of which more than 300 strains have been identified worldwide. Lyme disease has been recorded in more than 40 US states; when spending time in a forest, it is important to take precautions to protect against tick bites.

Black-legged tick

Lyme disease symptoms
Photos left to right: Scott Bauer, USDA ARS; Allen C. Steere; USDA Archives
www.forestryimages.org

Lone star tick

Few animals found in the forest are **venomous**. A venomous animal injects poison by biting or stinging. Venomous animals include stinging insects (e.g., bees and hornets), spiders, centipedes, scorpions, and snakes—probably the most feared of all. Most everyone can identify stinging insects, but not venomous snakes. There are two types of venomous snakes: **pit vipers** (which include rattlesnakes, cottonmouths or water moccasins, and copperheads), and **coral snakes**.

Timber rattlesnake
Photo: Arnold T. Drooz, USDA Forest Service
www.forestryimages.org

A pit viper has a triangular head, vertical elliptical pupils (that look like a cat's eyes), two fangs positioned in the front part of the jaw, heat-sensing "pits" located midway between and below the level of the eyes and the nostrils, and a single row of belly scales.

Coral snakes are identified by their distinctive color pattern of red, black, and white or yellow bands. An old saying goes: "Red on yellow, kill a fellow; red on black, venom lack." Coral snakes have a rounded head with round pupils, and their fangs are short and fixed.

Coral snake
Photo: Jeffrey J. Jackson

The following venomous snakes are found in these areas of the US:

Northeast: Cottonmouth; copperhead; timber rattlesnake; massasauga.

Southeast: Cottonmouth; copperhead; eastern diamondback, timber, and pigmy rattlesnake; eastern coral snake.

Central: Cottonmouth; copperhead; massasauga; timber, pigmy, and prairie rattlesnake.

Southwest: Cottonmouth; copperhead; Texas coral snake; pigmy, massasauga, rock, black-tailed, prairie, sidewinder, mojave, western diamondback, and red diamond rattlesnakes.

West: Red diamond, speckled, prairie, western diamondback, mojave, and sidewinder rattlesnakes.

Copperhead
Photo: Chris Evans, University of Georgia
www.forestryimages.org

Nearly all venomous snake bites recorded in the US are from pit vipers. Though equipped with a built-in "early warning device", a rattlesnake may strike without making a sound. Though a venomous snake may not inject its venom, any person bit by a snake should:

- Remain calm.
- Retreat from the snake to avoid another bite.

- Make a positive identification of the snake and note its size.
- Seek medical attention promptly.

Centipedes are fast-moving animals that are commonly found in protected places like soil, under tree bark, and in rotten logs. Centipedes feed on insects and other arthropods with a paralyzing bite from poisonous jaws. A bite from a small centipede is relatively harmless, but a bite from a larger one can be very painful.

Scorpions are nocturnal animals found in the South and West that feed primarily on insects and spiders. A scorpion sting can be painful, and stings from two species found in Arizona may be fatal.

Centipede

Scorpion

Black widow

Brown recluse

Centipede photo: Edward L. Manigault, Clemson University Donated Collection.
Brown recluse photo: James O. Howell, University of Georgia.
Scorpion and black widow photos: Clemson University - USDA Cooperative Extension Slide Series.
www.forestryimages.org

All **spiders** are venomous, but only two species are toxic enough to be of concern to humans: the black widow and brown recluse.

Do not attempt to handle a venomous animal in any way: leave it alone! A sting or bite will result in an emergency situation. Instead, let the animal retreat: their natural instinct is to avoid humans. Learn to identify venomous animals, recognize their habitats, and know what to do when one is encountered to help keep the forest experience safe.

Not everyone reacts the same when stung or bitten by a venomous animal. Besides experiencing pain and swelling, some people develop a severe allergic reaction called **anaphylactic shock**. This may cause breathing problems and other life-threatening conditions that demand immediate medical attention. If a person knows he or she is allergic and susceptible to anaphylactic shock, he or she should carry an emergency medical kit containing life-saving medication.

If a person is attacked and injured in the forest, administer basic first aid and proceed to the nearest medical facility for proper treatment and care.

To reduce the likelihood of bites and stings while in the forest:

- Be aware of your surroundings: watch, look, and listen.
- Dress properly. Protective clothing will increase the quality of your experience.
- Do not disturb. The natural instinct of an animal is to protect him or herself.
- Apply insect repellent: a simple, effective way to keep annoying insects away.
- If encounters with snakes are possible, wear chaps that cover ankle and calf.

First aid: Everyone should know what to do if a medical emergency arises. Knowing the care to provide and who to call are first-level priority issues. The three basic steps for providing assistance in a medical emergency are:

- ***Check:*** Make sure the scene is safe and attend to the victim.
- ***Call:*** Dial 9-1-1 or your local emergency number.
- ***Care:*** Provide first aid until professional help arrives.

Everyone should learn basic first aid procedures. The Red Cross and National Safety Council offer nationally-recognized first aid training programs. Each employee working in the forest should have a current Certificate of Training for first aid and cardiopulmonary resuscitation (CPR). Basic first-aid knowledge is also indispensible for everyday life. At a minimum, a basic first aid kit should include:

- Disposable latex gloves and hand wipes.
- Gauze roller bandages and pads of various sizes, and adhesive tape.
- Adhesive bandages (e.g., "Band-Aids") and triangular bandages.
- A splint.

- A blanket.
- Scissors and tweezers.
- Elastic wraps.
- Resuscitation equipment (e.g., a micro-valve rescue breathing guard, bag, and airway).
- Cold packs.
- Antiseptics, ointments, and pain relievers.
- Clear instructions for requesting emergency assistance.

If bitten or stung while in the woods: remember to stay calm, administer proper first aid, and seek medical attention promptly.

5. Government laws

The Occupational Safety and Health Act (OSHA) was established in 1971 to ensure that working conditions in the US are safe and healthful. OSHA regulations require that the following personal protection equipment are worn by all persons working in forestry operations:

- *Hard hat:* protects the head from falling or flying objects.
- *Foot protection:* as described above, heavy-duty logging boots that are waterproof or water-repellent.
- *Hearing protection:* ear muffs or plugs are required for workers exposed to 85 decibels per hour or higher.
- *Eye and face protection:* protection from flying and falling objects and debris. Complete face protection is required when operating such equipment as chippers and chainsaws.

Hard hat

Eye and face protection

- *Leg protection:* chainsaw operators must wear leg protection constructed with cut-resistant material (e.g., ballistic nylon).

- *Gloves:* protection against puncture wounds, cuts, and lacerations; preferably made of leather, but may be cotton or rubber.

Leg protection

OSHA also requires a first aid kit at each work site, and that all employees are trained to use the items in it.

Increasing one's awareness of unsafe acts or conditions in the forest workplace is something everyone can do to prevent personal injury. Forest work holds many potential dangers, such as a timber harvesting accidents, heat exhaustion, frostbite, insect stings and bites, or twisting an ankle. It is important to understand how to prevent accidents and stay safe.

Know what to do if an accident occurs. Remember to **check**, **call**, and **care** until emergency help arrives. Basic first aid and CPR are important skills to learn and use, both on the worksite and in private life. Safety is no accident: it is everyone's business.

Appendix 1:

US Land-Grant Colleges and Universities

ALABAMA
Alabama A&M University
Auburn University
Tuskegee University

ALASKA
Inupiat University *
Sheldon Jackson College *
University of Alaska, Fairbanks

ARIZONA
Dine College *
University of Arizona

ARKANSAS
University of Arkansas
University of Arkansas Pine Bluff

CALIFORNIA
Hehaka Sapa College at D-Q University *
University of California

COLORADO
Colorado State University

CONNECTICUT
University of Connecticut

DELAWARE
Delaware State College
University of Delaware

DISTRICT OF COLUMBIA
University of the District of Columbia

FLORIDA
Florida A&M University
University of Florida

GEORGIA
Fort Valley State College
University of Georgia

GUAM
University of Guam

HAWAII
University of Hawaii

IDAHO
University of Idaho

ILLINOIS
University of Illinois

INDIANA
Purdue University

IOWA
Iowa State University

KANSAS
Haskell Indian Nations University *
Kansas State University

KENTUCKY
Kentucky State University
University of Kentucky

LOUISIANA
Louisiana State University
Southern University

MAINE
University of Maine

MARYLAND
University of Maryland
University of Maryland, College Park

MASSACHUSETTS
University of Massachusetts

MICHIGAN
Michigan State University

MINNESOTA
University of Minnesota

MISSISSIPPI
Alcorn State University
Mississippi State University

MISSOURI
Lincoln University
University of Missouri

* - Denotes Native American tribal college

MONTANA
Blackfeet Community College *
Dull Knife Memorial College *
Fort Peck Community College *
Little Big Horn College *
Montana State University-Bozeman
Salish-Kootenai College *

NEBRASKA
Nebraska Indian Community College*
University of Nebraska

NEVADA
University of Nevada, Reno

NEW HAMPSHIRE
University of New Hampshire

NEW JERSEY
Rutgers - the State University of NewJersey

NEW MEXICO
Dine College – Shiprock Campus *
Institute of American Indian Arts *
New Mexico State University
Southwestern Indian Polytechnic Institute *

NEW YORK
Cornell University

NORTH CAROLINA
North Carolina A&T State University
North Carolina State University

NORTH DAKOTA
Fort Berthold College Center *
Little Hoop Community College *
North Dakota State University
Sitting Bull College *
Turtle Mountain Community College *

OHIO
Ohio State University

OKLAHOMA
Bacone College *
Langston University
Oklahoma State University

OREGON
Oregon State University

PENNSYLVANIA
Pennsylvania State University

PUERTO RICO
University of Puerto Rico

RHODE ISLAND
University of Rhode Island

SOUTH CAROLINA
Clemson University
South Carolina State University

SOUTH DAKOTA
Cheyenne River Community College* Oglala
Lakota College *
Sinte Gleska College *
Sisseton-Wahpeton Community College *
South Dakota State University

TENNESSEE
Tennessee State University
University of Tennessee

TEXAS
Prairie View A&M University
Texas A&M University

UTAH
Utah State University

VERMONT
University of Vermont

VIRGIN ISLANDS
University of the Virgin Islands

VIRGINIA
Virginia Polytechnic Institute & State University
Virginia State University

WASHINGTON
Washington State University

WEST VIRGINIA
West Virginia University
West Virginia State College

WISCONSIN
University of Wisconsin-Madison

WYOMING
University of Wyoming

Appendix 2:

US Technical Forestry Education Programs Recognized by the Society of American Foresters (SAF)

ALABAMA
Lurleen B. Wallace State Junior College, Andalusia. Forest Technology curriculum leading to an AAS.

CALIFORNIA
Reedley College, Reedley. Forest/Park Technology curriculum leading to an AS.

FLORIDA
Lake City Community College, Lake City. Forest Management curriculum leading to an AS.

GEORGIA
Abraham Baldwin Agriculture College, Tifton. Forest Technology curriculum leading to an AAS.

MAINE
University of Maine, Fort Kent. Forest Technology curriculum leading to an AS.

MARYLAND
Allegany College, Cumberland. Forest Technology curriculum leading to an AAS.

MINNESOTA
Vermilion Community College, Ely. Natural Resource Technology - Forest Management/Wildlife option leading to an AAS.

NEW HAMPSHIRE
University of New Hampshire, Durham. Forest Technology curriculumleading to an AAS.

NEW YORK
SUNY College of Environmental Science and Forestry, Wanakena. Forest Technology curriculum leading to an AAS.
Paul Smith's College of Arts and Sciences, Paul Smiths. Forest Technology curriculum (Forest Technician and Forest Recreation options) leading to an AAS.

NORTH CAROLINA
Haywood Community College, Clyde. Forest Management Technology curriculum leading to an AAS.

OHIO
Hocking College, Nelsonville. Forest Technology curriculum leading to an AAS.

OKLAHOMA
Eastern Oklahoma State College, Wilburton. Forest Technology curriculum leading to an AAA.

OREGON
Central Oregon Community College, Bend. Forest Technology curriculum leading to an AAS.
Mt. Hood Community College, Gresham. Forest Resources Technology Program leading to an AAS.

PENNSYLVANIA
Pennsylvania College of Technology, Williamsport. Forest Technology curriculum leading to an AAS.
Pennsylvania State University, Mont Alto. Forest Technology curriculum leading to an AS.

SOUTH CAROLINA
Horry-Georgetown Technical College, Georgetown. Forest Technology curriculum leading to an AA.

VIRGINIA
Dabney S. Lancaster Community College, Clifton Forge. Forest Technology curriculum leading to an AAS.

WASHINGTON
Green River Community College, Auburn. Natural Resources (forestry option) curriculum leading to an AAS.
Spokane Community College, Spokane. Forest Technology curriculum leading to an AAS.

WEST VIRGINIA
Glenville State College, Glenville. Forest Technology curriculum leading to an AS.

Appendix 3:

US Professional Forestry Education Programs Recognized by the Society of American Foresters (SAF)

ALABAMA
Alabama A&M University, Normal. Forest Management and Forest Science options leading to a BSF.
Auburn University, Auburn. Forest Resources and Forest Engineering (Forest Resource Minor) curricula leading to a BS.

ALASKA
University of Alaska, Fairbanks. Forestry Option leading to a BS.

ARIZONA
Northern Arizona University, Flagstaff. Forestry curriculum leading to a BS.

ARKANSAS
University of Arkansas, Monticello. Forestry curriculum leading to a BSF.

CALIFORNIA
California Polytechnic State University, San Luis Obispo. Forestry and Natural Resources curriculum with concentrations in Environmental Management, Forest Resources Management, Natural Resources Recreation, Urban Forestry, Wildland and Fuels Management, and Watershed Hydrology leading to a BS in Forestry and Natural Resources.
Humboldt State University, Arcata. Forest Resources Management, Forest Resources Conservation, and Forest Production Management options and Forestry option in Watershed Hydrology leading to a BS.
University of California, Berkeley. Forestry Curriculum leading to a BS.

COLORADO
Colorado State University, Fort Collins. Forestry curriculum with concentrations in Forest Biology, Forest Fire Science, and Forest Management leading to a BS.

CONNECTICUT
Yale University, New Haven. Forestry curriculum (two-year option) leading to an MF.

FLORIDA
University of Florida, Gainesville. Forest Resources Management curriculum leading to a BS in Forest Resources and Conservation.

GEORGIA
University of Georgia, Athens. Forestry, Wildlife, and Forest Environmental Resources curricula leading to aBS in Forest Resources.

IDAHO
University of Idaho, Moscow. Forest Resources curriculum with options in Science, Administration, and Forest Ecosystem Management, leading to a BS.

ILLINOIS
Southern Illinois University, Carbondale. Forest Resources and Outdoor Recreation Resources Management curricula leading to a BS.
University of Illinois, Urbana. Forest Science curriculum leading to a BSF.

INDIANA
Purdue University, West Lafayette. Forestry curriculum leading to a BSF.

IOWA
Iowa State University, Ames.
Forest Ecosystem Management, Forest Products, Urban and Community Forestry, and Natural Resource Conservation; all curricula leading to a BS with a major in Forestry.

KENTUCKY
University of Kentucky, Lexington.
Forestry curriculum leading to a BSF.

LOUISIANA
Louisiana State University, Baton Rouge.
Forestry curriculum leading to a BSF.
Louisiana Tech University, Ruston.
Forestry curriculum leading to a BSF.

MAINE
University of Maine, Orono.
Curricula leading to a BS in Forestry, BS in Forest Operations Science, and MF.

MASSACHUSETTS
University of Massachusetts, Amherst.
Forestry curriculum leading to a BSF.

MICHIGAN
Michigan State University, East Lansing.
Professional Forestry curriculum leading to a B.Sc.
Michigan Technological University, Houghton. Forest Ecology and Management Curriculum and Wood Science Curriculum leading to a BSF.
University of Michigan, Ann Arbor.
Curriculum leading to an MS degree with emphasis in Forestry.

MINNESOTA
University of Minnesota, St. Paul.
Forest Resources and Urban Forestry curricula leading to a BS.

MISSISSIPPI
Mississippi State University, Mississippi State. Urban Forestry, Environmental Conservation, Forest Management, and Wildlife Management options of the Forestry curriculum leading to a BS.

MISSOURI
University of Missouri, Columbia.
Forest Resource Management curriculum leading to a BSF.

MONTANA
University of Montana, Missoula.
Forest Resources Management curriculum leading to a BSF.

NEW HAMPSHIRE
University of New Hampshire, Durham. Forestry curriculum with options in Forest Management and Forest Science leading to a BSF.

NEW YORK
State University of New York, Syracuse.
Forest Resources Management curriculum leading to a BS.

NORTH CAROLINA
Duke University, Durham.
Forest Resource Management curriculum leading to an MF.
North Carolina State University, Raleigh.
Forest Management curriculum leading to a BSF.

OHIO
The Ohio State University, Columbus.
Forestry curriculum leading to a BS.

OKLAHOMA
Oklahoma State University, Stillwater.
Forestry curriculum leading to a BS in Agricultural Sciences and Natural Resources.

OREGON
Oregon State University, Corvallis.
Forest Engineering, Forest Engineering-Civil Engineering (dual-degree), Forest Management, and Forest Recreation Resources curricula leading to a BS; General and Silviculture curricula leading to an MF.

PENNSYLVANIA
The Pennsylvania State University, University Park. Forest Management and Forest Biology options of the Forest Science curriculum leading to a BS in Forest Science.

SOUTH CAROLINA
Clemson University, Clemson.
Forest Resource Management curriculum leading to a BS.

TENNESSEE
University of Tennessee, Knoxville.
Wildland Recreation and Forest Resources Management curricula leading to a BSF.

TEXAS
Stephen F. Austin State University, Nacogdoches. Forestry, Forest Management, Forest Wildlife Management, and Forest Recreation Management majors in the Forestry curriculum leading to a BSF.
Texas A & M University, College Station.
Forest Management option of the Forestry curriculum leading to a BS.

UTAH
Utah State University, Logan.
Forestry curriculum leading to a BSF.

VIRGINIA
Virginia Polytechnic Institute and State University, Blacksburg.
Forest Resource Management; Industrial Forestry Operations; Environmental Resource Management; Urban Forestry; Natural Resource Recreation curricula leading to a BS in Forestry or Natural Resource Recreation.

WASHINGTON
University of Washington, Seattle.
Forest Management curriculum leading to a BS.
Washington State University, Pullman.
Forest Management, Forest Business, Forest Wildlife, and Directed Studies options within the Forestry curriculum leading to a BS in Natural Resource Sciences.

WEST VIRGINIA
West Virginia University, Morgantown.
Forest Resources Management curriculum leading to a BSF.

WISCONSIN
University of Wisconsin, Madison.
Public Forestry, Industrial Forestry, and the BS/MS options in the Forest Science curriculum leadingto a BS; Forest Sciences curriculum leading to a BS in International Agriculture and Natural Resources.
University of Wisconsin, Stevens Point.
Forest Management, Forest Administration and Utilization, Urban Forestry, and Forest Recreation curricula leading to a BS.

Appendix 4:
Sample Timber Sale Contract

Provided by the Warnell School of Forest Resources, a unit of the University of Georgia.

A written contract is essential to all timber sales. A verbal agreement is subject to misunderstanding and misinterpretation. Both buyer and seller need the protection that only a well-written contract can provide.

All items in a timber sale contract are negotiable: there is no one standard contract form. Many timber buyers have their own preferred forms. Such a contract is usually written to protect the buyer, and may or may not protect the seller. Buyers and sellers, therefore, need to negotiate specific terms.

The "Essential Items" listed in this section should be included in all timber sale contracts. Items in the section labeled "Other Important Considerations" may also be essential depending on specific circumstances of the sale. Items in the "Special Provisions" section may be applicable under certain specific conditions.

Note that these suggested contract terms are written in lay terms by professional foresters. Any actual contract between timber sellers and buyers should be drafted or approved by an attorney. The authors of this book and of this sample contract assume no legal responsibility for the information presented here.

Note too that this is a timber sale contract. A logging contract is a distinct type of transaction, though it may share many characteristics in common with this document.

ESSENTIAL ITEMS

While the exact wording may differ, the following items should be covered in all timber sale contracts.

(1) Agreement entered into this ____ day of ____, 20__, between_____ of _____, hereinafter called seller, and _____ of _____, hereinafter called buyer.

Explanation: This specifies the parties to the contract.

(2) Laws of the State of _____ shall govern this agreement.

Explanation: This spells out the applicable State laws, thus avoiding confusion for absentee landowners and out-of-state buyers.

(3) Seller, having the right to sell, agrees to sell to buyer, who agrees to buy upon the conditions hereinafter stated, all timber that has been designated in the following way: and owned by the seller on the following described tract of land: _____.

Explanation: It is important that the agreement specifies how to identify the trees to be cut. For example, it may denote all trees marked with paint on both trunk and stump; all trees larger than a minimum stump diameter, all trees standing a specified height above the ground; all trees of a given species; or all trees within a marked boundary. Consult a professional forester to determine the best method. If paint is used specify the color, and also that a mark should be made below the level of the

stump. This provides some insurance against the cutting of unmarked trees. A plat book or warranty deed may be needed to determine the legal description.

(4) Seller is the legal owner of said timber and warrants the title to the timber hereby conveyed against the lawful claims of all third parties.

Explanation: This protects buyer from unknown third party claims.

(5) Buyer agrees to pay seller the total sum of ($) for said timber (if a lump-sum sale) or the following price for each unit of timber stumpage removed: _____ per _____ for _____ (if sale by unit) .

Explanation: In a lump-sum sale, seller is paid a fixed amount for the designated timber. This fixed amount may be determined through direct negotiation with one buyer or through competitive bidding by several prospective buyers. While buyers base their bids on an estimate of the volume to be harvested, the total dollar amount received by the seller is independent of the amount actually removed. Sellers are generally advised to use this method in conjunction with competitive bidding. In the sale-by-unit, sale-by-scale, or sale-by-piece method the designated trees are felled and measured to determine volume. Seller is then paid a set amount per 1,000 board feet, per cord, or per post. Since the unit rate will vary among species, size, and product classes, an item-by-item listing is included. Where weight is used as a basis to determine board feet or cords, some States' laws require buyer to provide seller with a price quotation calculated in dollars per thousand pounds. Because it is often difficult to obtain an accurate production tally, this sales method is more difficult to administer than the lump-sum sale. It has definite tax advantages to timber landowners making frequent sales, however (i.e., more than every five years).

(6) A down payment of ($) shall be made to seller upon execution of this contract.

Explanation: A down payment of 10-20% is common.

(7) Method and time of payment shall be the following:

Explanation: For lump-sum sales it is advised that the balance be paid in full before harvesting operations begin. For small sale-by-unit sales, it is customary for 75 to 80% of the total estimated value to be paid in advance. Final payment is due upon measurement of the final log. On large sale-by-unit sales, it may be necessary to establish a payment schedule, wherein the buyer makes periodic payments (i.e., weekly or biweekly) as the timber is harvested and scaled.

(8) All timber marked or products included in this contract, until paid for in full, shall remain as the property of seller.

Explanation: This protects seller from buyer's failure to pay.

(9) This agreement will be in effect from _____, 20__ to _____, 20__, after which time the contract is null and void unless seller grants a written extension. If no extension is granted, all rights to remaining timber return to seller.

Explanation: Buyer must be given a reasonable time period to harvest the timber. If no termination date is established the contract may continue indefinitely, with buyer harvesting growth in addition to

the original agreed-upon volume. Furthermore, extensions may be necessary due to poor logging conditions. Depending upon the circumstances of the extension, additional compensation to seller may be in order.

(10) Seller is free from responsibility for any injury, death, or property damage caused by buyer's logging operation in the sale area during the tenure of the agreement.

Explanation: This protects seller from liability for buyer's operation.

(11) It is understood by both parties that buyer is an independent contractor and not an employee of seller.

Explanation: This protects seller from liability for worker's compensation, unemployment insurance, and other costs.

(12) If requested by seller, buyer agrees to furnish current certificates for worker'scompensation and public liability insurance.

Explanation: Once again, this protects seller from liability.

(13) Seller may suspend operations, including removal of cut timber, if conditions of the contract are violated. Violations of conditions of the contract are sufficient grounds for termination.

Explanation: This protects seller from buyer's failure to follow agreed-upon terms and conditions.

(14) Any modifications or amendments to this contract must be written, dated, signed, and witnessed.

Explanation: This ensures that both parties are in agreement concerning any changes in the contract.

(15) Prior to commencing harvesting operations, buyer shall post a performance bond with _____ in the amount _____ of dollars ($).

Explanation: A performance bond of at least $500 and up to 10% of value on large sales provides evidence and insurance that buyer will not cause unusual damage or cut trees not in the sale. The performance bond is a separate transaction, in addition to the sale price. The bond can work as a joint deposit by buyer and seller in a local bank, from which a withdrawal can be made after certain conditions have been met. It may also be a surety bond purchased through an insurance agent. In either case, the bond is returned to buyer upon satisfactory completion of the sale.

(16) This agreement shall be binding on the heirs, administrators, executors, successors, or assigns of both parties.

Explanation: This ensures that the agreement is continued, if necessary, beyond the original parties.

(17) In witness whereof, the parties hereto have executed this Agreement this ___ day of __, 20___.

Seller(s):
_____ date _____
_____ date _____

Buyer(s):
_____ date _____
_____ date _____

Witness:
_____ date _____
_____ date _____

Notary Public:
_____ date _____
My Comm. Expires: _____

Explanation: The contract should be signed and dated by buyer and seller, witnessed by at least two impartial observers, and notarized. Each party should be provided with his or her own copy of the signed agreement.

OTHER IMPORTANT CONSIDERATIONS

The following items should be considered for inclusion in any timber sale contract. Some may be determined as essential as those listed above. Others may not be necessary, and should not be included simply as a matter of course. Note that too many restrictions may render the contract unacceptable to buyer.

(18) No unmarked trees shall be cut without prior written approval of seller. For each unmarked tree cut with seller's permission, buyer agrees to pay _____ ($) per _____. For unmarked trees greater than _____ inches in diameter at _____ inches above ground level that are cut without permission, buyer agrees to pay _____ dollars ($) per _____. For unmarked trees greater than _____ inches and less than _____ inches at _____ inches above ground level that are cut without permission, buyer agrees to pay _____ dollars ($) per _____. Upon payment of appropriate compensation to seller, the severed tree becomes the property of buyer.

Explanation: It may be necessary to cut additional trees in order to provide access. Seller is usually compensated for the additional timber; double or triple the stumpage rate is charged for cutting unmarked trees without permission. Such penalties vary by timber species, size, and quality, and serve to protect seller from buyer carelessness.

(19) Buyer may not subcontract any part of this contract without seller's prior written approval.

Explanation: This protects seller from unknown third party interests.

(20) In the event of dispute over the terms of this contract, final decision shall rest with a reputable person to be mutually agreed upon by the parties to this contract; and in case of further disagreement, with an arbitration board of three persons, one to be selected by each party to this contract and a third to be selected by the first two members of the board. Buyer and seller shall share costs of arbitration equally.

Explanation: This establishes procedures for settling potential disputes.

(21) Buyer must remain within the sale boundaries designated by seller.

Explanation: Boundaries must be marked clearly.

(22) Buyer has right of access onto seller's land for harvesting purposes. If buyer must cross a third party's property to enter seller's land, buyer must clear the right of access with the third party.

Explanation: Timber buyers generally know what is needed in the way of access. In the event of a dispute with a third party, it is better (from seller's standpoint) for the third party to negotiate with buyer and not seller.

(23) The location of all roads, landings, and decking areas must be agreed upon by buyer and seller before operations begin.

Explanation: The parties to the contract should discuss and agree upon which areas and how much area will be used.

(24) Seller shall be informed of the commencement of harvesting operations _____ days in advance.

Explanation: This is usually seven to ten days. This provision keeps seller better informed about what is happening on his or her property.

(25) All sawtimber is to be scaled by the _____ rule. Measurements shall be made at the small end of the log along the average diameter inside bark to the nearest inch.

Explanation: This provision is necessary only when selling sawtimber by the unit.

(26) Seller has the right to inspect the sale area at any time.

Explanation: This allows seller to check the adequacy of the logging job being performed on his or her land.

(27) Buyer and his or her employees shall exercise care at all times against the starting and spreading of fires in the sale and surrounding areas.

Explanation: This protects seller from loss due to fire.

(28) Neither buyer nor seller is liable for payments or performances due to uncontrollable events such as fires and floods.

Explanation: If events are uncontrollable, and occur due to buyer's action or negligence, then buyer is usually liable. Conversely, if buyer is not at fault, then a contract extension may be in order.

SPECIAL PROVISIONS

This section provides landowners with some specific provisions for unique situations. Not all will apply in every circumstance. Note too that numerous contract provisions may cost buyer money, which could mean less money to seller for his or her timber.

(29) Stump heights may not exceed _____ inches.

Explanation: Usually no greater than the diameter of the tree.

(30) Trees may not be left hanging on other trees.

Explanation: This is for safety.

(31) Roads and trails must be built and opened before the skidding operation begins.

Explanation: This provides an incentive for buyer to become familiar with the terrain and plan the harvesting operation accordingly.

(32) Roads shall be left free of treetops and limbs, and in good passable condition.

Explanation: This is to ensure access.

(33) Logging can only be done when the ground is dry.

Explanation: This is to prevent rutting.

(34) Logging operations can only be conducted from ___(date)___ to ___(date)___.

Explanation: This is to avoid conflict with special seasons such as hunting, growing, fire seasons, or harvest.

(35) Delimbing gates shall not be used in the logging operation.

Explanation: In a partial cutting, this avoids heavy buildup of logging slash at the delimbing gate and reduces the potential for damage to residual trees. It is an unnecessary provision in a clearcutting operation, where regeneration is absent.

(36) Damaged fencing shall be repaired with fencing of the like kind of existing fence.

(37) No use of surrounding fields during the growing season shall be permitted unless seller gives written approval.

(38) Any damage to buildings will be paid for based on a written estimate obtained by seller from a local contractor for repairing to previous condition and quality.

(39) All litter resulting from the logging operation must be removed from the woods.

(40) Crop damage shall be paid for by buyer.

(41) Loggers are prohibited from carrying firearms and/or hunting on the property.

(42) Buyer agrees to push logging debris to the sides of loading areas, in order to facilitate replanting of these areas when the logging operation is completed.

Index

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Page 11: (Glossary) and **p.100** (description): The definition of "dibble bar" is incorrect. It should read, "A hand tool made of steel used for planting tree seedlings. The shape of the blade is different depending on the type of seedlings to be planted. This tool is also called a planting bar."

Page 78: The photos at the top of page 78 are not representative of any species of ash (Fraxinus), rather they are photos of Mountain Ash from the genus Sorbus. Please insert the following correction:

Black Ash bark
Photo: Bill Cook, Michigan St.
www.forestryimages.org

Ash

Ash (*Fraxinus*) is a genus of the olive family (*Oleaceae*). Of 70 species of ash found throughout the world, 16 are native to North America.

Leaf:	Opposite, odd-pinnately compound; lance shaped; leaflet margins are varied - entire to serrate.
Fruit/Seed:	Samara with a single seed; seed has a dry, flat, terminal wing.
Economic Importance:	Wood from several species of ash are valuable and used to make furniture, tool handles, baseball bats and other wood products. Wildlife consume seeds and twigs. Green ash is planted as a shade and street tree.
Unique Characteristic:	Green ash is the most widely distributed species of ash, but white ash is most common.

Black Ash leaf
Green Ash flower
Photos: Paul Wray.
www.forestryimages.org

Green Ash fruit
Photo: Paul Wray.
www.forestryimages.org

Page 101: The photo of the fire plow is incorrect. The photo is that of a disk. Please insert the following correction:

Fire Plow
Photo: Kris Irwin

Kris M. Irwin is a Public Service Associate and faculty member at the University of Georgia's Warnell School of Forest Resources. He holds a bachelor's degree from the University of Missouri and a master's degree from the University of Florida, and has more than fifteen years' experience in natural resources education and outreach. Kris has worked with Philippine farmers as a US Peace Corps volunteer, helped develop programs and educational materials as an assistant community forester in Nebraska, and managed demonstration and training projects across the country as a technology transfer specialist with USDA's National Agroforestry Center. In 2002 he received a national Outstanding Educator award from Project Learning Tree. Currently Kris coordinates instructional design projects and agricultural education workshops, and teaches "Forest Science for Teachers" in UGA's Agricultural Education program.

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