Forest biomass varies widely across the Nation with the darker green hues representing the higher values and the lighter green hues representing lower values. The tan areas are not forested. Maps like this are made by linking field observations to satellite imagery, climate observations, and topographic data. The map clearly shows the higher productivity and biomass of the forests of the Pacific Northwest and Southeastern United States.

The information provided in this publication is also available online at https://forest-atlas.fs.fed.us
Forest Atlas of the United States

Edited by Charles H. Perry, Mark V. Finco, and Barry T. Wilson
“Unless we do [practice conservation], those who come after us will have to pay the price of misery, degradation, and failure for the progress and prosperity of our day.”

Gifford Pinchot, 1910
First Chief of the Forest Service (1905–1910)
28th Governor of Pennsylvania (1923–1927)

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Preface

From the creation of its Forest Inventory and Analysis (FIA) program in 1928, the U.S. Department of Agriculture (USDA), Forest Service has always been a leader in providing consistent, credible, and accessible information about the Nation’s forest resource. By 2001, it was clear the complexities of the new century’s problems required new tools supporting detailed consideration of the location-based context of forests. Improvements in remote sensing technology, geographic information systems, and statistics meant that field data could be used to vastly improve the classification and interpretation of digital imagery, complex results could be readily displayed, and resulting information could be widely shared and used.

But there were barriers to making information accessible for geospatial analyses. For example, forest inventory data resided in a complex database behind a sturdy firewall, impeding access by clients both inside and outside the agency. Despite these difficulties, research collaborations created some of the first national maps of selected forest characteristics (e.g., forest biomass and forest types). The challenge was that other research collaborations released different maps displaying the same attributes, creating consistency and credibility questions. Something more than incremental improvements were required to improve accessibility, consistency, and credibility. A large, audacious jump forward was needed.

We adopted a comprehensive vision: creating, assessing, and publishing authoritative, national geospatial information layers related to the Nation’s forests. Each information product would be developed using cutting-edge science from both the geospatial and ecological communities; have essential metadata (e.g., data sources, model descriptions, and estimates of accuracy or uncertainty); be distributed in a publicly accessible digital library; and be leveraged widely in other analyses. It took more than a decade of intensive work to meet expectations. This book and its associated website are the fruits of that leap forward.

We embarked on a journey whose destination was reasonably clear, but the path forward was uncharted. As an agency, we are very proud of these initial successes—the online digital map library and this book. Our longer term success will be measured by how quickly the online library is populated by a large number of high-quality information products portraying diverse characteristics about America’s forests from analysts inside and outside the Forest Service and how widely the maps are used by all. Our goal is for the data portal to inform and improve public dialogue about managing America’s forests, facilitating decisions in keeping with the Forest Service mission: “sustain[ing] the health, diversity, and productivity of the Nation’s forests and grasslands to meet the needs of present and future generations.”

Linda S. Heath
Staff Director (2016-present)

Richard W. Guldin
Staff Director (1996-2015)

Inventory, Monitoring & Assessment Research, USDA Forest Service
Introduction

The United States of America has a remarkable forest resource—more than 765 million acres of planted and natural forest land and an additional 58 million acres of woodlands. These lands provide clean water, clean air, wildlife and fish habitat, recreational opportunities, and for nearly four centuries have been the foundation for economic development. This atlas introduces the reader to a trove of information also available online at the forest atlas website, https://forest-atlas.fs.fed.us

Evolving from the first inventory of U.S. forests in the 1870s, the Forest Inventory and Analysis (FIA) program rigorously monitors the health and productivity of forests and the many benefits they provide. This atlas combines inventory and monitoring information from the 1870s to the present day with datasets prepared by other partners on wilderness, wildland fire, wildlife, and other issues to tell stories about the value of the Nation’s forests and the challenges they face.

Advances in technologies and analytical methods and the availability of other spatial data, such as satellite imagery and digital elevation models, now make it possible to present information about U.S. forests in novel ways. Much of the content is this atlas is derived from over 355,000 field plots, more than 19 million tree observations (some trees have been measured more than once to estimate growth), and two decades of satellite imagery that are transformed into rich and comprehensive information spanning the Nation’s entire forested landscape. Sources for all of the content published here are provided in the back matter.

The content is accessible to many audiences. Lay people can learn about forests through maps and infographics. Analysts can access the data behind the stories to answer myriad questions. This atlas supports the Forest Service’s strategic goals.

The Forest Service strategic goals:

• Sustain our Nation’s forests and grasslands.
• Deliver benefits to the public.
• Apply knowledge globally.
• Excel as a high-performing agency.

In the forest atlas, national experts explore these related questions:

• Where Do Trees Grow and Why?
• What Else Lives in the Forest?
• What Shapes the Forest?
• What Benefits Do Forests Provide?
• What is the Future of Our Forests?

The forest landscape is dynamic, and we encourage you to check back often as we continue to publish new information and knowledge to our companion website and related pages.
Where Do Trees Grow and Why?

Trees live in an amazing variety of places. They depend upon light, water, and nutrients to survive. The resources and substrate necessary for establishment and growth vary substantially across the landscape. Tree species are adapted to different combinations of these requirements. Generalist species can survive in a wide variety of resource environments; others are highly specialized and thrive in environments where limits of one or more resources inhibit most trees from growing. The borders of forests are often defined by the excess or limitation of one of these factors. The tree line in mountain landscapes is one example of limitations on tree establishment and growth: the increasing exposure and cold limits the ability of trees to grow farther up the mountainside. Bogs provide another example. Although some tree species can grow in the hummocks of moss, which keep their roots dry for part of the growing season, the hollows are too damp, even for trees like black spruce and tamarack, which are adapted to wet locations.

When tree species are adapted to similar conditions, it is possible to start to identify forest types: combinations of trees that tend to be found together. Some forest types are relatively simple and involve only a few tree species living together. Other forest types are very complex and include a large number of tree species uniquely adapted to the resource environments where they are found.

The occurrence of any individual tree species is strongly related to present and past disturbances. Pioneer species are well adapted to colonizing lands burned by fire, knocked over by wind, or harvested by humans. Their ability to establish themselves quickly after such a disturbance and grow rapidly in the abundant sunlight of the resulting clearing helps them compete for resources. However, the success of these pioneer species often spells their own demise. As they colonize the landscape, the shade they create favors the growth of a new cohort of trees that are more shade tolerant and may be less demanding of nutrients. Over time, the forest in any one location may transition from one forest type to another in a process called succession. Disturbances interact with natural succession to maintain diverse combinations of tree species and forest types even without specific management by humans.

TREES GROW IN A VARIETY OF LANDSCAPES. Bristlecone pines live long in locations too cold for many species. Shade-tolerant sugar maples may carpet a shady understory. Cypress trees thrive with submerged roots, and savannas exist on the boundary of too little water. Trees even find nutrients in thin cracks between rocks and within rotting logs of their predecessors.
Ecological Divisions of North America

The Earth’s surface can be divided into progressively smaller and more uniform units based upon climate, plants, and soil; some classification systems even include human management. The U.S. Department of Agriculture (USDA), Forest Service, system of classifying the landscape starts at the broadest scale with four domains defined by precipitation and temperature: polar, humid, dry, and humid tropical. The next level includes divisions, which are identified by more detailed separation in precipitation amount and pattern, along with temperature. These classifications are useful tools for understanding ecological variation across the landscape.

Managers, scientists, and others involved with ecological issues use a wide variety of classification systems. In biology, plants and animals are classified to better identify and understand their similarities and differences. Similarly, landscape ecologists divide the Earth’s surface using progressively smaller and more uniform units to facilitate resource management across the landscape. These units—domains, divisions, provinces, sections—are important to understanding forests because similar landscapes support similar types of forests.

Landscapes are generally classified based upon climate, vegetation, and soil. A few classifications include agricultural crops and other human-management factors. The importance of each factor varies among units, but climate is the starting point for dividing the landscape in this system. An area’s climate is described by its temperature, available moisture, and the timing of each; these influence both plant communities and soil development. And while a site’s climate is strongly related to latitude and its location on the continent (near the ocean or deep in the interior), mountains also have a profound influence and create their own ecosystems.

When applied at broader scales, landscape classification systems can be used to put ecosystems into an international context. These systems can also facilitate management of environmental issues that occur over large areas or transcend political and agency boundaries.

As landscape units get smaller, they also become more homogenous. For the sake of simplicity, the accompanying map focuses upon ecological divisions, a midpoint in the Forest Service’s landscape classification system.

AREA OF FOREST LAND IN THE CONTERMINOUS UNITED STATES BY ECOLOGICAL DIVISION. Forests are not distributed evenly across all ecological divisions of the conterminous United States. Forests are the common natural vegetation in the subtropics, but trees are generally absent in the temperate steppes. Forests in western divisions are found largely in the mountains. Timber is grown on “productive” forest lands, and those lands are most commonly found in the Eastern and Southern United States. It is no surprise that the subtropics are known as the Nation’s “wood basket.”

PHOTOS: The tremendous variation across ecological divisions in the United States is a result of different amounts of precipitation and energy from the Sun. These highly diverse landscapes support plant communities uniquely adapted to live in those locations.
Forest Extent

Across much of the United States, people can see trees in all directions. Does that mean they are also seeing forests? The answer is not always yes.

Nearly every definition of forest land involves three factors: tree density, land use, and patch size.

1. **Tree density** refers to the amount of land covered by trees. The most common measure of tree density is percent canopy cover.

2. **Land use** describes how people manage or modify the land. Forest land use requires that no activities prevent normal tree regeneration and succession.

3. **Patch size** defines the minimum area required to be classified as a forest. A patch of four trees, for example, does not constitute a forest.

Our Nation’s Forest Inventory and Analysis (FIA) program defines forest land to be at least 1 acre in size, have at least 10 percent tree cover or formerly had such cover, and be capable of regrowing trees.

This definition can lead to some seemingly strange situations. For example, industrial forest lands are managed to supply a sustainable source of wood. Lands that are harvested today are quickly planted, and they are still called forest land even if they have no trees at the moment. The definition of forest land is growing to capture the benefits trees provide, particularly in urban areas.

PHOTOS: Knowing the difference between tree land cover and forest land use is important to understanding information about forests. A harvested or burnt forest is just as much forest land use as a thriving dense forest if they are managed to regrow trees. Alternatively, urban and suburban landscapes may have trees, but are often not counted as forest land because they are managed for other uses and landscaping prohibits natural tree regeneration. Forest that is permanently converted to another land use, such as agriculture, is also no longer counted as forest.

WHERE DO TREES GROW? 

FOREST ATLAS OF THE UNITED STATES
Tree Species Ranges

Tree species differ in responses to their environment and ability to compete with one another for nutrients. These factors strongly influence where individual tree species are found across the landscape.

Our FIA program at the Forest Service recognizes more than 400 different tree species in its survey of forests of the United States. The next few pages highlight 24 of the most abundant tree species across the 19 ecological divisions found in the contiguous United States.

Determining which tree species to include in the atlas was somewhat subjective because it first involved defining “abundance.” Within each ecological division, FIA calculated the relative proportion of total number of trees and tree volume for each tree species. FIA chose the 5-6 most abundant species in each division with a focus on species that were abundant on both the total number and volume lists.

For example, FIA included red maple because it is one of the top three species in three ecological divisions when measured by either number of trees or tree volume.

FIA included redwood because it is the top-ranked species by tree volume and second-ranked species by number of trees in the Mediterranean Division found along the California coast. By these same criteria, FIA did not include some abundant species—as measured only by total volume across the United States, such as yellow-poplar and Engelmann spruce—because they are not among the most abundant tree species within the ecological divisions where they occur.

The larger maps in this feature depict current species abundance and distribution across the contiguous United States, modeled by using FIA field plot data. Although the absolute values associated with the maps differ from species to species, the highest values within each map are always associated with the darker colors. The smaller inset maps show their historical ranges across North America.

THE NUMBER OF TREES (LEFT CHART) AND VOLUME OF TREES (RIGHT CHART) OF EACH SPECIES FOUND IN EACH ECOLOGICAL DIVISION. In both sunburst charts, the outer ring represents the distribution of values across ecological divisions, while the inner ring represents the distribution of values across species within ecological divisions (map). Predominantly nonforested ecological divisions are grouped together as “Other,” as are minor species within each ecological division. The “Other” species group is large because most forested landscapes are incredibly diverse, yet those additional species add surprisingly little volume or numbers of individuals.

WHERE DO TREES GROW? TREE SPECIES RANGES
**Balsam Fir** (Abies balsamea) grows best in areas with cool temperatures and abundant moisture, on a wide range of soils that originated via glaciation. Balsam fir is also referred to as balsam, Canadian balsam, or eastern fir. Wildlife rely extensively on this tree for food and shelter. Moose, for example, feed on balsam fir during winter.

**Red Maple** (Acer rubrum) is widespread across the Eastern United States. Its range is likely limited by mean minimum temperature in the North and by the dry climate of the Great Plains in the West. Red maple, also known as scarlet maple or swamp maple, is adapted to grow on a variety of soils over a wide range in elevation. Red maple is an important source of winter food for livestock, elk, and white-tailed deer.

**Sugar Maple** (Acer saccharum) is restricted to regions with cool, moist climates. Across these regions, the growing season ranges from 80 to 260 days. Sometimes called hard maple or rock maple, sugar maple grows best on slightly acidic, well-drained loams and does not grow well on dry, shallow soils or in swamps. It is the primary source of maple syrup, made by evaporating sugar maple sap.

**Red Alder** (Alnus rubra) grows in humid to super-humid climates along the Pacific coast of the Northwestern United States. Average annual precipitation varies from 20 to more than 200 inches, mostly coming in winter while summers remain cool and dry. Red alder, sometimes referred to as western alder or Pacific coast alder, is found on a range of soils but grows best on deep, well-drained alluvial loams at elevations lower than 2,500 feet. Originally considered a nuisance tree good only for fuelwood, red alder is now also used for furniture and cabinetry.
**Ashe Juniper** (Juniperus ashei), also known as post cedar or mountain cedar, grows in a limited range within the hot, semi-arid Southwestern United States and is found extensively throughout central Texas. Although it has grown primarily on rock outcrops or dissected upland limestones, it has now spread to adjacent grasslands. It typically grows on soils derived from limestone. The endangered golden-cheeked warbler breeds exclusively in the mixed Ashe juniper and deciduous woodlands of central Texas.

**Utah Juniper** (Juniperus osteosperma) is native to the Southwestern United States. It thrives on very dry sites, with hot, dry summers and cold, wet winters. Utah juniper typically grows on alluvial fans and rocky hillside with shallow, alkaline soils at elevations ranging from 4,000 to 8,500 feet. Juniper berries, which are actually cones, are used to flavor gin.

**Sweetgum** (Liquidambar styraciflua), also known as redgum, sapgum, or starleaf-gum, is a common bottomland species throughout the Southeastern United States and is most abundant in the lower Mississippi Valley. It tolerates a variety of soil and site conditions but grows best on the moist alluvial clays and loams associated with river bottoms. Sweetgum is used for pallets, boxes, and crates, as well as for furniture and interior woodwork.

**Tanoak** (Lithocarpus densiflorus), or tanbark-oak, grows in the humid region along the Pacific coast, with annual precipitation ranging from 40 to 100 inches, most of it coming in winter. It grows well on a variety of soils, from deep, well-drained loams to shallow soils that are less suitable for conifers. Historically, tanoak’s large acorns have provided an important food source for Native American communities in the region.
Lodgepole pine (Pinus contorta) grows in a variety of climatic conditions, from the coasts of the Pacific Northwest to the inland environs of the northern Rocky Mountains. It grows best on moist soils derived from granites and shales, and it generally favors northern and eastern slopes. Along the coasts, however, lodgepole pine is often found in peat bogs or muskegs. Lodgepole pine is used in the round for posts, poles, and firewood; it is also processed for paneling and pulpwood.

Shortleaf pine (Pinus echinata), also known as southern yellow pine or shortstraw, has the widest range of any pine in the Southeastern United States. It grows in humid climates, with annual precipitation ranging from 40 to 60 inches and average annual temperature ranging from 50 to 70°F. It has adapted to a variety of site and soil conditions but grows best on deep, well-drained soils at elevations below 3,000 feet. Birds and small mammals feed on shortleaf pine seeds.

Common pinyon (Pinus edulis), also known as two-needle pinyon or nut pine, grows in the lowest and warmest forested region in the United States. In this semi-arid region of the Southwest, summers are hot, and winters are cold, with average annual precipitation ranging from 10 to 25 inches. The common pinyon tree grows primarily between the low plains and high mountains, on rocky plateaus, mesas, and lower mountain slopes. In North America, the common pinyon is one of the principal sources of edible pine nuts, which are large seeds extracted from the cones.

Ponderosa pine (Pinus ponderosa), also known as western yellow pine, grows across the Western United States. Except for the west slope of the Sierra Nevada, it is typically restricted to areas receiving between 10 and 30 inches of precipitation and having a frost-free period of 100 to 200 days annually. Ponderosa pine forests are used primarily for recreation, timber production, and livestock grazing.
LOBLOLLY PINE (Pinus taeda) grows primarily in humid climates, with long hot summers and mild winters. The main limiting factor to its range is likely low winter temperatures in the North and lack of adequate precipitation in the West. Sometimes referred to as oldfield pine, this species grows over a range of topographic conditions, predominantly within strongly leached, acidic soil. Natural stands and plantations of loblolly pine provide habitat for several game species, such as wild turkey.

QUAKING ASPEN (Populus tremuloides) is widely distributed across both the Eastern and Western United States. Climate conditions vary greatly across its range. In general, quaking aspen grows where annual precipitation exceeds plant water use and can be found on a great variety of soils from sea-level to more than 11,000 feet in elevation. Quaking aspen goes by many different names, including trembling aspen, mountain aspen, poplar, and popple. Aspen forests are a prized backdrop for hikers and naturalists, who enjoy their light bark and colorful autumn foliage.

HONEY MESQUITE (Prosopis glandulosa) grows on a wide variety of soils across the Chihuahuan Desert and into the southern edge of the Great Plains. It generally is found in areas below 4,500 feet in elevation and receiving fewer than 30 inches of precipitation annually. Previously, honey mesquite was more restricted to drainages but now has invaded grasslands. Honey mesquite provides nesting material and is an excellent source of nectar for bees. The inset map shows generic mesquite range, not specifically honey mesquite range.

DOUGLAS-FIR (Pseudotsuga menziesii) grows under a range of climatic conditions in the United States, from the mild, wet winters and cool, dry summers of the Pacific Northwest to the more extreme conditions of the Sierra Nevada. It grows best on well-aerated, deep, mildly acidic soils. Douglas-fir is sometimes called red fir, Oregon pine, or Douglas-spruce. Douglas-fir is commonly grown on short rotations as a Christmas tree.
**WHITE OAK** *(Quercus alba)* grows throughout most of the Eastern United States. It grows under a variety of climatic conditions, with average annual temperatures ranging from 45°F in the North to 70°F in the South and annual precipitation ranging from 30 to 80 inches. White oak grows on a wide range of soils and sites, where growth is good on all but the driest and shallowest soils. It is also known as stave oak. Because of its sweet aroma, white oak is favored for the cask aging of wine and whiskey.

**GAMBEL OAK** *(Quercus gambelii)*, also known as scrub oak or white oak, is usually found at elevations between 3,000 and 10,000 feet above sea level, in areas with between 12 and 24 inches of precipitation per year. It is more prevalent with disturbance in ponderosa pine woodlands. Gambel oak is an excellent fuel source for wood-burning stoves because it produces little smoke when it burns.

**CHESTNUT OAK** *(Quercus prinus)*, sometimes called rock oak, grows in a humid climate throughout its range, except for a super-humid region in the Appalachian Mountains. Average annual precipitation over most of its range is from 40 to 48 inches. It is most commonly found on dry upland sites in shallow soils with low moisture-holding capacity. Chestnut oak acorns are an important food source for deer, wild turkey, and small rodents.

**POST OAK** *(Quercus stellata)*, sometimes called iron oak, has a range that reaches from the semi-arid areas of Texas and Oklahoma to the humid Eastern United States, with average annual precipitation ranging from 20 to 60 inches. It grows on a variety of sites and soils but typically is found on dry sites, such as rocky outcrops and upper slopes with southerly or westerly aspects, well-drained, sandy soils. Post oak is a commonly used shade tree in urban parks.
**Redwood** (Sequoia sempervirens) grows in a humid to super-humid region of mild temperatures along the Pacific coast of northern California, where temperatures rarely rise above 100°F or fall below 15°F and average annual precipitation varies between 25 and 120 inches. These tall trees use the frequent summer fog as a source of water. Redwood grows from sea level to an elevation of 3,000 feet. Redwood is known for its ability to resist decay and is commonly used in outdoor furniture and decks.

**Pondcypress** (Taxodium ascendens) is found in humid and moist sub-humid climates along the southeastern coast of the United States, with a growing season ranging from 250 days in the north to almost 365 days in southern Florida. It grows almost exclusively on flat topography in shallow ponds or on poorly drained sites. Pondcypress is closely related to baldcypress. Submerged cypress logs provide spawning habitat for catfish.

**Western hemlock** (Tsuga heterophylla) thrives in mild, humid climates, particularly those with frequent fog and precipitation during the growing season. Also called Pacific hemlock and west coast hemlock, this species grows on a variety of soils and landforms but grows best between sea level and an elevation of 2,000 feet along the coasts and between 1,500 and 4,000 feet in the Rocky Mountains. Western hemlock is recognized as an important aesthetic component of several national parks in the Western United States.

**American elm** (Ulmus americana), also known as white elm or water elm, is found throughout the Eastern United States, in climates ranging from warm and humid to cool and dry. The average frost-free period of its range varies from roughly 120 days near its northern border to 250 days closer to the Gulf of Mexico. It is most common on flats and bottomlands, but not restricted to these areas. The interlocking grain of American elm makes it difficult to split and well-suited for use where wood needs to be bent, such as in the manufacture of hockey sticks.
Types of Forest Communities

Forest communities are made up of distinct assemblages of plant species. These communities are distributed quite variably across the landscape. Certain tree species are often found together in natural forest communities. Likewise, the associated understory vegetation, as well as the wildlife that depends upon it, often occurs in assemblages that are distinctive to the composition of the tree canopy.

There are many different approaches to classifying forest communities. These classifications are useful to scientists and natural resource managers alike. However, they inevitably imply distinct boundaries, while real forest communities transition gradually from one to another, both across the landscape and over time. For this reason, classifications of forest communities evolve over time as our understanding of these communities changes.

The accompanying chart identifies 140 forest types across the United States. These can be aggregated into 28 groups of similar forest types for mapping. This forest community classification scheme is based upon the relative stocking of tree species within stands, reflecting the amount of available light, water, and soil nutrients each use.

**CIRCULAR DENDROGRAM OF FOREST-TYPE GROUPS.** This dendrogram depicts the hierarchical relationship among forest types and forest-type groups in the conterminous United States. The cyan to violet palette represents hardwood forest-type groups while the red to green palette represents softwood forest-type groups. The distribution of forest types across the United States is quite variable. The majority of hardwood forest types are found in the Eastern United States, from the Midwest to the Northeast, as well as west Texas and the Central Valley of California. Softwood forest types are found primarily in the Southeast and throughout the Western United States from the Rocky Mountains to the Pacific Northwest.

**FOREST-TYPE GROUPS**
- 01. White fir
- 02. Spruce
- 03. Loblolly pine
- 04. Larch
- 05. Douglas fir
- 06. Ponderosa pine
- 07. Western larch
- 08. Redwood
- 09. Western hemlock
- 10. Lodgepole pine
- 11. Hemlock
- 12. Western redcedar
- 13. Red alder
- 14. Other western softwoods
- 15. California mixed conifer
- 16. Evergreen forest
- 17. Oak
- 18. Oak/hickory
- 19. Oak/gum/cypress
- 20. Elm/ash/cottonwood
- 21. Maple/beech/birch
- 22. Aspen/birch
- 23. Aspen
- 24. Western oak
- 25. Yellow-poplar
- 26. Sweetgum
- 27. Tropical hardwoods
- 28. Softwood
The resources an animal uses for food, cover, shelter, and all other needs is called its “habitat,” and forests provide habitat for a wide variety of birds, mammals, reptiles, amphibians, and even fish. Every organism plays an important role in the forest’s ecological web. Different types of forests support different numbers and types of animals. Each animal species is uniquely adapted to its niche through its morphology, physiology, and behavior. Animals occupying a wide niche are called “habitat generalists.” These species can use many different forest types and stages of growth to meet their needs; examples include white-tailed deer, black bear, raccoon, northern mockingbird, and American robin. Omnivores—species that eat both plants and animals—are usually habitat generalists and often have abundant populations; humans could be considered as habitat generalists. Other animals occupy narrow niches and are called “habitat specialists.” These species require very specific forest types and stages of growth. Examples of habitat specialists include martin, Kirtland’s warbler, wood thrush, red-cockaded woodpecker, and pygmy salamander. Habitat specialists often have small populations that may be threatened or endangered.

The sum of occupied habitat across the landscape makes up a species’ geographic range. This chapter highlights vertebrate wildlife species that are associated with forest habitats in the United States during one or more stages of their life history. Natural disturbances—such as fire, forest pests and diseases, hurricanes, or ice storms—and human disturbances, such as tree harvests, impact forest structure and its composition of plants. Many of these changes are temporary and contribute to natural processes of forest succession, benefiting some species while limiting others. For example, tree harvests create early successional habitat important for many game animals and many migratory songbirds. Those species benefit from the multitude of small-diameter trees and thick vegetation that quickly grow up in the clearings left by disturbances. With no further disturbance however, those shrubby clearings will eventually become areas of large trees with an open understory that are of less use to early successional species, but of vital importance to late successional specialists. Forests are dynamic, always changing environments, and most disturbances result in temporary changes in habitat structure and availability. It is the conversion of forests to other nonforest land uses that tends to result in greater long-term detrimental effects to native wildlife due to the permanent loss of forest habitat.

Wildlife habitat is composed of a combination of biological resources and environmental conditions that allow individuals and populations of species to survive and reproduce. Forests support many classes of vertebrate wildlife including amphibians, gray tree frogs, birds (Clark’s nutcracker, reptiles (eastern indigo snake), fish (jackknife salmon), and mammals (mountain lion).
Wildlife Habitat

Wildlife habitat describes where an animal lives. Every animal requires food, water, cover, and space to survive. Forest habitat, therefore, includes all of the existing resources and conditions within a forested area that allow an animal to live and accomplish other biological necessities (e.g., reproduce or find food). Forests provide habitats for a broad array of wildlife species, from fish to fowl to furry mammals.

As a forest passes through various developmental stages, the structure and composition of trees and other plants change, along with the animal communities that live within the forest.

Tree diameter class and tree species composition are among the characteristics of wildlife habitat that may be studied at a landscape scale. Maps of large-diameter and small-diameter forests can indicate where changes in developmental structure might affect wildlife. For example, maps of stand developmental stage can be combined with forest-type maps to better understand habitat availability for species of interest (e.g., red-cockaded woodpecker in old longleaf pine forests of the Southeast, or Kirtland’s Warbler in young jack pine forests of the western Great Lakes region).

The potential impacts of changing climate patterns have been at the forefront of environmental concerns in part because of the uncertainty in how climate change may affect wildlife species’ ranges and the availability of habitat for “niche specialists”—those animals that can live only within very specific, often localized habitats. Changes in land use and land cover, however, are having more immediate impacts, resulting in both the loss of habitat area and the degradation of remaining habitat as forest patches become more fragmented.
Forest Birds

Birds provide many essential services to forest ecosystems. Small, fruit-eating birds disseminate seeds; insectivorous birds help regulate insect populations; large, predatory birds control small-mammal populations; and scavenging birds help decompose animal and plant material on the forest floor. Birds also serve as important food sources for many other animals, including humans. Some birds, such as woodpeckers, construct nest cavities that later serve as shelter for other animals. And, with their mellifluous songs, diverse plumage, and graceful flight, birds also provide indeterminable aesthetic value.

Forest attributes of composition and structure are important to forest bird species at varying degrees and during different seasons. These attributes include tree and understory vegetation species, tree diameter, canopy and understory height and density, and abundance of standing dead trees and downed dead wood. The arrangement of forest and nonforest habitat on the landscape also plays an integral role in the ability of forests to meet bird life-cycle needs.

All types of forests are important for birds, and each bird species is adapted to the forest in which it resides. Suitable bird habitat provides food, water, shelter, nest sites, song posts, and perching sites. Some species, such as mockingbirds and crows, are habitat generalists—they occupy a wide range of habitats and are not dependent on any one type. Others, such as the red-cockaded woodpecker and Kirtland’s warbler, are habitat specialists and require a specific habitat type or feature for all or a critical part of their life cycle. The red-cockaded woodpecker, for example, makes its nest only in living pine trees.

Forest-breeding bird species diversity in the United States generally increases from southwest to northeast following gradients of moisture, topography, and vegetation. U.S. oak-pine and oak-hickory forest types support around 150 to 200 species of breeding birds, while coniferous forests support about 150 species. Some “endemic” species occur only within smaller geographic areas like the southwest, making their local conservation more important while also contributing to overall species diversity. Bird species diversity increases with forest succession in deciduous forests. Up to 75 percent of bird species in deciduous forests are neotropical migratory songbirds, which actually spend most of each year in other habitats, from the Southern United States to Central or South America.

In general, diverse landscapes support more species than do uniform ones with little variation in topography or vegetation. For example, mountainous regions tend to support numerous avian species because of the habitat diversity associated with topographical changes. Forest management techniques, such as thinning or prescribed burning, are sometimes used to manipulate forest communities to target a specific species or to support overall avian diversity in a stand or on the landscape.

**Forest Bird Habitat:** Each bird species may be primarily associated with a general habitat type. But many species use different features of a forest during different life stages, requiring a diverse set of characteristics even for an individual species. Species may be generalists during part of the year, such as in winter, but specialists during other life stages, such as during breeding season. Thus, depending on the life stage, a given species may occupy differing locations in the forest. For example, many warblers occupy mature to upper canopy habitats; particularly during migration, some warblers may be found in less than optimal habitats in winter if resources are scarce. Similarly, wood ducks are often associated with water, which is a necessary component of their habitat. Because wood ducks roost in tree cavities, however, they may be considered water birds as well as midstory canopy residents. The graphics provides examples of types of birds most likely to be encountered in a given forest vegetation layer for at least some portions of the bird’s life cycle.
Forest Fish and Aquatic Species

Freshwater streams in the United States are home to 801 known fish species, 322 crayfish, 300 freshwater mussels, 600 snail species, and more than 3,000 species of stoneflies, mayflies, caddisflies, dragon and damselflies, and stygobites, making the United States the seventh-ranked country worldwide for fish species diversity and the highest ranked country for all the other categories. The Southeastern United States hosts the greatest diversity of salamanders in the world.

Forests and fisheries are interdependent systems. Forests provide filtration for sediments, agricultural residue, residential runoff, and other pollutants, as well as thermal protection and regulation, stream bank stability, and flood protection benefits. In return, fish are invaluable sources of food for forest-dependent birds and mammals. The nutrients in fish carcasses and animal waste enrich the soil, providing resources for growing trees and other plants. In turn, fallen trees and other structural components of the forest, such as tree roots and canopy cover, provide important habitat features in streams and lakes. Healthy fisheries, therefore, depend on forests to provide adequate filtration and habitat.

Five States (California, Texas, Nevada, Tennessee, and Alabama) in the conterminous United States each have at least 14 endemic fish species in their lakes and streams. Forests are instrumental in maintaining the water quality and habitat characteristics that allow species like those to persist. Though one might not associate the National Forest System with fisheries, our public forests are an important component of fisheries habitat protection. In fact, national forests in the Eastern United States were established under the Weeks Law of 1911 to protect the watersheds of navigable streams. More than 150,000 miles of streams and 2.5 million acres of lakes are found on U.S. national forests and grasslands. The importance of forests to fisheries underscores how all biological systems are interdependent and the importance of landscape scale planning and perspectives.

RIPARIAN ZONE. The definition of a riparian zone varies across jurisdictions, but, fundamentally, riparian zones are interfaces where terrestrial and aquatic ecosystems interact in many ways. Trees provide shade, altering stream temperature and sunlight availability for aquatic plants. Falling leaves serve as important food supplies in headwater streams. Tree roots stabilize banks from erosion. Standing, down, and dead trees provide habitat structure for both terrestrial and aquatic species. Given these connections, sound management of the riparian zone considers potential impacts on adjacent water bodies.

EASTERN BROOK TROUT FOREST DISTRIBUTION. Brook trout (Salvelinus fontinalis) is native to Eastern North America and is named as the State fish in nine States. This species of char exhibits a variety of ecological forms, living in larger lakes; in smaller rivers, streams, and ponds; and as a sea-run form with short migrations from larger rivers to salt water. Just as the “canary in the coal mine” serves as an indicator of healthy air, so do brook trout populations indicate that watersheds are healthy. Population losses are primarily due to land-use changes, like the conversion of forests to urban development, so natural resource managers maintain intact brook trout populations by ensuring that watersheds are at least 65 to 70 percent forested, have low density of roads and agriculture, and low deposition of sulfate and nitrate.
Forest Mammals

When people think about forest wildlife, some sort of mammal usually comes to mind, whether it’s a large animal like a bear or a wolf, or a backyard creature like a squirrel or a mouse. Forest mammals are charismatic symbols of wilderness in the United States, and they are important to humans in myriad ways.

The most common ideal of “wildlife” in the United States begins with mammals—perhaps a bear, moose, deer, or wolf. As with all wildlife, mammals require food, water, and shelter to survive and reproduce. Some mammals require large tracts of uninterrupted wilderness that serve as “home ranges,” while others can live in harmony with human development and agriculture.

In the United States, the number of mammal species that live in forests varies across the country, with highest densities in the continental States occurring in California, Arizona, and New Mexico. All three States are home to multiple specialized habitat types and a variety of landforms, contributing to high species richness. These States harbor numerous small mammals like shrews, bats, and voles. Large mammals in the Southwest include two bear species, several species of large cats like mountain lions, several canines, and a variety of hooved mammals that reside in both forest and plains/desert regions. In general, the Western United States harbors higher densities of forest-dependent mammals than the Eastern United States. The Eastern States with relatively high densities of forest-dependent mammals include Tennessee, North and South Carolina, Kentucky, Virginia, and West Virginia. The Appalachian Mountains are well known for their overall biological diversity. Additionally, all of those States encompass a wide range of ecological regions and forest types.

Mammalian diversity contributes not only to the overall biodiversity of a given forest, but also to the ecosystem services provided by a forest. Recreational wildlife viewing has recently surpassed hunting in terms of the number of days people spent participating in the activity, and, combined, the two activities contribute substantially to local and regional economies.
What Shapes the Forest?

Forests change constantly. Change results from the subtle, slow, and continuous processes of natural growth and death of vegetation. Disturbances also shape forests depending on the way they kill or damage trees, what they leave behind, and how forests recover; disturbance events vary in terms of their magnitude, frequency, and spatial pattern. The magnitude of an event relates to how much of the forest canopy has been removed. Major disturbances remove or kill all the existing trees, while minor disturbances leave many trees alive. The frequency of disturbance varies widely by event type. Volcanoes erupt, expand, and erode over thousands or millions of years; major rivers flood several times a century; devastating hurricanes hit land every decade or so; and hundreds of lightning strikes start fires every year.

Different disturbances result in diverse spatial patterns—from scattered individual trees killed by disease, to clumps and patches of trees killed by fire, to large expanses of forest converted to suburbs. The combination of magnitude, frequency, and pattern dictate how disturbance events shape forests and how forests respond.

Natural disturbances (such as fire, wind, flooding, insects, diseases, and invasion of nonnative species) are a normal part of the life cycle of forests. Dry forest conditions, plentiful fuel, high winds, and an ignition source can lead to large fires. Old trees weakened by lengthy drought may be more susceptible to insect and disease outbreaks. People may play a role in “natural” disturbances. Humans provide triggers through the unattended campfire or transport of an invasive species. People also change disturbance patterns by fighting forest fires.

Natural disturbance patterns are often cyclical, and some forests may return to their predisturbance composition after a period of time.

Compared to natural disturbances, anthropogenic disturbances driven by human needs (such as timber harvesting, prescribed burning, and land clearing) often occur more frequently, and result in different consequences for forests. Harvesting and prescribed fire designed to mimic natural disturbances can enhance natural processes of vegetation recovery. Land development changes the way land is used for decades or longer.

Regardless of cause, there is a dynamic interplay between disturbance and regrowth, with both occurring at the same time over large landscapes and recurring at the same place over time.

VOLCANIC ERUPTIONS AND FOREST SUCCESSION. Volcanoes can devastate forested landscapes. Many dead trees may be left behind. Increased sunlight encourages colonization by hardy small plants. Soon even trees are reestablished on the landscape. After many decades, the forest looks much as it did before the eruption.
Native and Nonnative Insects and Diseases

Forest health refers to a forest's ability to function as a balanced ecosystem, meet management objectives, and be resilient to disturbances. Insects and diseases naturally occur in forests, so their mere presence does not necessarily mean that a forest is unhealthy. Over the past century, however, insects and diseases from other parts of the world have had an increasing influence on the health of forests across the United States.

One of the best-known examples of nonnative diseases affecting North American forests is the chestnut blight epidemic of the early 20th century. Chestnut blight is a pathogenic fungus that was accidentally introduced in North America from Japan around 1904 and spread quickly across the country. By the 1950s, chestnut blight had killed virtually all American chestnut, resulting in the death of up to 25 percent of all eastern hardwood trees, significantly changing the species composition of eastern hardwood forests.

Our Forest Health Protection program at the U.S. Department of Agriculture (USDA), Forest Service routinely reports on almost 50 major forest pests and pathogens whose impact is significant and is of local and national interest. The accompanying maps present some of the results of these surveys.

Native forest insects and diseases are an important part of well-functioning forest ecosystems. They influence species composition and stand structure by contributing to tree growth, mortality, and nutrient cycling. Interestingly, native insects and diseases are most abundant in the Western United States, whereas nonnative insects and diseases are found in largest numbers in the East.

Two factors affect the distribution of nonnative insects and diseases. Increased global trade has led to a greater number and frequency of unintentional introductions; these pressures have existed for a long period of time and are greatest along the coastlines, large commercial rivers, and busy international ports. The second factor influencing nonnative populations is susceptibility of the environment to establishment and colonization, otherwise known as invasibility; for example, do potential predators exist in the new environment? Together, the effects of invasion pressure and invasibility are reflected in the geographic distribution of native and nonnative insect and diseases.
Wildland Fire as a Natural Disturbance

Wildfire is a key natural disturbance process that shapes ecosystems throughout the United States. The ecological consequences of wildland fires depend on the type of fire, the type and structure of the ecosystem that burned, and the frequency of repeat fires. All these factors interact to define the fire's effects on an ecosystem and the ecosystem's response to the fire disturbance.

Wildfire is a natural disturbance that has a range of effects on biological and physical aspects of the environment. It creates conditions that temporarily favor some species and exclude others, and it is a major factor in shaping the way our Nation’s forests look, especially in the Western United States.

To understand the effects of a wildland fire, consider the type of fire and the type and structure of the ecosystem in which the fire took place. Fires are generally categorized as ground fires, surface fires, understory fires, or crown fires. A ground fire consumes organic material beneath the surface litter, such as in a peat fire. Surface fires burn along the ground without significant movement into the understory or overstory vegetation. Understory fires burn the small shrubs and seedlings and are more intense than surface fires. Crown fires are normally associated with an understory fire that moves into the tree crowns and spreads from top to top of trees and/or shrubs.

All these fire types occur in every region of the United States but with varying frequency and severity. Our interagency Monitoring Trends in Burn Severity (MTBS) project used satellite imagery to map burned area boundaries and severity for all fires from 1984 and beyond greater than 1,000 acres in the West and 500 acres in the East. We have mapped more than 20,000 fires. MTBS data are now helping scientists, land managers, and the public to understand national trends in fire activity and severity across the United States.

Photos: Surface fires burn in litter (dead fuel) and vegetation (live fuel) at or near the surface of the ground. Understory fires are not lethal generally to trees and do not substantially change the structure of the dominatant vegetation. Crown fires create a solid wall of flame from the surface through the canopy fuel layers and can be very destructive.
Wildland Fire Management

Understanding how fire has shaped the forests and grasslands of the United States and how a policy of fire suppression and exclusion can have detrimental environmental effects has resulted in a more complex approach to fire management. Our current fire management strategy includes suppression of some fires, use of naturally occurring fires where beneficial, and introduction of fire to achieve land management objectives that are based on the type and condition of the ecosystem.

Early in the 20th century, fire suppression became the management focus regarding wildland fire in the United States. In 1935, our Forest Service Chief established the goal of managing each fire by 10 a.m. the day after detection. The Forest Service adhered to this policy for many decades. The accumulation of dead trees and other fuels in the forest, joined with a warm and dry climate, has resulted in an increase in the size and severity of fires, as well as a decline in ecosystem health, particularly in fire-dependent ecosystems.

Today, fire management has more complex goals than simply extinguishing fires. Fire managers may be expected to suppress fires that threaten the safety of people or structures, or they may have some choice in suppressing wildfires that potentially harm the ecosystem. Some naturally occurring fires are allowed to burn because they are in a location and ecological setting that will benefit from a fire. Managers may also start fires (i.e., prescribe fire) designed to manage ecosystems and to help restore them to a more natural fire regime. Fire regime is an ecosystem characteristic defined by the combination of fire frequency, predictability, intensity, seasonality, and extent that are typical of fire in an ecosystem. For example, in some areas, frequent surface fires that occur every 5 to 20 years remove dead trees and wood from the forest floor, preventing the buildup of fuels that could feed a more intense wildfire. In other places, large forest areas are lost naturally to intense crown fires every 100 to 500 years.

There are many ecosystems and fire regimes associated with ground fires, surface fires, and crown fires in the United States. Much of the time, the effects of wildfire are beneficial to an ecosystem and are part of the natural cycle of forest revitalization. Following wildfires in these ecosystems, wildlife enjoy the fresh browse as plants and shrubs resprout from the forest floor, understory plants flourish, nutrients are released into soils, and a new generation of trees begins to grow.
Providing Quality Wood Products While Sustaining Our Forests

Before wood products can be manufactured, trees must be harvested from forests and the timber must be transported to processing facilities. Timber resources and harvesting operations exist throughout the United States, but only a small proportion of forests are harvested intensively. Cutting trees for wood products can be accomplished sustainably to maintain renewable and resilient forests that regenerate into the future.

Harvesting timber (i.e., cutting trees) for wood products is an important forest management activity that shapes the forest. By selectively removing both live and dead trees from the forest, forest managers are better able to prescribe forest attributes and shape forests to meet the needs of current and future generations. Plant, animal, and human populations depend on forests for resources such as clean water, shelter, and food. Timber harvest occurs all across the Nation and in other countries. Because wood products are used all over the world, timber is often harvested and processed in one place, while the products may be used thousands of miles away.

Trees are a renewable resource because they grow back after being harvested. Amongst a host of forest management goals and objectives, sustaining our forests includes carefully managing them so the sum of harvest and mortality levels does not exceed growth—this helps maintain the timber resource and ensures that harvested forests are enabled to regrow into the next forest.

**TIMBER HARVEST BY OWNERSHIP IN THE PACIFIC NORTHWEST.** Characteristics of timber harvest have shifted over time, with marked shifts in ownership mix. This trend has been most pronounced in the West, where most forest resources reside on Federal lands. Looking at California, Oregon, and Washington over three points in time, not only have overall harvested volumes dramatically decreased, but also the ownership mix of timber harvest has shifted increasingly from public to private lands.

**TOTAL PRIVATE PUBLIC**

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**TIMBER HARVEST AS A FRACTION OF LIVE VOLUME.** Timber volume in forests is constantly in flux, and harvest plays an important role in shaping forests. While most countries have some timber harvest, harvest volumes represent low percentages of standing timber volumes.

**TIMBER HARVEST LEVELS AS A FRACTION OF ANNUAL NET GROWTH.** Examining harvest in the context of tree growth and mortality (net growth) helps describe the sustainability of timber harvest and net effects on forests. When growth exceeds harvest and mortality combined, total tree volume increases. Alternatively, mortality from disturbance events such as wildfire or bark beetle infestation can offset growth and reduce volume. Ensuring that harvest and mortality do not exceed growth over the long term is an important aspect of sustainable forest management.

**WOOD MOVEMENT IN THE UPPER MIDWEST.** Timber is often processed and used far from where it was harvested. The depiction of timber flow in the Upper Midwest illustrates harvest levels and the movement of logs to mills. Clearly, timber is moving all over the region, and some logs are even shipped overseas. Similar patterns exist in other parts of the country. This movement results from the complexity of wood product markets that connect landowners, loggers, mills, and consumers.
Planted Forests

To better satisfy the seemingly insatiable global appetite for forest products, land managers have increasingly turned toward planting as a way of regenerating new forests. The story of planted forests in the United States is long and successful, especially in the Southeast and Pacific Northwest. For decades, forests have been established through artificial regeneration techniques and sustainably grown across the United States, becoming a tremendous natural resource.

Trees do not live forever, and attention to establishing the next generation is critical. Forests regenerate two ways, naturally and artificially. Natural regeneration relies upon seeds, seedlings, and sprouts from the harvested or adjacent forest. Artificial regeneration, primarily planting, results in what is often called a plantation.

Forest plantations, forest communities created by humans, date as far back as the 10th century in Japan. Plantations primarily differ from natural forests in their origin and, typically, have less biodiversity. Foresters manage plantations with greater control of forest characteristics, fine-tuning species composition and tree density to optimize productivity.

Plantations are not an alternative to natural forests, rather the two are complementary. Planted forests ease management pressures on natural forests and grow more fiber on fewer acres. Plantations are one of the best methods for maintaining wood supplies in the face of shrinking areas of forest available for wood production.

Thirty percent of the world's forests are primarily used for production of wood and nonwood forest products. The area of planted forests is increasing and now accounts for 7 percent of total forest area globally. In the United States, planted forests account for about 9 percent of all forests (or 13 percent of forest land available for timber production). Unlike many areas of the world, 98 percent of U.S. planted forests are comprised of native tree species.

The growth of human populations and globalization increases the pressures on forests. Managed forests will play a more significant role in the future, meeting our increasing appetite for wood products while providing essential environmental services. A future with sustainable forests will include a combination of unmanaged or preserved forests, multiple-use managed natural forests, and intensively managed plantations.

PLANTED FOREST STANDS. Planted forests in the United States are primarily initiated by the planting of small seedlings grown in nurseries and planted as bare-root stock or containerized seedlings. The most common planted species are loblolly pine and slash pine in the South, red pine in the North, ponderosa pine in California, and Douglas-fir in the Pacific Northwest.

PHOTOS: Sustainable forest management requires a consideration of tree regeneration. Landscape restoration can be facilitated by tree planting. These plantations can be used to breed trees able to withstand lethal pests and diseases (chestnut blight, for example). These types of forests are often managed quite intensively, including the use of prescribed fire.

COMPARISONS OF TREE HEIGHT AND FORM. The primary species used in forest plantations varies across the country. Plantation species are typically selected to maximize growth rates while requiring management inputs. The product's expected end use, which could be influenced by local industrial capacity and/or market availability, is also a large factor in species selection. Plantations can also reflect conservation efforts. For example, both loblolly pine and shortleaf pine are gaining attention as managers attempt to save these species.
Our Changing Forests

Human activities affect the area of land covered by forests and the condition of those forests. For centuries, forests have been cleared for agriculture, industrial uses, and urban development. In the past 80 years, however, forests have returned in areas through active reforestation, suppression of wildfire, and agricultural abandonment. Forecasts of future land use, however, predict a reversal of this trend in the coming decades and a return to declining forest land proportions. Predictions of modest population growth and high-income growth are expected to yield high rates of urbanization.

The landscape of the United States is constantly changing due to many natural and human-caused factors. Natural disturbances, such as destructive weather events, fire, and pest outbreaks, often modify the landscape in dramatic ways. In many places, however, the dominant driver of landscape change is more slowly acting human development. This is particularly true in forests.

Before the arrival of Europeans, Native Americans used forests as a source of building material, fuel for heat and cooking, and a place for hunting and gathering food. For example, there is evidence that Native Americans used fire to alter the extent and composition of forests in ways that assisted with hunting, improved grazing for big game and horses, and cleared overgrown areas.

European settlement of North America introduced new tools and technologies that increased the pace of forest change. Since the 1930s, it is estimated that the area of forests in the United States has declined by more than 30 percent. East of the Mississippi River, large areas of forest were cleared for agriculture in the 1800s; some of these lands regrew to forest land in the 1900s when farms were abandoned and then reforestation programs. West of the Mississippi, agriculture and development reduced forest land to a lesser extent. In some Rocky Mountain States, however, fire suppression has resulted in a net increase in forest land area.

Field-based inventories of forest land are used to quantify the status and trend of the Nation’s forest land line in the Forest Service’s Resource Planning Act (RPA) assessment. The most recent RPA report shows that, in the United States, forest land has increased in all but the Pacific coast region. Forecasts for the next 40 years are not so positive, and all regions of the country are expected to experience a decline in forest land.

Trends in forest land. Over the past 80 years, the amount of forest land in the conterminous United States has been variable. For the first 30 years of this history, the trend in all regions of the country was negative, with the largest declines in the Northern region. Over the past 50 years, however, forest land has increased in all but the Pacific coast region. Forecasts for the next 40 years are not so positive, and all regions of the country are expected to experience a decline in forest land.

Percent of state in forest land. Prior to European settlement, the Eastern United States was more than 70 percent forested. By contrast, the Western United States was only 36 percent forested with much of the forest land concentrated along the west coast and in the northern Rocky Mountains. During the country’s westward expansion in the 18th and 19th centuries, eastern forests were converted to farmland and urban areas, with the greatest change occurring in what are now Indiana, Ohio, and Maryland. Forest management over the past 80 years has resulted in a reversal of this trend with forests increasing in the East and experiencing lesser declines in the West. Forecasts for the next 50 years, however, suggest that increasing population and demand for resources will lead to declining forests, again.

Current national land cover. The National Land Cover Database (NLCD) 2016 is the most recent land cover map produced by a consortium of Federal agencies. It provides the capability to assess patterns of land cover across the United States. The database for the conterminous United States was created using circa 2001 Landsat satellite imagery while Alaska and Hawaii were created using circa 2011 imagery. The database for Puerto Rico was created using circa 2001 imagery.
What Benefits Do Forests Provide?

Forests provide us with many things that make our lives better. Historically, wood was the primary material used to build and heat our homes and cook our meals. Today, wood remains the leading building material, but most domestic heating and cooking have transitioned to other sources of fuel, such as electricity or natural gas. In addition, countless consumer products contain wood fiber or chemicals derived from wood. Furniture and books have a clear connection to forests, but, less obviously, toothpaste and many food products are also made in part from wood products. As our population continues to increase, so will the demand for wood products and our need for healthy, productive forests.

Forests also provide a wide range of environmental services that are important to people. None of these is as important as producing clean, fresh water. Forests are nature’s living reservoirs and water treatment plants. Nationwide, more than half of all domestic water supplies originate in forests. Forests also help mitigate climate change. Indeed, the United Nations recently reaffirmed the valuable role forests play in sequestering carbon dioxide and mitigating the effects of human emissions.

Forests provide benefits to rural and urban environments alike. In agricultural regions, forests improve water quality by filtering field runoff and controlling erosion. They also provide habitat for beneficial insects that prey on crop pests. In urban environments, forests improve air quality by absorbing pollutants and reduce energy use by shading buildings. Nationwide, it is estimated that urban trees result in $2.0 billion per year in reduced building energy consumption.

Many nature-based recreational opportunities are often associated with forests. Whether in national forests, city parks, or private woodlots, forests are places where we go to seek refuge from daily stresses and to picnic, hike, bike, hunt, fish, and generally relax in a natural setting.

Forests and the wood that comes from them are truly a renewable natural resource that helps all of us, and employs more than 1 million people nationwide. With the advent of the 21st century, society is once again recognizing the numerous benefits of forests, not only for consumer goods and construction materials, but for energy, clean water, and recreation.

FORESTS PROVIDE VALUABLE GOODS AND SERVICES. The Millennium Ecosystem Assessment offered three categories of direct goods and services. Many of these are “public goods,” meaning the benefits are shared with more than just the landowner. First, we obtain many products from forests (e.g., food, fiber, and fuel). Second, forests regulate many ecosystem processes (e.g., clean air and erosion control). Third, forests provide many nonmaterial benefits (e.g., inspiration and recreation). Well-managed forests help sustain our well-being over time.
Clean Water

Forests have long been recognized as critically important for water supply. While the Forest Reserve Act of 1891 allowed the President to establish forest reserves, the Organic Act of 1897 provided that reserves would be established for forest protection, watershed protection, and timber production. Protected forests and those on private land remain the primary source of high-quality water across the United States.

Forest lands—of all land uses—tend to provide the cleanest drinking water. Because of the relatively minor soil disturbance that occurs in forests, even in managed forests, most rainfall seeps into the soil and flows to streams through the ground. This infiltration and percolation allows the forest soil to remain in place, and it also permits chemical processes in the soil to help maintain water quality. By contrast, most other land uses increase the amount of water flowing over the ground, leading to erosion and transport of soil. The eroded soils are carried to nearby streams and rivers along with many associated fertilizers and pesticides.

While the amount of precipitation leaving the forest as streamflow or ground water varies by climate, it ranges from 4 percent for the Lower Colorado River Basin to about 55 percent for the Pacific Northwest and New England. Across the contiguous United States as a whole, 53 percent of the water supply originates on forest lands, which are only 28 percent of the total land area. In the eastern half of the country, the portion of water supply originating on forests corresponds closely to the proportion of the land area in forest. In the Western United States, however, forests play a much more important role. For example, across the 17 most Western States, forests—because they are located largely at the higher elevations—contribute 65 percent of the water yield from only 23 percent of the land area.

ANNUAL WATER YIELD. Subwatersheds can be ranked to highlight where forest lands are most important in protecting surface drinking water. The Eastern United States has a high population density and a great reliance upon surface water (as opposed to ground water). While the Western United States has a much greater reliance upon ground water, the forests in the Rockies, Cascades, and Sierras stand out as important sources of clean water.

WATER IS CONNECTED BY THE HYDROLOGIC CYCLE. Water moves between the atmosphere, landscapes, rivers and lakes, and oceans in processes and pathways known as the hydrologic cycle. Forests influence the cycle in profound ways. Through evapotranspiration, trees use water from the soil and facilitate evaporation of raindrops caught on their leaves. Trees reduce soil erosion and protect streambanks. The establishment of national forests was amended in 1897 to include, in part, “the purpose of securing favorable conditions of water flows.”

FORESTS ARE SOURCES OF WATER. Forests are disproportionately important sources of water. Their contribution to total streamflow consistently exceeds their relative abundance in the landscape.
Wilderness began with the 1964 Wilderness Act. This law created the National Wilderness Preservation System with approximately 9 million acres across 13 States. Today, this wilderness system has expanded to include 803 wildernesses on 112 million acres in 44 States and Puerto Rico. Four Federal agencies manage designated wildernesses: the U.S. Department of Agriculture, Forest Service and the U.S. Department of the Interior's Bureau of Land Management, U.S. Fish and Wildlife Service, and National Park Service.

The goal of wilderness is to set aside landscapes “for the use and enjoyment of the American people in such manner as will leave them unimpaired for future use and enjoyment as wilderness.”

To meet this goal, Congress designates wilderness as “an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain... (Wilderness is) an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions” (The Wilderness Act of 1964, Public Law 88-577).

Congress designates wilderness area with the intent to ensure that we do not "occupy and modify all areas within the United States and its possessions, leaving no lands designated for preservation and protection in their natural conditions... to secure for the American people of present and future generations the benefits of an enduring resource of wilderness” (The Wilderness Act of 1964, Public Law 88-577).

There are many benefits provided by wilderness areas. They protect our cultural and spiritual heritage, providing an opportunity to learn how wilderness forged our American identity. Wilderness areas provide and protect ecosystem services, like fresh water, and economic vitality to local communities from visitors and residents who value beautiful scenery and opportunities to hike, hunt, and watch wildlife. Wilderness areas are also places to learn how relatively undisturbed ecological systems function and to better understand the effects of development, land use change, and climate change.

As the pace of global change increases, the values and benefits of wilderness are more important than ever. As Aldo Leopold wrote, “The richest values of wilderness lie not in the days of Daniel Boone, nor even in the present, but rather in the future.”
The Nation expects our agricultural landscapes to provide food, fiber, and energy while protecting soil, air and water quality, and wildlife habitat. We also want these working landscapes to be pleasant and healthy places with vibrant local economies. Trees outside of forested landscapes can assist in this important work.

Agroforestry is the intentional integration of trees and shrubs into crop and animal production systems to create environmental, economic, and social benefits. Farmers have implemented these practices in the United States and around the world for centuries.

Environmental benefits from agroforestry can include clean water by reducing nutrients in runoff, improving wildlife habitat, increasing soil productivity by controlling wind and water erosion, and reducing offsite damage from spray drift. Woody species can provide habitat for pollinators as well as beneficial insects that prey on insect pests, reducing the need for pesticides.

Increased crop yields and quality, more efficient use of nutrients and water, enhanced crop pollination, and reduced energy inputs are several of the ways that agroforestry can provide economic benefits. Additional income can come from wood for energy generation, fruits and nuts, high-value timber, and other products grown in agroforestry plantings.

Agroforestry also offers social benefits, such as mitigating odor from livestock facilities, screening undesirable views, and managing drifting snow near roads and buildings. Agroforestry practices can add variety that enhances the visual quality and recreational opportunities in agricultural landscapes.

**AGROFORESTRY PRACTICES.** There are five widely recognized agroforestry practices in the United States. A sixth practice—special applications—uses agroforestry knowledge in other environments.

1. **SILVOPASTURE SYSTEMS.** Trees can be combined with livestock and pasture. While providing shade and shelter for livestock, trees can be managed for timber and other tree crops.

2. **ALLEY CROPPING SYSTEMS.** In this practice, widely spaced rows of high-value trees create alleys for agricultural crops that benefit both the trees and crops, create annual and long-term income, and provide conservation benefits.

3. **FOREST FARMING.** High-value nontimber crops (food, medicinal plants, woody florals, and crafts) are cultivated under the protection of a forest canopy that has been managed to provide a favorable crop environment.

4. **WINDBREAKS.** Rows of trees and shrubs reduce wind speed and improve crop yields, reduce soil erosion, improve water efficiency, protect livestock, and conserve energy.

5. **RIPARIAN FOREST BUFFERS.** Trees, shrubs, and grasses planted alongside streams reduce water pollution and bank erosion, protect aquatic environments, and enhance wildlife habitat.

**SPECIAL APPLICATIONS.** Tree plantings can help solve special resource concerns. Some special applications include the utilization of wastewater to produce a short-rotation, woody bioenergy crop and to assist in stormwater management.

**AGRICULTURAL LANDSCAPES.** Management actions play an important role in determining the health of our Nation’s lands. Trees have important roles minimizing soil erosion, loss of biodiversity, and water quality degradation, some of the issues threatening the health and sustainability of our agricultural landscapes.

**CROPLAND, WIND, AND WATER EROSION.** Erosion has serious impacts to soil quality and crop productivity and offsite impacts on water and air quality and biological activity. Trees and shrubs can minimize soil erosion by reducing wind velocity and stabilizing soil with roots and vegetation cover.

**WHAT BENEFITS DO FORESTS PROVIDE?**

**AGROFORESTRY**
Urban Forests
Provision Benefits Where We Live

More than 80 percent of Americans now reside in urban areas. Trees found within these areas provide numerous benefits to society that affect human health and well-being. These benefits are valued in the billions of dollars annually across the United States. As urban lands continue to expand, managing the urban forest will be increasingly essential to sustaining environmental and human health.

Urban forests are comprised of all trees in urban areas. These trees supply numerous ecosystem services and values to the environment and society, but they also incur costs. These benefits include improved air and water quality, reduced air temperatures and building energy use, enriched wildlife habitat, reduced ultraviolet radiation, increased property values, reduced atmospheric carbon dioxide, improved aesthetics, and improved human and environmental health. Costs associated with the urban forest include maintenance, potential property damage, possible increases in building energy use from winter shade, and emission of volatile organic compounds that can lead to pollution formation. On balance, however, urban forests in the United States provide billions of dollars of benefits annually. For example, nationwide, health benefits associated with improved air quality are estimated at $4.7 billion per year. The benefits associated with the reduction of carbon dioxide, the dominant greenhouse gas, are estimated at $2.0 billion per year.

Urban and community areas—including cities, their suburbs, and towns—in the conterminous United States occupy 121 million acres of land, which is larger than California, and house more than 80 percent of the U.S. population. This area increased by 18 million acres between 2000 and 2010, an area larger than the State of West Virginia. While urban and community land is increasing, tree cover in several U.S. cities is on the decline and impervious surfaces, such as buildings and roads, are on the rise. Tree cover within urban and community areas average 35 percent, with tree cover in cities developed within forest regions substantially higher than tree cover in cities developed in grassland or desert areas.

Managing urban forests is critical to sustaining environmental and human health benefits for current and future generations. The Forest Service and its collaborators recognize the increasing importance of urban forests and are developing tools to assess this important resource and improve its management.
Taking Stock of Carbon

Forests are the most important land-use when it comes to the sequestration of carbon dioxide from the atmosphere—sequestering far more than any other land-use on an annual basis. Identifying where forest carbon resides, its status (e.g., live biomass or forest floor), and future is paramount to managing forests in the context of climate change.

By far, forests sequester more carbon annually than any other land-use (e.g., agriculture). As the current carbon stocks of U.S. forests contain approximately 25 years' worth of U.S. fossil fuel carbon dioxide emissions at their current rate, the location and condition of these carbon stocks is critical to mitigating the potential effects of future climate change. Most forests across the United States have rather stable carbon stocks, with land-use change, mortality (e.g., beetles or drought), and wildfires reducing carbon stocks at local scales. Broadly, U.S. forests are still recovering from the land-use conversion and exploitive harvests of the late 19th and early 20th century. Trends in forest carbon sequestration and emissions over the past few centuries demonstrate how rapidly we can lose forest carbon, while at the same time, the trends demonstrate how sustainable management can restore some of those “lost” stocks. Given the complexity of forest ecosystems, carbon stocks can be broadly delineated among various “pools,” such as live tree biomass or deadwood. Living biomass associated with trees and understory components can often account for the majority of carbon in many forests. In contrast, sometimes deadwood and/or organic material in the soil account for the majority of carbon in forests at high latitudes or coastal areas. Although most forests aren't solely owned or managed for their carbon stocks, it is evident from the quantity and diversity (e.g., soil or vegetation) of forest carbon stocks across the United States that every forest activity affects emission and/or sequestration of carbon dioxide, thus playing a role in what our future climate will be.

### Principal Carbon Stocks Vary Regionally

<table>
<thead>
<tr>
<th>Aboveground Live Carbon Stocks</th>
<th>Deadwood Carbon Stocks</th>
<th>Soil Organic Carbon Stocks</th>
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<tbody>
<tr>
<td>Aboveground live carbon (Mg/ha)</td>
<td>Deadwood litter carbon (Mg/ha)</td>
<td>Soil organic carbon (Mg/ha)</td>
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</table>

**Aboveground Live Carbon Stocks.** Aboveground live biomass in forests often consists of both live trees and understory vegetation, thus a diverse array of flora that constitutes the largest portion of total forest carbon stocks in many areas of the United States.

**Deadwood Carbon Stocks.** Standing dead, down dead, and litter stocks are typically highest in highly stocked and/or disturbed forest stands where decomposition is slow due to high elevations/latitudes.

**Soil Organic Carbon Stocks.** Soil organic carbon stocks are typically highest in high-quality forest sites in areas with slow decay processes such as the Pacific Northwest and high latitudes/elevations.

**Principal Carbon Stocks Vary Regionally.** Major forest carbon pools are reported as the plurality of total forest carbon stock for each mapping unit. Major pools are:

1. **Aboveground Biomass (Aboveground, Belowground, and Understory).**
2. **Deadwood and Forest Floor (including standing dead, down dead, and forest floor).**
3. **Soil Organic Carbon.**

Vehicle emissions: 1,821 million metric tons of CO₂ Eq. (MMT) annually
Electrical power generation: 1,753 MMT annually
Refrigeration and air conditioning: 129 MMT annually

**Aboveground live carbon:** 55,680 MMT
**Deadwood and litter carbon:** 28,318 MMT
**Belowground live and soil organic carbon:** 127,000 MMT
Wood Products in Everyday Life

Nothing can better illustrate our Nation’s dependence on wood than examining how often wood is used for a surprising number of purposes. From firewood, to paper, to building materials, to energy utilities, to furniture, even televisions and food flavorings and fragrances, Americans use a lot of wood in their daily routines.

Collectively, Americans use 10 to 15 billion cubic feet (more than 100 million tons) of wood each year in the form of wood and paper products, as well as wood for energy. With more than 313 million people in the United States, that translates to roughly 640 pounds of wood per person each year, or 1.75 pounds of wood per person each day. This would be a cube of wood roughly 6.5 inches on each side, every single day.

On average, we have been building more than 1 million new single-family homes each year for more than 40 years. The last 10 years, however, have been a very dynamic period for wood use in the United States. With the Great Recession of 2007–2009 and collapse of new home building, the number of homes built and consequently the total use of wood in the United States decreased dramatically. The ensuing economic recovery has seen wood products markets recovering at a slow but steady pace.

Since neither people nor forests are evenly distributed across the country, the patterns of wood production (where timber is harvested) and wood consumption (where people live and use wood and paper products) vary. This means that some States are net exporters of wood, while others are net importers.

Wood is a major input in construction, and this is especially the case with residential homes, which are commonly framed with dimensional lumber and have many wood finishes throughout their interior. Wood products used in construction are a product of harvesting timber and managing our forests. To put this in perspective, it takes trees from roughly 2 to 3 acres of forest to build a typical single-family house in the United States. Construction applications, however, are just the beginning of the myriad ways we use wood.

TYPES OF WOOD PRODUCTS AND WHERE WE ENCOUNTER THEM. Wood products are ever present in our daily lives, and they are especially evident in and around our homes. Wood products are found in many forms. In a typical home, they are present in bedrooms, living rooms, kitchens, garages, or outdoor living spaces.

From teakettles to cooking utensils, to wood-derived fragrances and food flavorings, wood products fill our homes and our daily lives from morning to night. Although most people know that paper products come from wood, many may be unaware that wood products are also used in countless other applications: from toiletries to cooking utensils, to wood-derived fragrances and food flavorings, various toiletries, and other manufacturing applications.

Solid wood products may be the most iconic and recognizable of the wood products we use, including products such as lumber, log homes, dining room tables, flooring, and picture frames.

Reconstituted wood products tend to be made from smaller diameter logs. Reconstituted products include various types of paper, tissue, cardboard, particleboard, and other engineered wood products, like oriented strand board and medium density fiberboard.

Wood chemicals include a wide array of products with applications including food flavorings and fragrances, various toiletries, and other manufacturing applications.


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Forest Industries Keep America Working

The forest industry is composed of many different occupations, from natural resource professionals working in the field, to production workers in mills and factories, to statisticians and financial experts working in office settings. Forest and logging workers study the timber resource and deliver raw materials to wood products facilities, while wood and paper mill employees work in the manufacturing sector. The common thread among these jobs is the resource they are ultimately tied to—trees harvested from the Nation’s forests.

For the purpose of measuring employment in the industry through time, the forest industry is defined as the sum of employment in three sectors: forestry and logging, wood product manufacturing, and paper manufacturing. This is a somewhat narrow definition of the industry; it does not include forestry support personnel or those working in furniture manufacturing. Also, these figures include only private employees, so State and Federal Government employees who work in forestry and wood products are not included.

The forest industry’s importance to State manufacturing sectors is highlighted by the percentage of manufacturing employment that is composed of wood and paper manufacturing jobs. For example, wood and paper employment in West Virginia and Montana may be relatively small compared to more populous States with larger forest industries; the industry, however, is very significant to those States in terms of contribution to those States’ manufacturing sectors.

While the forest products industry remains an integral part of the Nation’s economy and vital to many local economies, the industry was particularly hard hit by the dramatic downturn in the housing sector and the associated Great Recession of 2007–2009. The 7.5 percent drop in housing starts from 2005 to 2009 had a major impact on the forest industry throughout the country, culminating in a loss of more than 350,000 forest industry jobs. A modest recovery in housing and improving economic indicators in 2011–2012, however, suggest that forest industries may be positioned for a sustained recovery with a rebound in forest industry employment.

PHOTOS: Many jobs are performed to bring wood products from forests to consumers. A Sawyer cuts a tree that has been selected for harvest and helicopter pilots transport logs from the harvest site to the landing. A strove-hose-delimiter operator is one of the workers involved in processing and merchandising logs. Employees in wood and paper manufacturing work in increasingly automated facilities, monitoring their production lines for quality, safety, and efficiency, often from a central control room.

IMPORTANCE OF WOOD AND PAPER TO STATE MANUFACTURING SECTORS. By examining the percentage of manufacturing employment coming from wood and paper product manufacturing in each State, it becomes clear that the manufacturing sector in many States is for example, Maine, West Virginia, Arkansas, and Montana rely heavily on forest products, symbolized in the map by darker shading in those States. The size of the icon on each State indicates the number of workers in wood and paper manufacturing.

VENEER MILLS (NMFB) | SAWS MILLS (NMFB) | PLYWOOD MILLS (NMFB) | PULPMILLS (NMFB) | COMPOSITE PANEL | OTHER PRODUCTS (pounds per ton)

* MILLIONS OF BOARD FEET OF TIMBER (NMFB). Softwoods and hardwoods are sold by the board-foot. The board-foot is the volume of a 1-foot length of a board 1-foot wide and 1-inch thick. The cord, usually sold by the cord or by weight. A standard cord is equivalent to a pile of closely stacked wood 4-feet high, 4-feet deep, and 8-feet long.

FOREST PRODUCTS INDUSTRY EMPLOYMENT, 1990–2016. The U.S. forest products industry—defined as the three sectors including logging and logging, wood product manufacturing, and paper manufacturing—employed more than 1.2 million workers annually from 1990 through 2000. With the onset of a collapse in U.S. housing markets and an official recession from 2007 to 2009, employment in the industry dropped precipitously and was under 1 million workers during 2008 through 2011. Significant improvements in housing markets during 2011 and 2012, however, generated optimism for industry stakeholders going forward.
What is the Future of Our Forests?

Forests will change due to complex interacting stresses, an increasing population, and a changing climate (see Chapter 3), as well as shifting demands for the goods and services that our forests provide (see Chapter 4). The decisions made by private landowners and public land managers will be pivotal. In the Eastern United States, forests are largely privately owned, with corporations owning a third of them. In the Western United States, forests are primarily owned by the public and are managed by State and Federal land management agencies. Indeed, the notion that lands can be publicly owned and managed is an idea born during the Nation’s westward expansion. Public lands have served the country for more than a century. Gifford Pinchot, the first Chief of the Forest Service, an agency of the U.S. Department of Agriculture, famously stated, “Where conflicting interests must be reconciled, the question shall always be decided from the standpoint of the greatest good of the greatest number in the long run.” Environmental laws like the National Environmental Policy Act and Clean Water Act help facilitate an acceptable balance between competing national priorities and play an important role in determining our forest’s future.

Projections for the next 50 years suggest development will be the greatest human-caused change in forests, leading to an overall loss in forest land, with important consequences as forests influence and are influenced by the climate. Carbon is sequestered in live trees by converting carbon dioxide into wood and thus lessening the effects of greenhouse gases; currently, more than 11 percent of all greenhouse gas emissions in the United States are sequestered by forests. Forest land have been expanding and contracting across the landscape since the last Ice Age, and the extent of forests and their composition will continue to adapt to population pressures and environmental conditions.

The consequences of interactions between forests, people, and climate are complicated and not completely predictable. Ultimately, it will be the landowners, both public and private, that will decide if and how they will react to these changes and shape our future forests.
Who Owns the Forest?

The future of a forest lies largely in the hands of those who own it. The owners' objectives, needs, knowledge, and resources, within biophysical capabilities, social norms, and political regulations, will determine not only what land remains in forest cover but also what part of the forest is managed and how.

Who owns America’s forests? Some 56 percent of the forest land in the United States is owned by families, individuals, corporations, Tribes, nongovernmental organizations, and other private landowners. Although the Forest Service is the single largest steward of public forest land in the country, public forests—including lands managed by other Federal, State, and local government agencies—account for less than half of the Nation’s forest land.

Forest ownership patterns vary significantly across the United States. In general, private forests are dominant in the East, and public ownership is dominant in the West, but many types of ownerships are interspersed throughout the country. The locations of specific ownerships are a result of settlement patterns, laws, land use values, history, and other factors, all of which can result in changing ownership patterns over time.

Understanding the social context of forests and their complex ownership patterns is important because it is the owners who will ultimately decide how land will be managed and passed on to future generations. Whether private or public, landowners form the link between society and nature and will influence the future of our forests.
America’s Private Forest Owners

Private forest owners control 56 percent of the forest land in the contiguous United States. This group includes more than 11 million families, individuals, corporations, Tribes, and other private groups. The values and objectives of these owners, within the constraints and opportunities their forests provide, determine what can and will be done on their land.

Most private forest land (62 percent) is owned by an estimated 10 million families, individuals, trusts, estates, and other groups who are collectively referred to as family forest owners. Although many share traits from more than one of these categories, there are four major “types” of family forest owners:

1. Those who seek to establish a woodland retreat with high amenity values (49 percent).
2. Those attempting to meet multiple aesthetic, recreational, and financial objectives (28 percent).
3. Those focused primarily on the financial gains they can earn from their land (9 percent).
4. Those who do not express clear objectives for their property (18 percent).

Corporations own 33 percent of private forest land. This group includes multinational, regional, and local companies. Forestry is the primary objective for some of these owners, but others are energy companies or own it for other reasons, such as buffers around manufacturing plants. Two newer types of corporations are timber investment management organizations (TIMOs) and real estate investment trusts (REITs). Timber production is still a primary ownership objective, but these companies do not own primary wood processing facilities. TIMOs manage land on behalf of institutional investors and other groups/individuals of large net worth; REITs are an alternative legal structure offering tax advantages, with additional constraints.

The remaining 5 percent of U.S. private forest land is owned by Native American Tribes; nongovernmental organizations; and clubs, associations, and partnerships. This percentage is not enormous at the national scale, but these owners do control substantial forest acreage in some areas, such as Arizona and central Washington.

The cumulative decisions of private owners determine which private lands remain forested; what, if any, forest management occurs; and what goods and services are provided. Private forests can provide valuable public benefits.

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America's Public Forest Owners

More than 300 million acres of forest land are managed by Federal, State, and local government agencies on behalf of the general public. Gifford Pinchot, the first Chief of the Forest Service, believed in “the greatest good, for the greatest number,” and these lands are managed to provide the American public with clean water, recreational opportunities, forest products, and countless other benefits.

Diverse objectives are reflected in the missions of the different types of agencies that manage public forest lands and can include forestry, wildlife, recreation, water protection, grazing, and mining.

Historic settlement patterns vary substantially across the United States. Following many homesteading acts, forfeited land claims were returned to the public domain and formed the nucleus of many Federal holdings. Governments also acquired lands that were heavily exploited and deemed of little benefit to private owners; many of these lands are now crown jewels of the public lands. Other lands were acquired to protect unique areas, such as Yosemite Valley.

Once forest land is acquired by the Government, it is unlikely to be returned to private owners. Land exchanges for inholdings, however, are one exception. Over the past couple of decades, the area of public forest land has steadily increased, but the proportion of forest land in public ownership remains relatively steady at 30 percent. It is challenging to manage public lands. The public is frequently divided over the “best” uses of specific areas. Should they be preserved as wilderness or open to multiple uses? Biological, physical, financial, and social stresses add to the challenge.

FORST STEWARDSHIP BY FEDERAL, STATE, COUNTY, OR LOCAL AGENCIES.

Based upon the Protected Areas Database, this particular map highlights the assignment of agency stewardship across public lands. These lands are owned by the public, and management is assigned to one of many different public agencies on their behalf. As a result, each individual parcel may vary in management designations and conservation status. Designations range from strictly protected areas where use and impacts are controlled and limited to those permitting sustainable use of natural resources.

PUBLIC FOREST LAND OWNERSHIP

- United States Forest Service (USFS)
- Fish and Wildlife Service (FWS)
- National Park Service (NPS)
- Bureau of Land Management (BLM)
- Forest Service (FS)

Other:
- Local, county, municipal, etc.
- Joint ownership
- Other
- Private forest land

PHOTOS: The many stewards of public lands have widely varying missions. Each entity is responsible to the original and evolving legal foundations for their stewardship as well as the many constituencies they serve.
Forests and the Carbon Cycle

Plants are the lungs of the Earth, shaping the atmosphere which sustains us today. Every natural process and human activity eventually results in gases being added to or removed from the atmosphere. A century of fossil fuel burning has raised international concern over levels of carbon dioxide that could substantially alter Earth’s climate. Forests remove carbon dioxide from the atmosphere and store it in long-lived pools (like trees and soils) and products (like furniture and building timbers), offering an alternative approach to storing carbon than the combustion of living and dead biomass in forests results in the immediate emission of gases such as carbon dioxide. Across the Western United States, wildfires on forest lands and grasslands occur annually, ranging in size inverses of 100,000s of acres. The emissions associated with these “mega-fires” can easily exceed several million tons of carbon dioxide. This map highlights fires mapped by the Monitoring Trends in Burn Severity program and assessed by extended methods; these methods focus on mapped by the Monitoring Trends in Burn Severity program and assessed by extended methods; these methods focus on

A STORY OF GIVE AND TAKE: FOREST CARBON STOCKS AND FLUXES WITH THE ATMOSPHERE SCALED IN THE CONTEXT OF FOREST ECOSYSTEM COMPONENTS/PRODUCTS AND FOSSIL FUEL EMISSIONS. Forests have always altered the amount of carbon dioxide in the atmosphere, removing (or sequestering) it as they grow and returning it to the atmosphere as they decay or burn. Annual forest sequestration currently exceeds emissions from decay and fire. Within the United States, this net sequestration offsets approximately 14 percent of annual greenhouse gas emissions. This dynamic is expected to continue, but climate change may alter drought and fire frequency. Forest conversion to other land uses may also reduce the amount of forest land. These changes could result in forests emitting more carbon than they remove. Scientists continue to study forest carbon cycle processes to support land managers and policy makers facing challenging decisions.
Forests on the Move

Global climate change will influence the distribution of tree species. Past glaciation and warming events caused changes in the distribution and abundance of forests, and rapid changes in climate predicted during the 21st century have the potential to transform forest ecosystems. People need to understand how trees may adapt to these changes; a critical component of adaptation will be species migration.

Tree species migration is closely related to why species occur where they do: how do climate, soil, and landscape characteristics create suitable habitats for different tree species? While generalist species respond to broad ecological conditions, species with narrow ranges of environmental conditions are constrained by specific site characteristics. The Forest Service uses predictions from climate models to examine how today’s suitable habitats may change in the future. Tree species with projected declines in suitable habitat will likely face greater stress under new conditions and may have reduced reproductive capacity or be less able to respond to other stressors. Species with projected increases in suitable habitat will likely be in a better position to grow and reproduce. Understanding species’ responses to habitat changes will be especially critical if newly suitable habitat does not occur near where it presently exists and colonization across the landscape becomes necessary. Because trees can live for decades, and many years pass before they begin to reproduce, there will be lag time between when the location of suitable habitat changes and when the shift in distribution occurs. In some cases, shifting distributions of mature trees and seedlings of the same species are already evident. In other cases, such shifts at species range edges are not seen, making it important to monitor how these changes unfold as climate changes continue. In the end, it is difficult to predict the timing and direction of range shifts, but computer models and multiyear approaches integrating climate predictions, disturbance patterns, and habitat needs allow us to evaluate forest vulnerabilities to climate change.

MOVEMENT PREDICTIONS. Like the past, the future has the potential for large changes in suitable habitat for tree species; suitable habitats may shrink, expand, move north, remain stable, or even move south. The concern is that the climate is changing—and suitable habitat is moving—more quickly than in the past. Can tree species migrate as fast? Models suggest “no,” especially given the fragmented state of today’s forests. Tree species migration could be facilitated by creating landscape corridors or directly assisted by physically moving plant materials.

SUGAR MAPLE (Acer saccharum). This economically and culturally important species is distributed across the northern half of the Eastern United States (A–G). It is likely to lose substantial habitat by 2100 under a harsh climate model and emission scenario (E), but could lose much less or even gain habitat in some States under the mild scenario (B).

SHORTLEAF PINE (Pinus echinata). This southern pine occupies much of the Southeastern United States and has high commercial value (F–I). Shortleaf pine is likely to gain substantial habitat under any scenario of climate change, with modest increases under the more mild PCM B1 model and emission scenario (E) to larger gains in habitat under the harvester A1B (F).

FOREST TYPES. Forests group associated tree species into forest types (G–I). Because each tree species has the potential to respond differently to climate change, the Forest Service assesses how their habitats may change independently and then can reassess the species to reveal changes in forest-type groups. These results suggest northern forest types (like spruce/fir and aspen/birch) will become uncommon, while the oak-hickory types will increase in abundance, particularly under more harsh scenarios (I).
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NATIVE AND NONNATIVE INSECTS AND DISEASES

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Map Source


Photographs


WILDLAND FIRE AS A NATURAL DISTURBANCE

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General References


Map Source


Photographs


Icon


WILDLAND FIRE MANAGEMENT

Authors

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General References


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