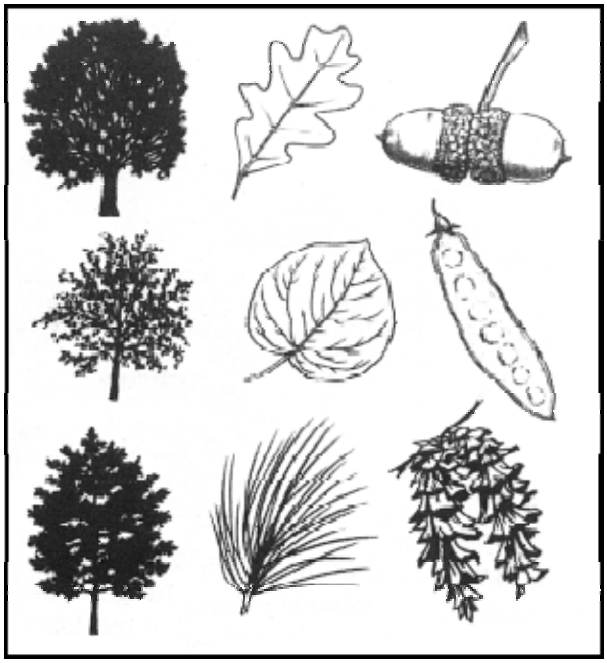
BEHIND THE WALL OF GREEN
A Close Look at the Forest

By Dwight Barnett
Tennessee Division of Forestry

TREES

Types of Trees



Almost 200 kinds, or *species*, of trees grow wild in Tennessee. Every species has its own distinctive leaves, bark, twigs, branching pattern, buds, flowers, fruits, wood, shape and *behavior*. Yellow poplar and white pine grow to be quite tall. Dogwood and redbud don't. Poplar grows fast; beech grows slowly. Some trees, like white oak, are long lived; others, like locust, are short lived.

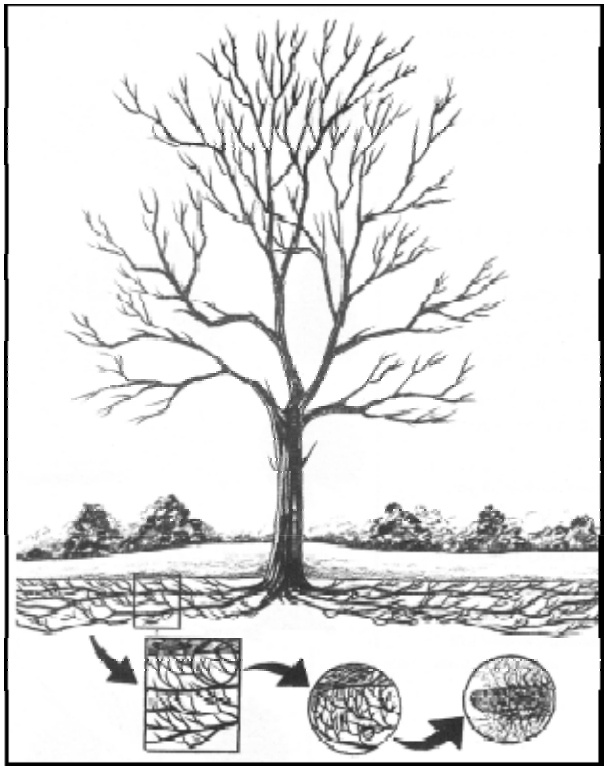
The degree to which trees tolerate drought, flooding, heat, cold and shade largely determine where they grow. Sugar maple can live in the shade; cherry can't. Cypress lives in swamps; scarlet oak on dry ridges. Walnut is very particular and will grow well only on the best soils. Redcedar will grow almost anywhere. Pines, firs and spruces keep their leaves or needles all year. They are called *evergreens*. Trees that lose their leaves in the fall are called *deciduous* (duh-SID-you-us).

Conifers bear their seeds in cones; usually conifers are evergreens. Conifers are also called *softwoods*. Trees that aren't conifers are called *hardwoods*. Most hardwoods are deciduous. Not all hardwoods have hard wood, and not all softwoods are soft.

Tree Structure & Growth…From the Roots Up

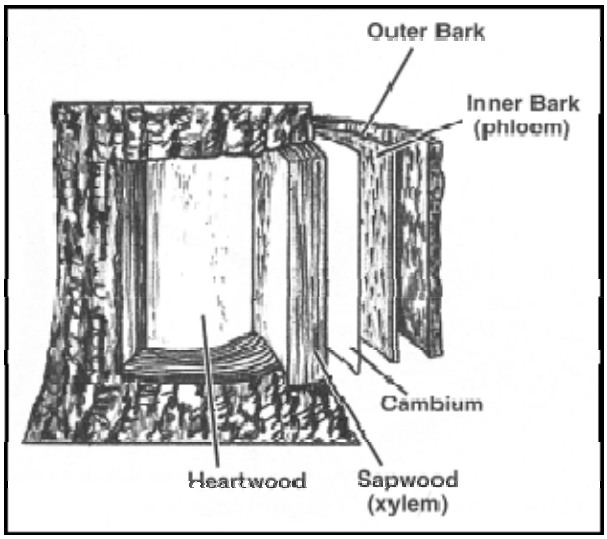
There is more to a tree than meets the eye—half is underground! The roots spread out about twice as far as the longest branches. Tiny *feeder* roots soak up water and nutrients. Most feeder roots of forest trees are right at the surface. Larger roots deeper down in the soil hold the tree up. Roots elongate about one or two feet per year.

Fungi (plural of fungus) help the feeder roots do their job. Microscopic strands of these fungi, called *mycorrhizae* (my-ko-RYE-zee), live in and on the rootlet and feed on sugar made by the tree. In return, the mycorrhizae gather water and nutrients for the roots. This is one reason why trees can grow on much poorer soil than crops can.



The *trunk* holds up the tree top. The growing part of the trunk is the *cambium* (KAM-bee-uhm), a thin layer of cells between the bark and the wood. The outside of the cambium layer produces bark, and the inside of the cambium makes new wood. The cambium layer is found under the bark of the trunk, branches and twigs.

Sugar from the leaves moves down to the roots through the inner bark, or *phloem* (FLO-um). As the phloem dies, it becomes bark, which protects the trees from fire, insects and disease.

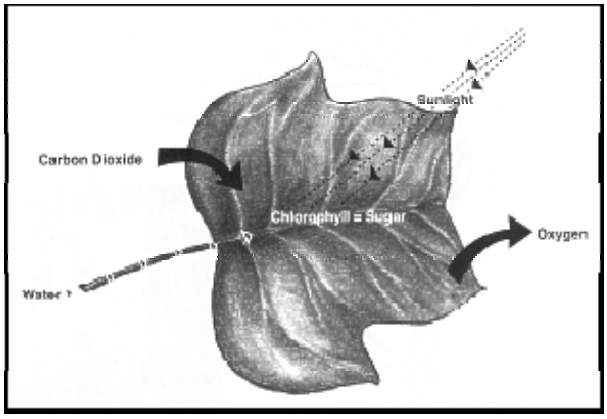


Water moves up from the roots to the leaves through the sapwood, or *xylem* (ZY-lum). Trees also store food (sugar and starch) in their sapwood. Heartwood is dark-colored wood in the center of the trunk. Heartwood is dead. Its dark color comes from resins, oils and minerals deposited there by the tree.

Every year the tree adds a layer of wood over the entire outside of the tree: over the trunk, branches and twigs. Wood formed in the spring ("spring wood") is less dense than wood formed in the summer ("summer wood"). These layers, called *growth rings*, can be seen in a cross section of a trunk or branch. Growth rings record the tree's history. Wide rings grow in good years, narrow rings in poor years.

The *buds* contain tiny new leaves and sometimes flowers. The bud also adds new cells to the tip of the twig. This causes the twig to elongate. The tips of twigs are the only parts of the tree that grow in height.

Leaves are food factories. They contain *chlorophyll* (KLOR-o-fill), a green chemical which uses the energy of sunlight to make sugar through the process of *photosynthesis* (fo-to-SIN-thuh-sis). Sugar from photosynthesis is the building block trees use to make leaves, roots, bark and wood. In the short term, photosynthesis takes carbon dioxide out of the atmosphere and releases oxygen.



In the long term, plants use up just as much oxygen as they produce. They "burn" (*respire*) oxygen in their cells to stay alive, much as we do; and when they die and decompose, the rest of the oxygen they produced while they were growing up is used up. Humans, animals, insects, fungi and bacteria all break down plant tissue, using up oxygen and releasing carbon dioxide. Oxygen production and use is a balanced chemical equation.

FORESTS

The Inside of a Forest

The inside of a forest is shadier than open areas (in deciduous forests this is true mainly in summer). It has less extreme temperatures than open areas (in deciduous forests this is true mainly in summer). It is protected from wind (specially in summer in deciduous forests). It tends to be more humid than open areas during dry periods. It is "deep", extending from below the ground up to the topmost branches. It also contains a lot of organic matter on which microbes and insects feed.

Animals, insects and plants find a variety of foods and places to live in the forest—in branches, under bark, under leaf litter, etc. Some creatures cannot survive outside the forest. Some forest animals specialize in living in one layer of the forest: in the treetops or *canopy*, in the *understory* of smaller trees growing under the canopy, on the ground in the *herbaceous* (her-BAY-shus) layer, in the leaf litter or under the ground.

Not all forest environments are the same. Some are dark and shady with only a few small plants scattered over a carpet of dead leaves on the forest floor; others are relatively open and sunny with a tangle of undergrowth. Some forests are old, others young. Some contain many kinds of trees, while some contain only a few kinds.

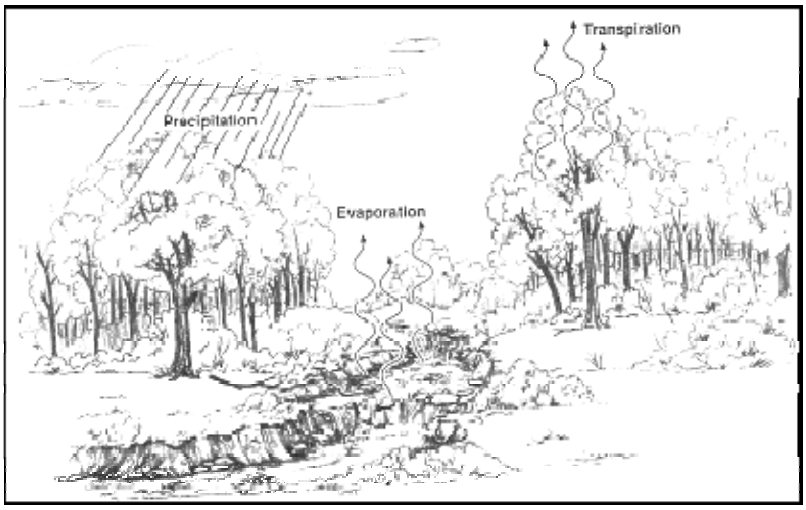
Each type of forest is home for particular kinds of insects and animals. As a forest changes, the types of plants, insects and animals living there also change.

Cycles in the Forest

Nature operates in repeating patterns called *cycles*. Take weather, for instance. Weather can change a lot from day to day, but over a year's time the daily changes fit into a cycle of spring, summer, fall and winter. Just about everything in nature follows some kind of cycle. Cycles may be simple or complicated, fast or slow. Some cycles take centuries, and some (like rocks weathering and reforming) take millions of years. Some cycles are so subtle and complicated that we don't know how they work—or even that they exist.

The Water Cycle in the Forest

Water evaporates from the ocean, lakes and rivers. Winds carry it over land, where some of it falls as rain. Some water is taken up by plants and released from the leaves into the air, a process called *transpiration* (trans-per-AY-shun). Some water returns to the ocean, where it again evaporates.



The forest keeps streamwater clean and helps even-out streamflow. Dead leaves protect forest soil from raindrops, and thick mats of tree roots bind it together like reinforcing bars. Forest soil is spongy and absorbent. Rain soaks through the soil into the subsoil and bedrock, where it is stored. From there it seeps slowly and steadily into streams and springs.

Evaporation from tree leaves cools and humidifies the air. Trees are such powerful water removers that the soil in the forest sometimes gets drier than soil in open fields. During dry summers, streams in the forest often have *less* water than streams in open areas!

The Carbon Cycle in the Forest

Trees take carbon out of the air and turn it into leaves, roots and wood. As these rot, most carbon goes back into the air, some dissolves in stream water that flows into the ocean, and what is left becomes *humus* (HUE-muss), a dark brown substance that enriches the soil. Humus decomposes slowly, releasing carbon dioxide back into the air to complete the cycle.

Soil humus is a great storehouse of food (energy) for microbes, which are a source of food for other creatures. Roots are an especially important source of humus. Rootlets don’t live long, and the tree is constantly renewing them as they die and decompose.

The Nutrient Cycle in the Forest

Tree vitamins, called *nutrients*, are simple chemicals found in the soil. The most important are nitrogen, potassium and phosphorous. Potassium and phosphorous come from the bedrock—the solid rock that lies underneath the soil. There are usually huge quantities of these elements in the soil, but they are mostly "locked up" in soil particles.

These particles release their stored nutrient molecules slowly into the water that is always present within the soil. Roots pick up these "loose" nutrients.

Nitrogen comes from the air. Before nitrogen can be used by plants, it must be changed from a gas into a salt called nitrate. That process is accomplished by lightning and by micro-organisms. Lightning "zaps" nitrogen and oxygen gas molecules together in the air to make nitrate; microbes ease them together in slower chemical reactions in the soil. Clover, locust, redbud and certain other plants enrich the soil by adding large amounts of nitrogen, using microbes that live in their roots. Nitrogen is usually the nutrient that is in shortest supply.

When plants decompose, their nutrients are released into the soil. (Leaves and small roots are rich in nutrients; wood is not). Most "loose" nutrients either stick to soil particles or are picked up again by roots. Only tiny amounts are washed out of the soil into streams. New nutrients are constantly being added from soil particles, bedrock, lightning and microbes.

Energy in the Forest

It takes energy to build and run a car. It also takes energy to "build" living things and keep them running. The sun is the energy source for almost all living things. Plants capture energy from sunlight and store it as sugar, starch, and other chemicals. All organisms (except some microbes) live by "burning" the energy stored in plant parts. They convert stored chemical energy into heat energy. When these organisms are eaten, the chemical energy in them is passed on to the animal that eats them. For example, a mouse eats seeds; a snake eats the mouse; a hawk eats the snake. This passing of food energy from one animal to another is called the *food chain*. Links in the food chain include plant eaters (herbivores), flesh eaters (carnivores), insectivores, omnivores which eat many things, decomposers (including many types of organisms), and parasites, which draw energy from living "host" organisms.

As the sun’s stored energy flows through various chemical forms within the forest (plants, animals and organic matter) it is gradually used up and dissipated as heat. Energy does not follow a cycle, because it doesn’t return to the sun.

Trees can capture more of the sun’s energy if they have plenty of water and nutrients. That’s why forests on rich, well-watered soil grow faster and support more wildlife than forests on poor, dry soil. A long growing season helps too. The total weight of plants and animals in a forest is called its *biomass*. The rate at which a forest grows biomass is called its *primary productivity*.

Wildlife Habitat

Animals need food, water, shelter from the weather, cover to hide in and enough space. Lack of *one* of these will limit the population of any given species. That *one* critical need is called the *limiting factor*. Any location that provides these needs for a species is a

habitat for that species. Habitat for an insect could be a rotten log; for a grizzly bear, a mountain range.

Food. Animals need food all year; the foods a species eats usually changes with the seasons. For example, deer eat grass and other small plants from mid-spring through summer, acorns and other nuts and fruits in the fall to early winter, and anything they can find (buds, mushrooms, bark, dry berries, etc.) in late winter and early spring, the most critical time of year for them.

Water. Some species live *in* the water, others need access to standing or flowing water, and still others survive in drier surroundings by using water from dew and food. Wet areas and areas near water are especially rich in wildlife.

Hilltops are usually dry; lower slopes are damper. As we have seen, rainwater seeps down through the rock and soil and emerges in or near the stream. The closer to the stream, the more moist the soil (usually).

Moist areas along streams, which may extend 100 feet or more, are so different from the rest of the landscape that they have their own name: *riparian zones* (ry-PAIR-ee-un). These moist woodlands are home to more species than are the dry woodlands. The stream itself is a whole world of its own, fed and nourished by the forest. Tree canopies shade and cool the stream; leaves and fallen trees add nutrients and habitat for fish, frogs, snails, aquatic insects, etc. This richness makes riparian areas especially valuable to a wide variety of wildlife: mammals, insects, birds, amphibians, crustaceans and reptiles.

Shelter may include holes, rocks, pines or cedars, etc. Shelter helps protect animals from cold winter winds and conserve their energy. Animals can die of hypothermia, starvation and disease if they do not have enough shelter. Shelter also includes *cover* or dense vegetation which shields animals (especially young) from the eyes of predators.

Home range. Some people live in tiny apartments; others live in mansions. But people can live in either. That's not true for animals. Each species needs a certain amount of area in which to wander and seek food. Squirrels require a few acres, deer a few hundred, and wolves thousands. Wolf packs must roam far and wide to satisfy their voracious appetites. The *arrangement* or layout of the area can be important. For example, some species don't like to cross open areas and won't use forest that is chopped up into little blocks.

Generalists and Specialists

Each species jostles for survival, finding a *niche* (NITCH) where it can outdo its competitors. Some species, *generalists*, compete well in many situations. Coyotes, crow, deer, red maple and gypsy moth are prime examples of generalists. *Specialists* compete best in very specific habitats: bogs, cedar glades, swamps, etc. In fact, some specialists may actually *depend* on these unique habitats for their very survival. Examples of

specialists are given on the next page. These happen to be songbirds, but specialists are found among mammals, insects, fungi or any other sort of organism.

Generalists adapt well to change; specialists often don't. A big change may force the specialist to move to another suitable area (if one is available and the specialist can move fast enough), or it may eliminate the population. If the habitat later recovers, the specialized animal or plant may move back.

No habitat can satisfy every species! This is very important to keep in mind when managing the forest.

Animals and People

Humans affect animals in many ways:

ACTION	RESULTS		
	Good	**Bad**	**Neither**
Agriculture	Grain eaters	Prairie & deep forest dwellers	Some generalists
Urban development		Most species	
Hunting	If done wisely *	If done in excess *	
Habitat improvement	For benefited species	Others	Others
Forestry practices	Some species/practices	Others	Others
Roadkill	Overpopulated area	Underpopulated area	
Introduce new species	If they provide food & cover	Many natives killed/crowded out	New species "fit in well"
"Fragmenting" habitat	Generalists, game species	Some specialists	
Burning	Grazing & prairie species	Some moist-site flowers	Many generalists
Erosion	Poor-site colonizers	Most species (lower fertility)	

** In some cases where natural predators have been exterminated, the correct level of hunting will keep the animals healthy by preventing overcrowding.*

Songbirds: A Sampler of the Wild Diversity of Specialists' Habitat Needs

Cerulean warblers need very large areas (thousands of acres) of solid, mature (*late mid-successional*) hardwood forest with a closed canopy (no openings) and a are, sparse understory (bushes and small trees growing under the large trees). They prefer bottomland and moist mountain forests. **Scarlet tanagers** also need large areas of mature deciduous forest.

Chestnut sided warblers, yellow breasted chats and **prairie warblers** require large, uninterrupted areas (ideally hundreds or thousands of acres) of *young* trees. **Golden winged warblers** like abandoned fields on hillsides with scattered trees up to 25 feet tall.

Water is important to many songbirds. **Kentucky warblers, Swainson's warbler** and **wood thrushes** favor rich, moist deciduous forests, especially near streams, with a *dense, leafy* understory with viney, jungle-like small openings. **Louisiana water thrush** lives in woodlands near streams. **Warbling vireos** live only in open, mature hardwoods lining rivers in open country. **Yellow-throated vireos** live in open stands of tall deciduous trees, usually near water. **Blue winged warblers** like brush, thickets and saplings near water. **Prothonatory warblers** live only in swamps and bottomlands where there are cavities in dead trees.

Moist soils and shade are also important or essential to some species, such as **salamanders, trillium, bleeding heart** and **ginseng**, which prefer rich, moist soil and older forest. The **smoky shrew, hairy-tailed mole, woodland jumping mouse** and **red-backed vole** live only on moist lower hillslopes. **Woodcock** favor forests of young saplings (trees 1-5 inches in diameter) growing on rich, moist soil.

Wildlife "Cycles": Population Dynamics

As the number of "eaters" (*predators*) increases, the amount of "eaten" (*prey*) decreases. Many predators must then utilize a small amount of available food. Some die of starvation, disease or exposure to the weather—or they go elsewhere to look for food. Now, relatively free of enemies, the "food" species multiplies. As it does, the remaining predators have plenty to eat, so they begin to multiply—until they again run out of food.

Say it takes 30 frogs per year to feed a trout, 300 grasshoppers per year to feed a frog, and .07 pounds of grass per year to feed one grasshopper. Let's look at a field near a stream.

Year one – plenty of grass; 9,000 grasshoppers multiply to 90,000. Frogs feast, multiply to 900.

Year two – There are more frogs than the 10 trout in the stream can eat; the trout population doubles. But last year and this year, many grasshoppers have been eaten or died from disease and starvation; only 9,000 are left – 100 per frog. 600 frogs starve, and the survivors don't lay many eggs.

The third year there are only 15 frogs per trout. 10 trout starve. Meanwhile, grasshoppers are multiplying again because there are few frogs to eat them. And so the cycle starts over.

(Adapted from food chain data in "Living in the Environment: Concepts, Problems and Alternatives" by G. Tyler Miller, Jr., 1975.)

This is a good beginning for understanding how populations change, but it is too simple; it is based solely on food. Many other factors affect organisms. For example,

- Disease, parasites, fire and all types of weather (how weather affects each species and how it adapts);
- Competition between different members of the same species and between *different* species for food or other resources; ability of similar organisms to minimize competition by "sharing" slightly different kinds of food;
- Life span (rate of survival from one season or generation to the next);
- The amount of food an organism can ingest at one time, the ways it searches for food, its choice of foods, the number of predators preying on one species of prey, predators' preference for various prey species, success in avoiding predators (camouflage, hiding, speed, flight, spines, shells, poisons, bad taste, etc.);
- Methods and frequency (seasonal, periodic, constant) of reproduction, age and size at which reproduction begins, number and size of offspring (many small or few large), care given them, distribution of reproduction rates over a life span;
- Energy devoted to reproduction, dormancy, migration and dispersal.

A web of factors interacts constantly to cause complicated twists and turns in plant and animal populations, health and distribution.

A simplified equation for the number of an organism in a given area is:

New population = old population + recruitment + immigration – mortality – emigration.

- **"mortality"** is deaths;
- **"recruitment"** is new organisms: births, seed germination, vegetative shoots or sprouts;
- **"immigration"** (im-me-GRAY-shun) is organisms coming into an area (think of "in"-migration);
- **"emigration"** (em-me-GRAY-shun) is organisms leaving (as in "emit"gration).

Over the long term, the population of any species in a given area will wobble around an "average" or "ideal" or "sustainable" number, called the *carrying capacity* for that place.

Life Cycles of Trees and Forests

Trees and forests don’t seem to change much from year to year. But if we could compress centuries into seconds by watching a forest on "fast forward," we would see trees disappearing and new trees coming up in their place. We would sometimes see the forest stripped by a natural disaster, then watch it renew itself. We would be witnessing the life cycles of trees.

Trees face many hazards throughout their lives:

Insects Wind Ice Root injury Pollution	Diseases Tornado Hail Animal damage Logging	Fire Drought Crowding Flooding Sun scald	Lightning Extreme cold Shading Landslides

Often trees die from the combined effects of two or more hazards. For example, drought weakens a tree and insects finish it off; or a storm opens a wound through which decay enters and topples the tree.

Trees which survive all else eventually succumb to old age. Biological changes set in as a tree nears the end of its life cycle. Growth and fruit production nearly cease. The ability to send up root sprouts is lost. Branches begin to die back and break off. Vigor declines, and the tree can no longer withstand pests, drought and other environmental hazards.

The maximum lifespan of mid-south tree species ranges from one to a few centuries under *ideal* conditions—which seldom exist. Only scattered specimens ever approach the maximum age possible for their species.

When trees die, are broken off by storms or are cut down, new trees grow up to replace them. Seeds are always present in the forest floor. Other seeds blow in, are carried in by birds and animals, wash in, or roll in from uphill. Some seeds, like cedar, won’t germinate unless they pass through the digestive tract of a bird or animal. Others, such as oak, must be cooled below a certain temperature for a certain period of time. Some must have full sunlight and bare soil to germinate; others can germinate in cool shade.

Deciduous trees and some evergreens also grow back from buds on their roots and stumps. These sprouts grow faster than seedlings—several feet per year—because they draw on a large root system full of stored food.

New trees compete with each other for space and sunlight. Tree species adopt two basic strategies in this struggle. Some species try to outgrow their opponents. These "high performance" trees grow fast—if they have full sunlight. They die or become stunted in the shade. This is because the leaves of these trees are very efficient at using full sunlight, but are inefficient at using dim light. These species are called *intolerant* because they

don’t tolerate shade. Walnut, cherry, green ash, tulip poplar, red oaks, persimmon, sweetgum, cottonwood and sycamore are intolerant.

Other species depend not on speed, but on their ability to survive in the shade. These *tolerant* trees utilize dim light very efficiently, but they can’t utilize full sunlight as efficiently as the intolerant species. Tolerants are slow but steady, growing at about the same rate whether they are in sun or shade. Tolerant species include beech, certain maples, hemlock, blackgum, sourwood, dogwood and ironwood.

"Tolerant" and "intolerant" are simplifications. In reality there are many degrees of tolerance and intolerance. Tolerance also varies with age among the oaks, which are tolerant only for their first ten or so years. And there are exceptions to the generalization that intolerant trees grow fast and tolerant trees grow slowly.

The Changing Forest

Forests change constantly due to many factors:

- **Weather**
- **Climatic changes**
- **Fire**
- **Insect and disease outbreaks**
- **The interactions of plants and animals** which fight for water, sunlight and space, eat each other, provide shelter for other organisms, and occasionally "make a deal" to help each other, a process called *symbiosis* (sym-by-OH-sis). This type of change is very complex. Volumes have been written on it.
- **Humans** have had a greater effect on forests than any other inhabitant of earth. As with animals, some effects are/have been bad (imported diseases, cleared and farmed steep hills, practiced poor timber cutting methods) and good (replanted trees on eroding farmland, wisely managed forest, protected rare species).
- **Forest succession** is a very important process of change that the forest "does to itself." Let’s take a closer look.

A peaceful undisturbed forest is actually a battleground between trees. If you could watch a forest on "fast forward," trees would be straining for light and shading competitors to death. Eventually, only a few big champions (less than 100 per acre out of the 10,000 original seedlings) reach maturity.

The initial winners are usually fast-growing *shade-intolerant* species. We might nickname them "sprinters." They can grow rapidly in full sun, but die in the shade.

Shade-tolerant species are able to use very dim light, but their leaf chemistry is such that they can’t grow rapidly in full sun. Sun or shade, they grow at about the same rate. We might think of them as "plodders." They usually end up in the shade of taller "sprinters"—for a time.

Eventually the giant "sprinters" (tulip poplar, sycamore, walnut, red oak, etc.) begin to die. They are replaced by the plodders (maples, beeches, hickories, etc.) who have been patiently waiting for this opportunity. Slowly, the forest changes from an *early successional* forest to a *late successional* forest.

> A group of conservationists once raised money and bought the last remaining old-growth white oak forest in the eastern US. They were justly proud of this and said, "Now we will have an old-growth white oak forest forever!" A famous ecologist, Daniel Botkin, looked it over. "No," said Dr. Botkin, "look at what is growing under the oaks: sugar maple! It will be a maple forest."

In an early successional forest, the trees are usually about the same age. They stand tall, "shoulder to shoulder." The canopy is solid and of uniform height. Late successional (or *climax*) forests contain trees of many ages. The canopy is "bumpy" (trees are of different heights) and there are brushy gaps where large trees have died. Most of the forest floor is so shady that only tolerant species can reproduce. Intolerant species can return in significant numbers only when a major disturbance clears enough ground to let full sunlight in.

Tolerance and succession don't fall into neat categories. Tree species exhibit a wide range of tolerance, and some forests undergo only partial succession or none at all. Still, the concept of tolerance and the tendency toward succession are important considerations in timber and wildlife management.

Ecosystems: Stability in the Midst of Change

A group of organisms which live in one area is a *community*. The interactions between these organisms, and between the community and its physical setting, is called an *ecosystem* (EE-ko-sys-tem). An ecosystem is the sum of all cycles and interactions mentioned so far. Examples are endless. Here is a simplified example of the forest/grassland ecosystem that existed in many parts of Tennessee.

> Native American frequently set fires. Fire favors grass and oak (oak tolerates fire better than most trees); grass and crunchy oak leaves favor fire. Bison grazed the bunch grasses so short that fire did not spread well. The bison moved to better pastures, and the grass grew tall and burned again. Oak seedlings and root sprouts took advantage of these fire-free times, and, combined with wet years, grew to a fire-proof size. An added help in re-establishing oak were blue jays, which picked up two acorns and almost always dropped one in flight. The result of all this was a continually shifting pattern of prairie, oak (and chestnut) forest and savanna dotted with oaks. We see that members of this *community* (humans, bison, grass, oaks, jays) were interacting with their *environment* (fire, weather) to form a forest/grassland ecosystem.

One change in the ecosystem triggers others, but all, even big changes like insect or disease epidemics, occur in more or less stable patterns. For example, a hot fire kills most trees but releases the seeds of table mountain pine, thus continuing the "table mountain pine ecosystem," which includes not only the pine but the creatures which live in and among them. A forest can change and *look* different over time, but still remain the same ecosystem—just in different stages.

Forest ecosystems are amazingly resilient, bouncing back from (and even depending upon) massive natural and manmade disturbances: hurricanes, hot fires, extreme cold, repeated heavy logging, insects and diseases. Some are more resilient than others. The oak-prairie-pine ecosystem is resilient, exposed to frequent fire, violent storms and large herds of bison. In mountain cove forests, flowers, birds and amphibians are not adapted to frequent major disturbances and may be adversely affected by them.

Populations of trees, animals, insects—all come and go as conditions change. But when we *lose* a species, then we have a problem. Other creatures will move in and try to take the place of the extinct species, but they will not be entirely successful. Example: oaks grew up on sites where chestnuts had been killed by the blight, but many are now in decline. Even where a species seems to have a minor role, its loss is *our* loss.

When managing the forest, we should remember what conservationist Aldo Leopold said: "The first step in intelligent tinkering is to save all the pieces."

Biodiversity: The Richness of All Life Forms

Animals and plants fascinate us with their diversity of forms and behavior. Tiny hummingbirds migrate thousands of miles from Mexico to Alaska and back; black snakes strangle and swallow copperheads almost their own size; orange slime molds ooze slowly over rotten logs. One can discover bizarre new insects every summer. All of nature is fascinating to the careful observer. The richness of life in all our ecosystems is called *biodiversity* (By-oh-de-VER-sa-tee). Biodiversity includes all native species and their regional variations and *genetic* variety. The study of biodiversity must take into account whole regions and even different continents, as in the case of migratory birds. This is habitat diversity on a grand scale, diversity among habitats—not just forests, but rivers, bogs, prairies, bluffs—**all** habitats. *Specialists* are the "crucial critters" in biodiversity. They can "die out" if their habitat areas disappear, or if habitats get too small or widely separated. *Generalists* are far more adaptable.

Specialized habitats—bogs or patches of prairie, for example—usually occur in scattered spots. Imagine that these spots are tiny lights on a map. Occasionally one or more spots will "wink out" as the habitat is degraded or destroyed; later they may light up again as the habitat recovers, and other lights will "wink out." Specialists need to be able to move to a new spot if their local habitat disappears. If there are only a few spots of habitat, there is a greater chance that too many will disappear at once. The farther apart the spots, the harder it is for animals to migrate. How fast can the specialists move? Birds move readily; dwarf ginseng does not. On the other extreme, large blocks of relatively uniform forests also contribute to biodiversity. The cerulean warbler needs five to ten thousand acres of even-aged mature hardwood forest with little undergrowth. Many songbirds can’t use a large forest if it is *fragmented* (chopped up or disrupted) by farms, towns, roads, power lines, etc.) Fragmented forests have a lot of edges, which attract jays, crows, and other predators. Edges also attract the brown-headed cowbird, which lays its eggs in other birds’ nests.

HISTORY OF FORESTS IN TENNESSEE

Pre-Columbian Times

Humans and their fire shaped the forests of prehistoric Tennessee. Natural fire (caused by lightning) is rare in Tennessee, but Native Americans frequently set fires to clear land for farming, to get rid of undergrowth that slowed travel and concealed enemies, to drive game, and to improve grazing for buffalo, or bison, an important source of food, clothing and shelter for Native Americans.

Most of the landscape burned frequently. Some areas burned as often as every few years, others every few decades. Fire seldom reached places protected by streams and other natural barriers. The varying effects of fire (and bison herds) created a beautiful and interesting mix of old forest, new forest, clearings, prairie and *savanna* (sa-VAN-na), a park-like forest of spreading oak trees scattered among a tallgrass prairie. Prairie and savanna were widespread over the flatlands of Middle and West Tennessee and the Cumberland Plateau. One early explorer said he rode for three days without seeing a tree! Forests of oak and chestnut, able to survive occasional light fires, were common throughout the uplands. Open, needle-carpeted pine stands grew up after hot fires in the drier parts of the hills. Towering old-growth forests of many species occupied river bottoms and moist mountain coves. Some trees were 200 feet tall and several feet thick.

Historic Times

In 1520 and 1540 the Cortez and Desoto expeditions introduced smallpox and other European diseases to North America. Perhaps 80 to 90 percent of the native population died. Forests grew back on many abandoned Indian farms, to be cleared again for farming 200 years later by European settlers.

By the Civil War millions of acres had been cleared. Crops were grown even on very steep hillsides. Much topsoil washed away. Cows, pigs and goats grazed in the woods and on open rangelands such as parts of the Cumberland Plateau.

As in Indian days, grassland and forest were burned every year to provide better pasture. Farmers also set fires to clear fields, prepare tobacco beds, get rid of insects, clear the undergrowth and improve hunting. Millions of acres burned in some years, but the fires were generally light. Large trees were rarely killed, but fire often damaged them near the ground and opened them to decay. Grazing livestock also caused this kind of damage by trampling and scarring roots and trunks.

Large areas of forest were logged for lumber, fuel and railroad ties. A 400 square mile area in the hills of west-central Tennessee was repeatedly cut over in the mid-1800s to feed local iron smelters. Lumbering and sawmilling began to increase in 1870 and reached a peak in the early 1900s, when Tennessee led the nation in lumber production.

By the 1890s much of the forest had been cut over, but there were still 7 million acres of old forest left in rough, remote mountain areas. That changed when railroads were built in the mountains. Between 1905 and 1938 most of the forest in the Unaka Range was removed by "cut and get out" companies. Hot fires raged through the leftover limbs, exposing the steep slopes to erosion. Only a few pockets of the old forest were left in the Smoky Mountains. Yet, new forests grew up on the cut-over areas and now contain some of the finest timber in the state.

The most common logging practice in Tennessee was "high-grading"—take the best and leave the rest. Although it often doesn't look bad, this was (and still is) a very harmful practice. Generations of high-grading robbed the forest of its best timber and prevented the regrowth of new high-quality timber trees. The most valuable species and best formed trees do not grow in the shade of a high-graded forest.

The Cherokee National Forest was established in 1911, and the Great Smoky Mountains National Park in 1935. In the 1920s the state established a Bureau of Forestry to fight fires and plant trees on depleted, eroding farm land. During the Great Depression of the 1930s the federal government formed the Civilian Conservation Corps (CCCs) to provide employment and do conservation work. The CCC fought fires, planted trees, and built roads and fire towers. A fine example of their work can be seen at Natchez Trace State Forest. What were barren eroding fields in the 1930s is now a healthy forest.

In the 1930s and 1940s a fungus from Asia killed all the chestnut trees in Tennessee. This was a terrible loss. The tall, stately chestnut had been one of the most common and valuable trees. It provided light, strong, rot-resistant wood and highly nutritious nuts which were an important food for wildlife, people and livestock. A few scattered chestnut stumps still send up sprouts, but the blight always gets them.

In the early 1950s the state stepped up efforts to control wildfires by stationing firefighting crews in most counties. They reduced the area burned each year from one million acres in 1952 to an average of only 35,000 acres per year since then.

Over the past 60 years nature has reforested thousands of abandoned fields and pastures. Man has assisted nature by planting millions of trees on worn-out farm land, beginning with the Civilian Conservation Corps (CC) in the 1930s and continuing with other federal reforestation programs from the 1960s through the 1990s. Thousands of acres have also been reforested by paper companies over the last 40 years. Today Tennessee has almost a million more acres of forest than it did in 1950, and four and one half million more than in 1900 when land clearing reached its peak. At the present time the total amount of forest land is not changing. In the 1980s Tennessee's forests were growing three times as much wood as was being harvested. Unfortunately, much of this new wood is growing on defective, low-value trees that were left standing when their more economically valuable neighbors were cut.

The rate of timber harvest has increased substantially during the 1990s, but we are still growing more wood than we cut in almost all counties.

TODAY'S FORESTS

Introduction

Forests cover 13.6 million acres, or about half of Tennessee. The most heavily forested regions are the eastern mountains, the Cumberland Plateau and the western highlands on either side of the Tennessee River.

One hundred seventy-eight tree species are native to Tennessee. More kinds of trees grow in the Appalachian forest of East Tennessee and neighboring states than in any other forest in the temperate zones. Only the tropical rain forests are more diverse.

Tennessee lies in the central hardwood forest region of north America. Nearly 9 out of 10 trees in Tennessee's forests are hardwoods, and the remainder (11 percent) are evergreens, mostly pines and redcedar. Oaks are the most numerous type of tree in Tennessee. Twenty native oak species grow everywhere from dry hilltops to wet river bottoms. Hickories, yellow-poplar, maples, gums and ashes are also common.

Several different types of forest grow in Tennessee. The most common type is *oak-hickory*, which covers 72 percent of the forested area. This is an upland forest made up of oaks and hickories mixed with many other species.

Cove hardwood forests grow in rich hollows and lower mountain slopes. Cove forests are made up of many different types of trees, including several species which are usually found farther north, such as sugar maple, northern red oak and basswood. Cove forests can grow valuable timber and supply good wildlife habitat and are important for their beauty, recreational and ecological values.

Pine and *oak-pine* forests grow in the mountains and plateaus in East Tennessee. Virginia pine is common there, especially on thin, dry mountain soils. The nation's fastest growing white pine is native to the Cumberland Mountains. Shortleaf pine was once common in parts of the Plateau and the West Highland Rim, but early timbering removed most of it. Loblolly pine has been planted by paper companies, especially near Chattanooga, on the Plateau and in the West Highland Rim. Loblolly has also been planted on thousands of acres of worn-out farm land, especially in West Tennessee.

Forests similar to those of New England and Canada grow in the eastern mountains. Some common trees in these high, cool forests are maple, beech, white pine and hemlock. Fir and spruce grow on the highest mountaintops.

At the other end of the state, along the rivers of West Tennessee, grow *bottomland hardwood* forests of oak, sweetgum, tupelo, cypress, elm, ash, cottonwood, sycamore and other water-loving trees. Rich soil and plenty of water allow them to grow quickly. These forests provide excellent wildlife habitat. Most of the original bottomland forest has been cleared for agriculture.

The nation’s most extensive *redcedar* forests grow in the Central Basin around Nashville. Redcedars are not true cedars. They are actually junipers which thrive on the thin, rocky limestone soils of the Basin. Oaks, hickories and other hardwoods are often mixed in with the redcedars.

Value of Today’s Forest

Today the forest provides many valuable products and benefits: wood products, wildlife habitat, clean water, a variety of useful wild plants, natural beauty and a place to play, to "get away from it all" and commune with nature.

Wood Products: Wood products manufacturing is Tennessee’s fourth largest basic industry (a basic industry produces new dollars), adds $5 billion to the economy each year, pays annual wages of $1.6 billion, and employs about 60,000 people, counting loggers and foresters. Wood delivered to mils is one of Tennessee’s most valuable agricultural crops.

Tennessee produces a wide variety of wood products which can be classed into three main groups:

- Paper and similar products
- Lumber and lumber products, and
- Furniture

Of these, the paper industry employs the most people and produces the greatest dollar value. In the past, paper was made mostly from plantation-grown pine. Today, much more hardwood is used. This has created a rapidly growing market for Tennessee’s "low grade" hardwood, which are poorly suited for lumber. It has also raised concerns about possible over-cutting.

Tennessee, Virginia, North Carolina and Pennsylvania are the nation’s leading producers of hardwood lumber. Tennessee is the nation’s top producer of hardwood flooring, log homes and pencils, and is a leading manufacturer of cabinets and furniture, tool handles and many other specialty products. This great variety of products is possible because Tennessee has a plentiful supply of many different kinds of hardwoods. Other important tree products include particle board, Christmas trees, firewood and mulch.

Wildlife: Tennessee’s forests are rich in wildlife, including deer, turkey, raccoon, squirrel, bobcat and many kinds of songbirds. Hunting and fishing have always been very popular in Tennessee, and now our forests, streams and lakes are attracting many out-of-state sportsmen. Income from hunting and fishing is estimated to be $1.3 billion per year. Bird watching has also become popular. More than $350 million is spent every year in Tennessee on bird watching and other wildlife observation.

Clean Water: Clean water is another forest product. Fifty inches of rain falling every year on 13 million acres of forest give Tennessee plenty of clean water, something which is scarce in many parts of the nation.

Outdoor Recreation And Scenic Beauty: Forests and scenery help make Tennessee a good place to live and are important reasons why tourists come here. The tourism industry, estimated at about $7 billion per year, is very important to the state's economy.

Forest recreation takes many forms: driving and sightseeing, hunting, fishing, hiking, trailer and RV camping, tent camping, backcountry/wilderness camping, rock climbing, horseback riding, bicycling, bird watching, picnicking, wildflower observation, orienteering, or just sitting and enjoying the peace and beauty—even in your own back yard!

Recreation means "re-creation" of the body and soul. In forests we can find peace, beauty, adventure, an escape from everyday life, and health benefits from fresh air and exercise. Trees and forests also have a curative effect of their own. Just looking at trees lowers blood pressure and reduces stress. Hospital patients recover faster if they can see trees from their windows, and kids who grow up around trees and animals do better on IQ tests.

Wild Plant Products: The roots of the native wildflower ginseng are as much in demand as medicine in east Asia. People in rural Tennessee make several million dollars per year digging wild ginseng roots. Goldenseal and mayapple are also used as medicines. Some of the many other Tennessee forest plant products are grape vine wreaths, gourmet mushrooms, sourwood honey, maple syrup, walnuts and walnut hulls (used as abrasives), cedar chip animal bedding, mulch, sassafras tea and fruit jellies.

MANAGEMENT AND CONSERVATION

Why Conservation?

Conservation is "use it, but don't use it up." If we use the forest wisely it will always supply clean water, wood products, wildlife, beauty and outdoor recreation. The forest is our most renewable resource. Unlike coal, oil and ore, the forest replaces what we use by means of solar power.

The first step in conservation is to protect the forest from insect and disease epidemics, wildfires, careless road building and poor logging practices, and livestock in the woods.

Wildfire can damage trees, incinerate seedlings, destroy property and threaten lives. Controlled fire, however, is a useful tool in timber and wildlife management.

Insect and disease outbreaks are best prevented or lessened by cultivating vigorous, healthy trees. Thinning out weak or crowded trees and harvesting mature trees are good defenses. Be on the lookout for patches of dying and dead trees.

Careless road building and logging can compact the soil and cause erosion. Following simple state guidelines called "best management practices" will prevent this:

- Plan and locate roads and log "skid" trails carefully;
- Provide ways for water to get off the road as quickly as possible;
- Don't build very steep roads; avoid creeks; build temporary protective structures when you have to cross a stream;
- Close roads and seed them to grass and wildlife foods, etc.

Livestock compact the soil, damage tree roots, cause erosion, and trample seedlings, which hinders regeneration of the forest. If you want a healthy forest, fence out livestock.

Bare eroding land can be protected by planting tree seedlings. Pines are preferred because they have tough roots, tolerate drought, and leave a carpet of needles which protects the soil from raindrops.

Protection from high grading. We have already mentioned "high grade" logging—taking only the best trees and leaving the rest. High-grading is like embezzling from the timber supply; no one notices when a few trees are slipped out every decade or so, but eventually sawmilers have trouble finding good timber. Poorly formed trees and trees not wanted for timber or wildlife should be cut along with the good trees.

Protecting rare and special plants, animals and places. These usually occur in small, special habitats. Protecting them is usually not difficult if you know what to look for. There are several places to go for information: the state Department of Environment and Conservation's Natural Heritage Division, the Tennessee Conservation League, and the Tennessee Department of Agriculture's Forestry Division.

Improving the Forest

Growing Valuable Timber

Tall, straight, solid trees of desirable species (like oak) with few limbs are quite valuable, selling for hundreds, even thousands of dollars a piece. A 20-year-old stand of yellow pine is worth $2,000 per acre in some locales. Short, limby, rotten, crooked trees and tree species with wood that is not useful for high-value products (like blackgum) are worth little or nothing.

Growing valuable timber is like raising a garden:

- Grow it on fertile soil;
- Grow commercially valuable, fast growing species;
- Cut out "weed" trees;
- Wait until your crop is ready to harvest.

Fertile soil. Trees, especially hardwoods, grow best on deep, fertile, moist but well-drained soil, conditions most often found along streams, in hollows, and on the north and east side of hills. Only about a third of the forest land in Tennessee is good enough to grow large amounts of excellent hardwood timber.

The right kind of tree. Some species (oak, walnut, ash, cherry, hard maple, hickory, yellow poplar, some pines) are especially valuable for timber. We have a responsibility to replace the timber we cut, even though we may not see it mature. But when choosing species to grow, don't put all your eggs in one basket. Who knows what species will be in demand in the future?

Replanting is usually unnecessary after logging in eastern forests, since nature normally provides plenty of seedlings and sprouts. But will your favored species survive, thrive and develop? Sunlight is the key. The amount of sunlight that reaches a seedling is determined by the way we harvest timber. Timber cutting should serve two purposes: to harvest old trees and to grow new ones.

Cut one tree at a time and shade-tolerating species like maple and blackgum will tend to dominate. Sugar maple is probably the only commercially valuable species that can be grown this way in Tennessee.

Cut small groups of trees—1/4 to ½ acre (an acre is almost as big as a football field)—and a greater variety of species will grow: white ash, white oak, hickory, red maple and white pine, which tolerate some shade. An occasional poplar or other shade-intolerant tree may survive as well.

Harvesting trees on areas of ½ acre or larger allows the greatest variety of species to grow, including shade-intolerant walnut, cherry, poplar and red oak. Trees (mainly oak) can be grown in two-aged stands where wildlife or aesthetics are high priorities. First,

half or more of the trees are cut, leaving more widely-spaced large trees. This lets in enough sunlight for seedlings to grow. When the new trees are 20 to 40 years old, the overhead trees are cut.

Will Timber Harvest Damage the Environment?

First, we need to define "damage." *Permanent* damage, in the opinion of this author, is:

- Loss of species and/or
- Loss of primary productivity (as in loss of soil)

Temporary damage would include:

- Failure to regenerate tree species which are valuable to wildlife and humans (we are part of the environment!)
- Harm to water quality and
- Cutting trees faster than the forest grows them (thus reducing our future timber supply).

Therefore, timber harvest should not damage the environment if:

- On a small scale, local unique habitats for rare plants and animals are protected;
- On a larger scale, one method of timber harvest is not used so extensively and at such a rapid rate that the forest habitats for "specialist" wildlife species are reduced below what they need to survive in the long term;
- Soil and streams are protected;
- Trees desirable for timber and wildlife are regenerated.

Forest Recreation and Beauty

Some lands are owned by the government and are left untouched for wilderness recreation, scientific study, biodiversity and other reasons. Other government lands are managed for a mix of timber, wildlife and recreation.

But 87 percent of the forest in Tennessee is privately owned, and some of this land is managed primarily for timber. Timber cutting is unsightly to many people, but its looks can be improved considerably.

- Plan and build roads carefully.
- Keep harvest areas small.
- Leave borders of trees along roads and streams.
- Protect interesting and beautiful places.
- Cut low stumps and chop up leftover limbs.
- Put logging roads ‘to bed’ by grading and planting grass and wildlife foods.
- Leave wildlife trees.

If it’s done right, timber harvesting can actually improve forest beauty and recreation in some ways, depending on your personal taste. It can add sunlight, views, flowers,

butterflies, wildlife habitat and, later, stands of tall timber. Logging roads provide access to the forest.

Improving and Protecting Wildlife Habitat

There are many ways to improve wildlife habitat, but remember "**anything we do to the forest, including doing nothing, will help some species and hurt others**." So a landowner first has to decide which species to manage for, then create the habitat they prefer. Here are some common tools of the wildlife manager:

- Manage forests for food-bearing trees (oak, dogwood, sumac, etc.) which are of seed bearing age and are vigorous so that they produce high yields.
- Thin crowded forests to increase yields of acorns and other fruits.
- Carefully burn under pines. This encourages growth of soft, nutritious plant foods.
- Create food plots by plowing and seeding with wildlife foods and native grasses.
- Mow or burn food strips or plots (but not during nesting seasons!). Food plots and burning especially benefit deer, quail and turkey.
- Harvest patches of timber. These clearings are best for most wildlife if they are less than 20 acres, or are long and thin. When done in a densely forested area, this can benefit deer, turkey and many other species.
- "Feather" edges of harvested areas by leaving some trees and brush. Abrupt "clean" edges offer little cover and provide easy meals for predators like jays, crows and snakes.
- Grow a variety of trees.
- Leave some large or dead trees in large timbered areas.
- Build nesting boxes.
- Leave trees in riparian (streamside) areas!
- Use controlled hunting to keep populations of animals like deer near but not above the carrying capacity of their local area.
- Move animals (turkey, bear, etc.) from crowded to uncrowded areas. (Wildlife managers must consider how close an area's population is to its carrying capacity before moving animals.)

Managing For Biodiversity

Biodiversity can be studied and preserved only over very large areas. It requires grand strategies encompassing whole regions of the country, and cooperation among many individuals, agencies, and even countries are needed to preserve biodiversity. The goal is to keep enough of every kind of habitat needed to provide healthy populations of all native species. In the real world, this may not be possible. So how can we preserve the most biodiversity and save the most specialists? We need a well-thought-out strategic plan, based on the answers to these questions:

- Which *species* are we worried about?
- What *habitats* do they require?
- Are there *groups* of these species that share the same habitat?

- Which ones demand the largest and/or most *specialized* habitats? (If we can please these "keystone" species, chances are we will also please many others, too).
- Where are *existing* habitats?
- How can those be *protected* or managed?
- In what *critical* areas are habitats too far apart? (Recall the "winking lights")
- How can we provide those "most wanted" habitats *where* they are needed?

Example: We find that several specialists we are worried about (fringed orchid, prothonatory warbler, warbling vireo, swallow-tailed shrike, etc.) require the same sort of habitat, mature forests along large streams in West Tennessee. The shrike is the most "picky," requiring 10,000 acre blocks of bottomland forest. If we can provide that, all the other species will be provided for.

Preserving patches of habitat to save a single endangered species is sometimes necessary, but in the long term those little spots may "wink out" and that species will be lost anyway. Setting aside key blocks of scarce habitat in the right locations for groups of species is far more effective.

Some areas are more important to biodiversity than others. The bottomlands are very important; the vast, dry oak-hickory forests of the Cumberland Plateau are less so (except for scattered bogs and other special habitats).

Preserving biodiversity does not always mean "leaving things alone." Sometimes we need to do things to the habitat to keep it the way it needs to be. Example: burning prairies.

But what can *individuals* do to promote biodiversity?

- Protect rare plants, animals and their habitats where they exist.
- Sign "conservation easements" to do or not do certain things. (This is much more effective if several neighbors do it jointly.)
- Use prescribed fire (with professional assistance) to improve habitat for bobwhite, quail, etc.
- Contribute to the Nature Conservancy or other groups which buy lands important to biodiversity.
- Educate others.

Biodiversity is exceedingly complex and we don’t know a lot about it yet. But there are some general principles to follow:

1. Human needs for food, shelter, energy, transportation, etc. must be considered.
2. All types of forest and all types of forest management are needed.

- **Wilderness**. Large areas of fairly uniform aging forest (some will eventually become late successional). Government is by far the biggest owner. Private groups such as the Nature Conservancy also buy, preserve and manage unique, important habitat areas. From the standpoint of biodiversity, wilderness should be located where it is most needed. Some wilderness may need to be managed to

create and maintain a desired habitat. For example, fire can be used to create savanna and open pine stands.

- **Agro-forests** or fiber farms. Trees are managed intensely, grow fast, and are cut at a young age (10 to 30 years) and produce a lot of wood on a small area. By growing up to six times as much wood as unmanaged forests, these "fiber farms" supply a disproportionately large share of our wood fiber. That lessens the pressure to cut trees elsewhere. These forests also provide some wildlife and hunting benefits.
- **Mixed ownership and management**. "Mom & Pop" forests, mostly in small acreages, but also large individual and corporate forests where a wide variety of timber and wildlife management techniques are practiced. These forests provide large, high-quality logs (and pulpwood as well) and a variety of wildlife habitats.

1. The amounts of these three general types of land management might vary greatly and still be OK. But there should be enough of each, which is often a subject of debate! Timber harvesting should be sustainable; we should grow more than we cut.
2. We need to plan and act on a regional basis. Managing for one endangered species, where it happens to occur at the moment, is stop-gap and often ineffective.
3. Incentives and public purchase of lands might be necessary to carry out the plan.

Landowners

Until now we have focused on the forest, how it works and what can be done with it. But what *will* be done depends on the landowner. Most of the forest in the eastern US is owned by private, non-corporate individuals—not the government or corporations.

These people have a wide variety of objectives for their forests: income, beauty, hunting, birds, speculation or investment, or a hobby. There are many "right" ways to manage a forest. Your ideal forest may be very different from someone else's. All forests produce a mix of benefits, not just one. But by careful planning, work and patience a landowner can enjoy a fairly high level of all benefits—a **multiple use** forest.

Economics

Many landowners make money practicing sound forestry and wildlife management; others do so with little or no thought of profit in their lifetime. Both types of landowners benefit not only themselves, but all of society.

Money is very important in how the forest is managed. Landowners buy the land, pay the taxes and pay any added costs of practicing good forestry. Money tied up in land can't be invested in other things, like the stock market. Land may cost $1,000 per acre or more; taxes may be thousands of dollars per year; and it can cost quite a bit of money and time to establish and properly care for a forest.

A key hidden cost is **compound interest**. Say you buy a car at 10 percent interest and make no payments. Each month the interest you owe gets added on to your debt. This has little effect at first, but as the years go on, the interest you pay goes out the roof! An accounts-conscious landowner may decide to sell timber "young, cheap and often" to avoid compound interest. Landowners, like most of us, occasionally run short of money. Sometimes the only way to keep the land is to cut the timber. Or if a person wants to make money, he might buy land, cut the timber and resell the land at a net profit. Sometimes heirs will sell the timber off the land they've inherited—with little thought to the land.

The Landowner Rights/Regulation Debate

Landowners, who bear the costs and risks of ownership, and enjoy its benefits, naturally value and defend their right to manage their forest as they see fit. How would you feel if you bought a new car and the government told you where and when you could drive it—or that you must let someone else drive it?

Other people, who enjoy the beauty of other peoples' or corporations' forests often say, "Just because you temporarily have a title to the land doesn't mean you should be able to destroy things we all enjoy. Just because you own a house in town doesn't mean you can put a chicken coop in your yard! The forest is a legacy for all mankind, and your ownership is limited."

Landowners might respond, "I worked hard for this. This is a free country. If you want scenery or whatever, pay for it yourself! Don't make **me** pay for what **you** want!"

Should the "good of society as a whole" take precedence over individual rights? Who will define "the good of society"? What is the right balance? This is a hot topic, and as more people expect more things from the forest, it won't cool down soon.

Are laws an answer? Laws governing land use and houses are common in town: zoning, codes, etc. The federal government and many states now have forestry laws. Many landowners think that some of these laws are unfair. The federal Endangered Species Act, for example, has been quite costly for some landowners.

What about education and incentives instead? Most people agree these are desirable, but disagree on how effective they will be. Some questions to consider:

- Just what are the problems? Can we agree?
- Will laws solve a particular problem?
- What would happen without a particular law?
- Is the law necessary?
- Is it fair?
- Can laws be enforced?
- Can laws or incentives be paid for?
- Should landowners be compensated for loss or restrictions of uses of their land?

- Will laws have unforeseen bad effects?
- Will good laws be repealed by our descendants?
- How effective is education? Won’t there always be "bad actors" who know better but don’t care?
- How important a motive is money? Greed? Philanthropy? Love for the land?

The forest of the future is determined by the decisions we make today. We all help shape the forest resource in some way—as land owners, users or producers of forest products, recreators, voters, political activists, educators—or simply through inaction. We are more likely to make good choices for the forest if we understand how it works and the indispensable things it provides.

But for many people, the forest is just a wall of green along the road. You’ve had a look behind that wall. There is much more to see!

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GLOSSARY OF TERMS

Biodiversity – the variety of life forms, the ecological roles they perform, and the genetic diversity they contain; the richness of life that includes all species and all interactions among species.

Biomass – the amount of living matter per unit area.

Cambium – thin layer of dividing cells located between the xylem (sapwood) and phloem (inner bark).

Canopy – uppermost spreading, branchy layer of the forest.

Chlorophyll – the green photosynthetic coloring matter found in chloroplasts and made up chiefly of a blue-black ester $C_{55}H_{72}MgN_4O_5$ and a dark green ester $C_{55}H_{70}MgN_4O_6$.

Climax forest – a relatively stable stage or community of plants that is achieved through a successful adjustment to an environment; more specifically, a forest of trees which is able to reproduce in its own shade.

Community – a group of populations of organisms occupying a given locality.

Conservation – planned management of natural resources to prevent exploitation, destruction or neglect.

Deciduous – in woody plants, the habit of losing leaves in winter.

Ecosystem – a community of organisms interacting with each other and their environment.

Food chain – the transfer of energy in the form of organic compounds from one organism (living, dead or decayed) to another successively until the compounds are broken down and their energy released.

Forest management – the selective manipulation of vegetation to protect the forest resource and improve the quantity and quality of benefits derived from the forest.

Fragmentation – the breaking up or separation of the habitat of certain species into pieces of less value to that species.

Generalist – a species which can live and reproduce in a relatively wide range of habitat conditions.

Habitat – the place or type of site where a plant or animal normally lives and grows.

Hardwood – angiosperms (trees which produce seed in closed ovaries) as opposed to gymnosperms ("naked seeds"), i.e., conifers.

Herbaceous layer – low-growing plants on the forest floor.

Humus – a brown or black complex, variable material resulting from partial decomposition of plant or animal matter and forming the organic portion of the soil.

Inner bark – phloem, which conducts sugar solution from the leaves down to the roots.

Intolerant – unable to live under a certain specified condition (shading, flooding, drought, etc.).

Limiting factor – the one single necessity of life which keeps the population of a particular wildlife species from increasing in a given location.

Midstory – bushes and small trees growing under the forest canopy or overstory.

Multiple use – management of one tract of forest for simultaneous production of a relatively balanced mix of timber, wildlife, watershed and recreation values.

Mycorrhizae – fungus growing in or on plant roots which maintains a symbiotic relationship with the plant: the fungus gathers water and nutrients, and the root provides sugar to the fungus.

Niche – a fundamental niche is an environment in which an organism could successfully survive and reproduce in the absence of competition. A realized niche is the portion of that environment in which that organism can survive and reproduce in the presence of competitors.

Nutrients – for plants, simple salts (nitrate, phosphate, potassium, sulfate, iron, etc.) necessary for life.

Phloem – inner bark which conducts sugar solution down to the roots.

Photosynthesis – formation of carbohydrates from water and carbon dioxide in the chlorophyll containing portions of plants exposed to light.

Primary productivity – the capability of a site to produce biomass.

Respiration – energy-yielding oxidative reactions in living matter.

Specialist – a species which has relatively specific habitat requirements.

Stand – a group of trees of similar age and species composition.

Succession – gradual replacement of one community of organisms with another community of organisms.

Timber – wood suitable for carpentry; also trees of the species, size and shape necessary to produce such wood.

Tolerant – able to withstand shade, flooding, drought of other environmental stress.

Transpiration – the passage of water vapor from a living body through a membrane or pores.

Understory – plants growing under larger forest trees; generally from the ground to a height of about 25 feet.

Xylem – a complex tissue in plants which conducts water from the roots to the leaves and supports the pant; called "sapwood" in trees.