USDA Forest Service
U.S. DEPARTMENT OF AGRICULTURE

FS-1172 | July 2022

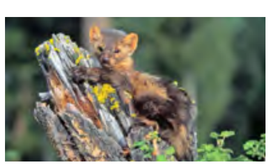
Forest Atlas of the United States

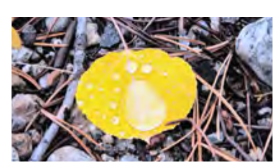
Forest carbon varies widely across the Nation with the darker green hues representing the higher values in live trees and the lighter green hues representing lower values. More information about this map can be found on page 58.

The information provided in this publication is also available online at https://doi.org/10.2737/FS-1172.

Forest Atlas of the United States

U.S. Department of Agriculture, Forest Service




Forest Atlas of the United States

USDA Forest Service

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)

Contents

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.usda.gov/.

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 inhibits most trees from growing. The forest is the result of competition between species as they fight for survival in landscapes with even minor variations in light, water, or nutrients.

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.

Rainforest

Marine

Temperate steppe

Prairie

Hot continental

Warm continental

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.

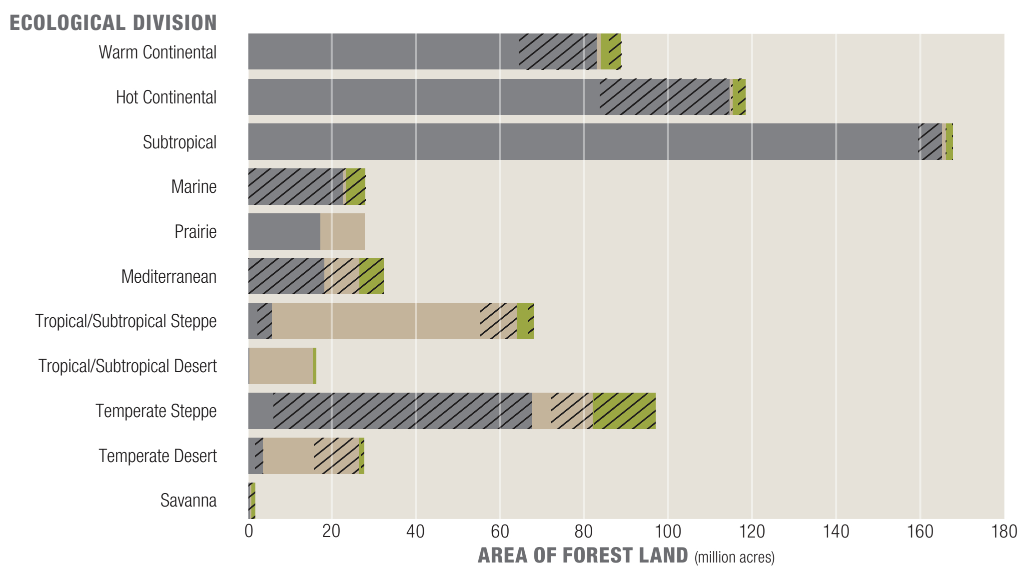
Landscapes are generally classified based upon climate, vegetation, and soil. A few classifications include agricultural crops and other human-management factors. The importance of each factor varies among units, but climate is the starting point for dividing the landscape in this system.

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.

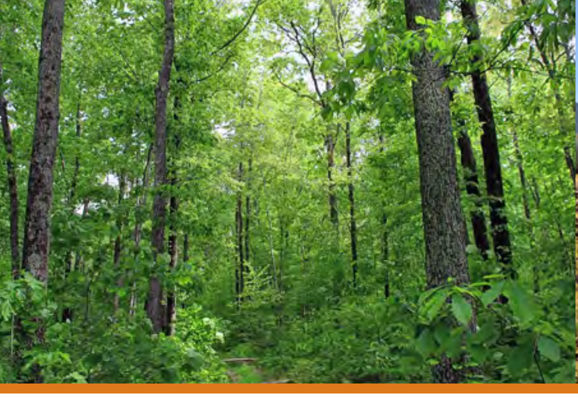
As landscape units get smaller, they also become more homogenous. For the sake of simplicity, the accompanying map focuses upon ecological divisions, a midpoint in the Forest Service's landscape classification system.

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 steppe. 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.

ECOLOGICAL DIVISIONS OF CANADA, THE UNITED STATES, AND MEXICO. The strong temperature gradient from north to south is evident with tundra and subarctic divisions in the north transitioning to subtropical, rainforest, and desert divisions in the south. The strong precipitation gradient from the east coast across the Great Plains to the Rocky Mountains is also visible. A thin strip of marine ecosystems hugs the Pacific coast, and the wet winters and dry summers of California are captured by the Mediterranean division. Mountains across the continent (noted by hash marks on the map) create large variations in climate and vegetation over short distances.



Dense forest, Pike County, Pennsylvania

Post wildfire, Coconino National Forest, Arizona

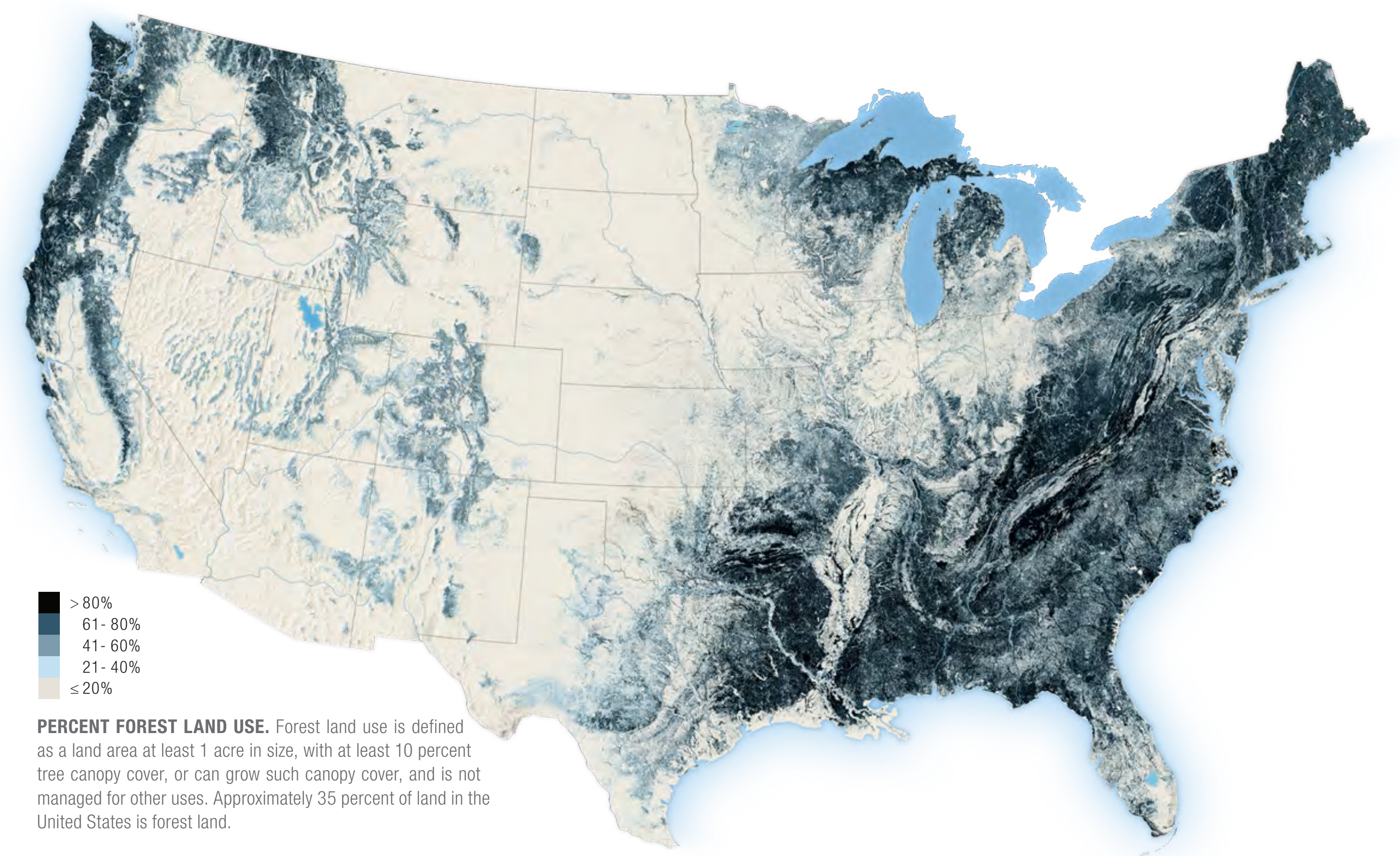
Industrial forest management, Oregon

Golf course, Newport, California

Central Park New York, New York

Farmland, Wisconsin

THE RELATIVE ABUNDANCE OF TREES MEASURED USING TREE CANOPY COVER. Roughly 70 percent of land in the United States has some tree canopy cover; trace amounts are hard to see in maps at this scale.



PERCENT FOREST LAND USE. Forest land use is defined as a land area at least 1 acre in size, with at least 10 percent tree canopy cover, or can grow such canopy cover, and is not managed for other uses. Approximately 35 percent of land in the United States is forest land.

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.

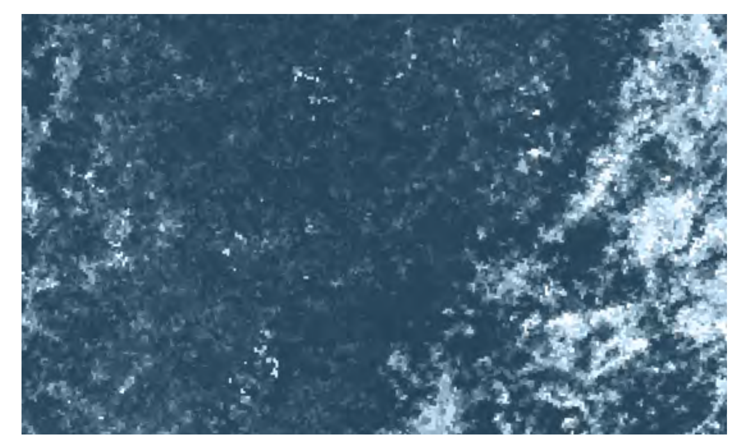
1. Tree density refers to the amount of land covered by trees. The most common measure of tree density is percent canopy cover.
2. Land use describes how people manage or modify the land. Forest land use requires that no activities prevent normal tree regeneration and succession.
3. Patch size defines 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.

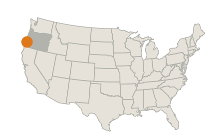
This definition can lead to some seemingly strange situations. For example, industrial forest lands are managed to supply a sustainable source of wood. Lands that are harvested today are quickly planted, and they are still called forest land even if they have no trees at the moment. The definition of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

PHOTOS: Knowing the difference between treed 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.

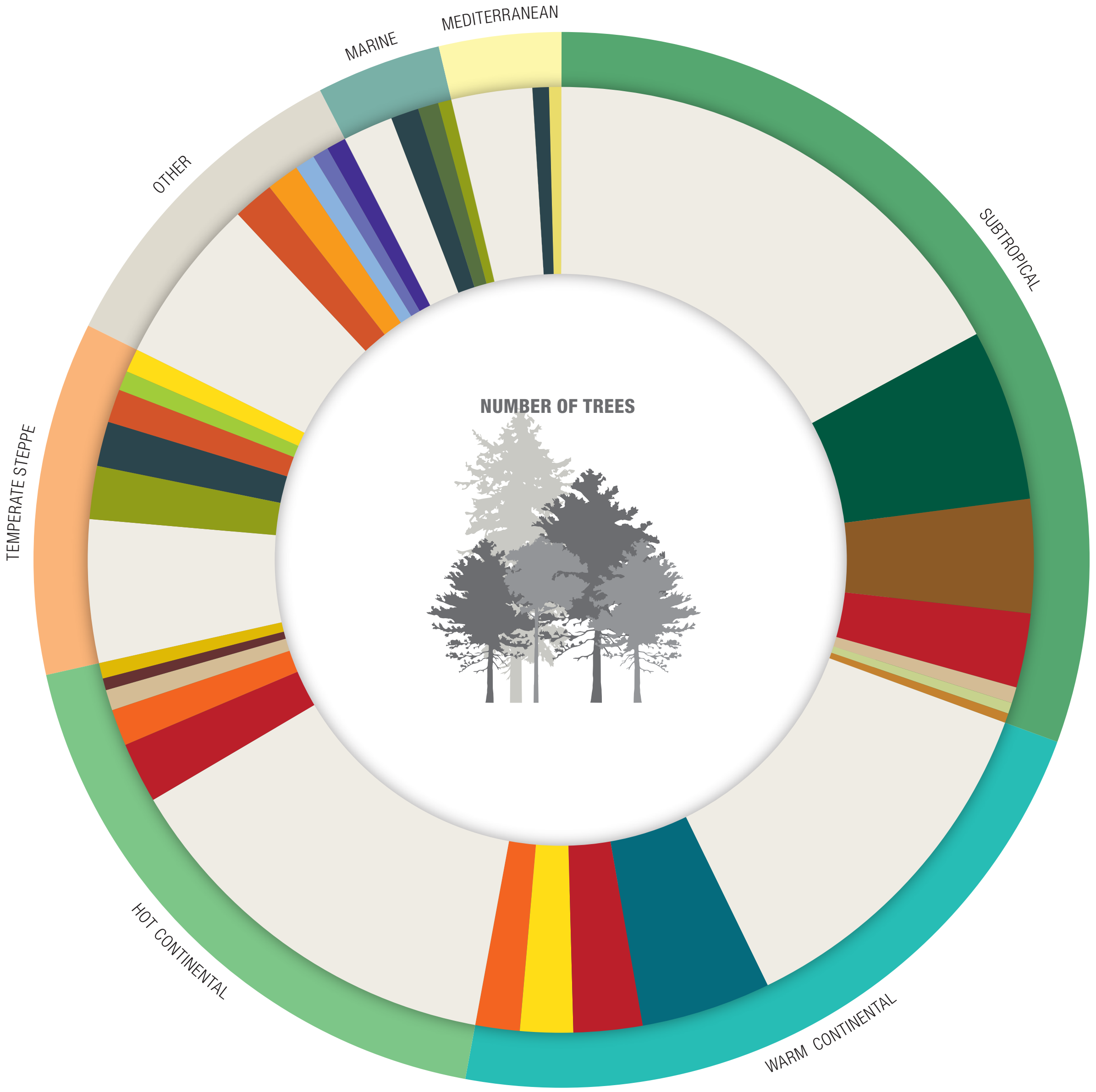
TREE CANOPY COVER



FOREST LAND USE



TREE COVER AND FOREST LAND USE. These two maps allow you to compare and contrast percent tree canopy cover and forest land use. This area in Camas Valley, Oregon, is a mix of federally and privately managed forest lands. The checkerboard pattern in the tree canopy cover map is the result of industrial tree harvest. Despite the fact that the white checkerboard squares no longer have trees (green map), they are managed to regrow trees and are therefore still forest land use (blue map). By contrast, if you zoomed into most cities, you would see treed lands in parks and golf courses that are not forests.



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.

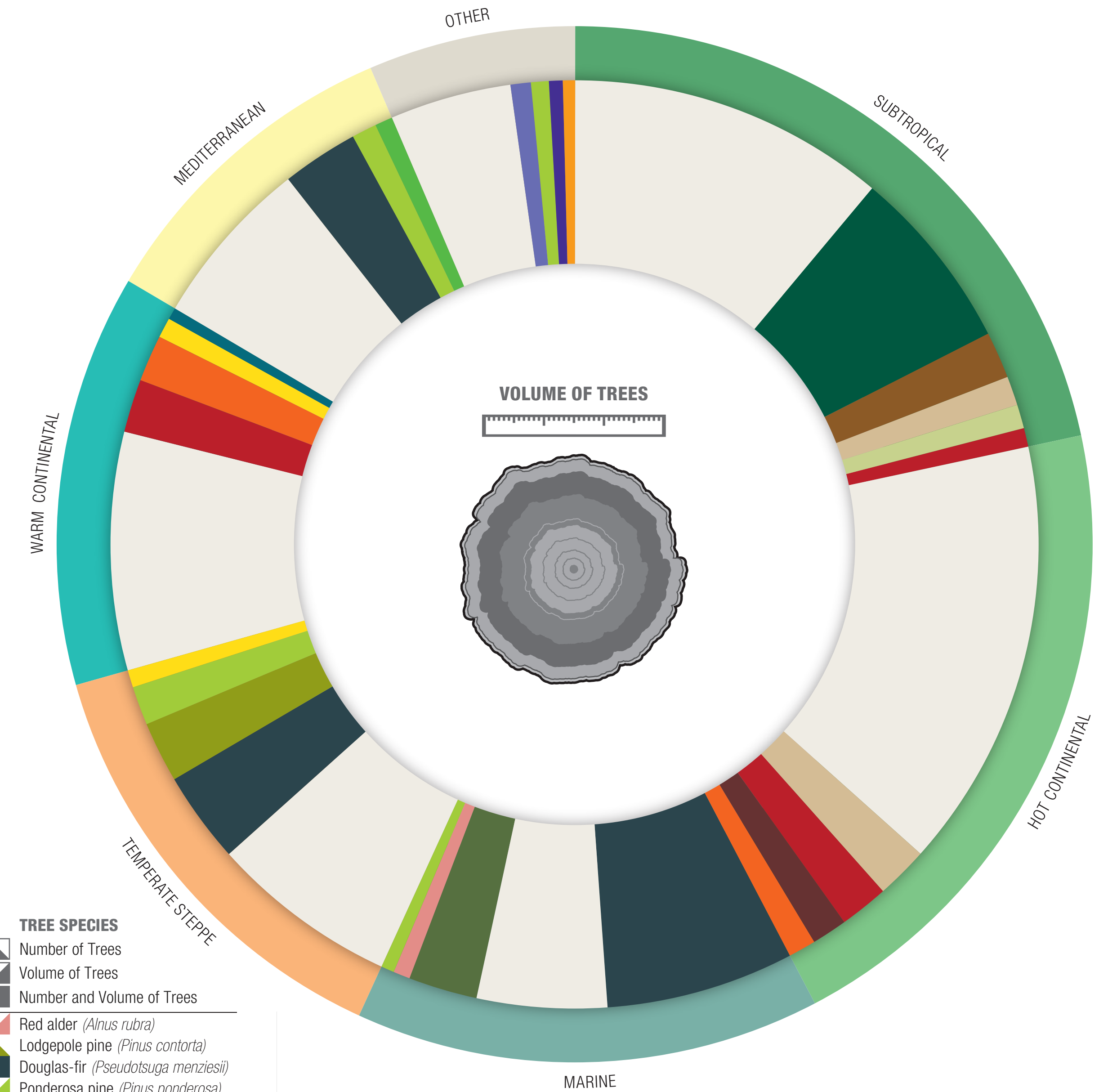
Determining which tree species to include in the atlas was somewhat subjective because it first involved defining "abundance." Within each ecological division, FIA calculated the relative proportion of total number of trees and tree volume for each tree species. FIA chose the 5-6 most abundant species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

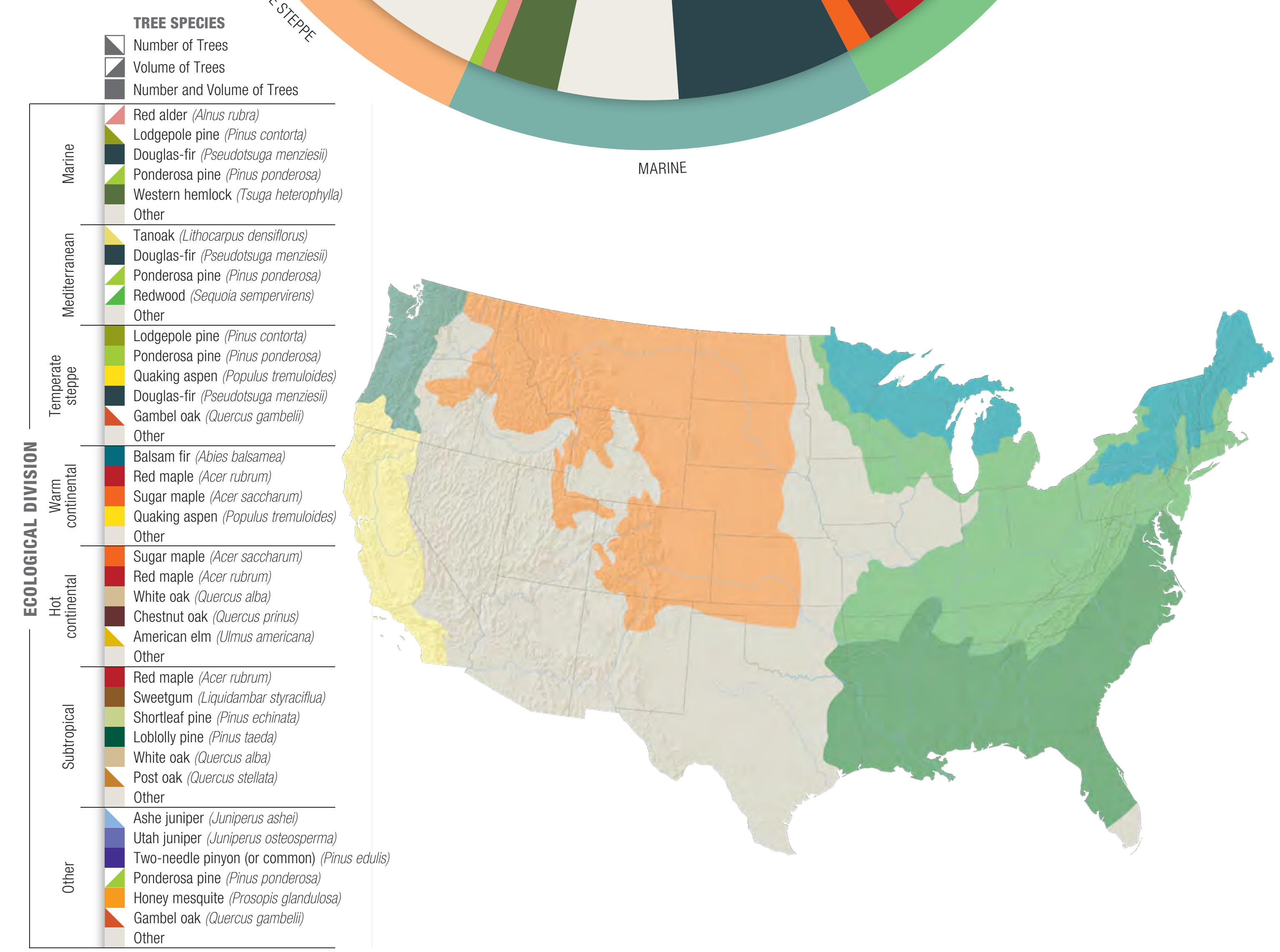
For example, FIA included red maple because it is one of the top three species in three ecological divisions when measured by either number of trees or tree volume.

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.

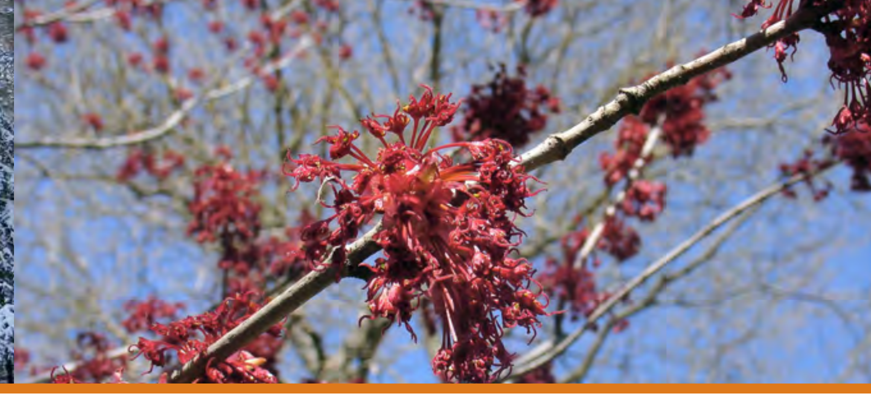
The larger maps in this feature depict current species abundance and distribution across the contiguous United States, modeled by using FIA field plot data. Although the absolute values associated with the maps differ from species to species, the highest values within each map are always associated with 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 these additional species add surprisingly little volume or numbers of individuals.





Balsam fir *(Abies balsamea)*

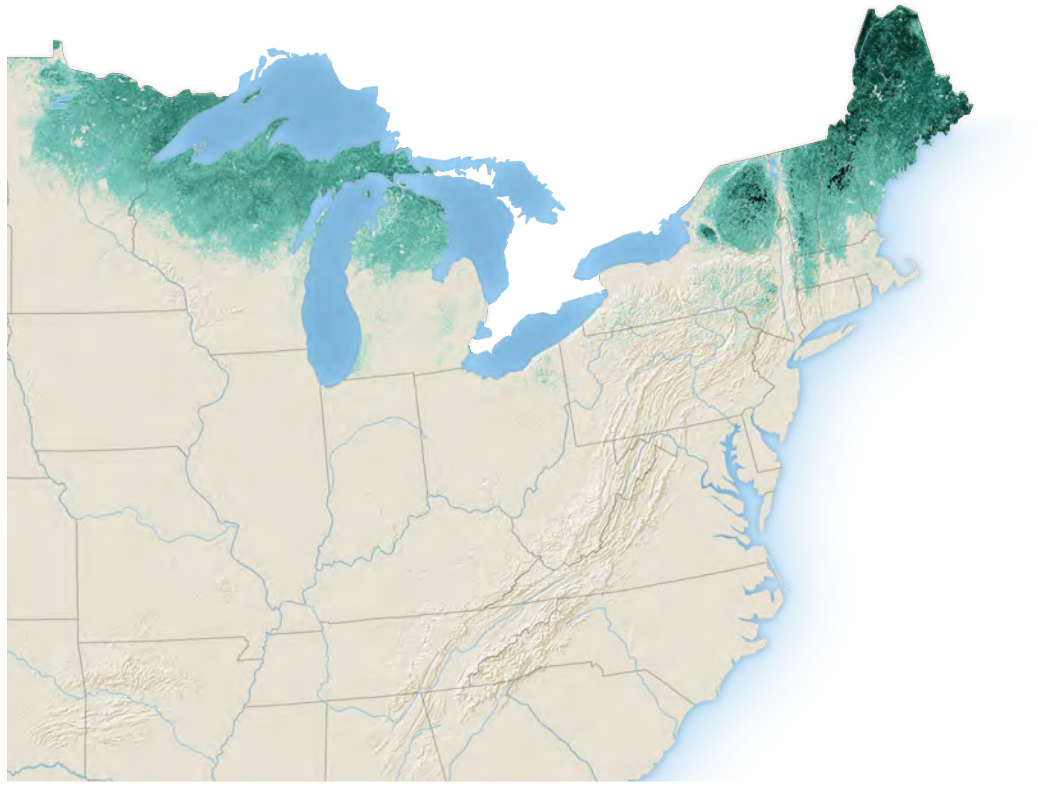


Red maple *(Acer rubrum)*

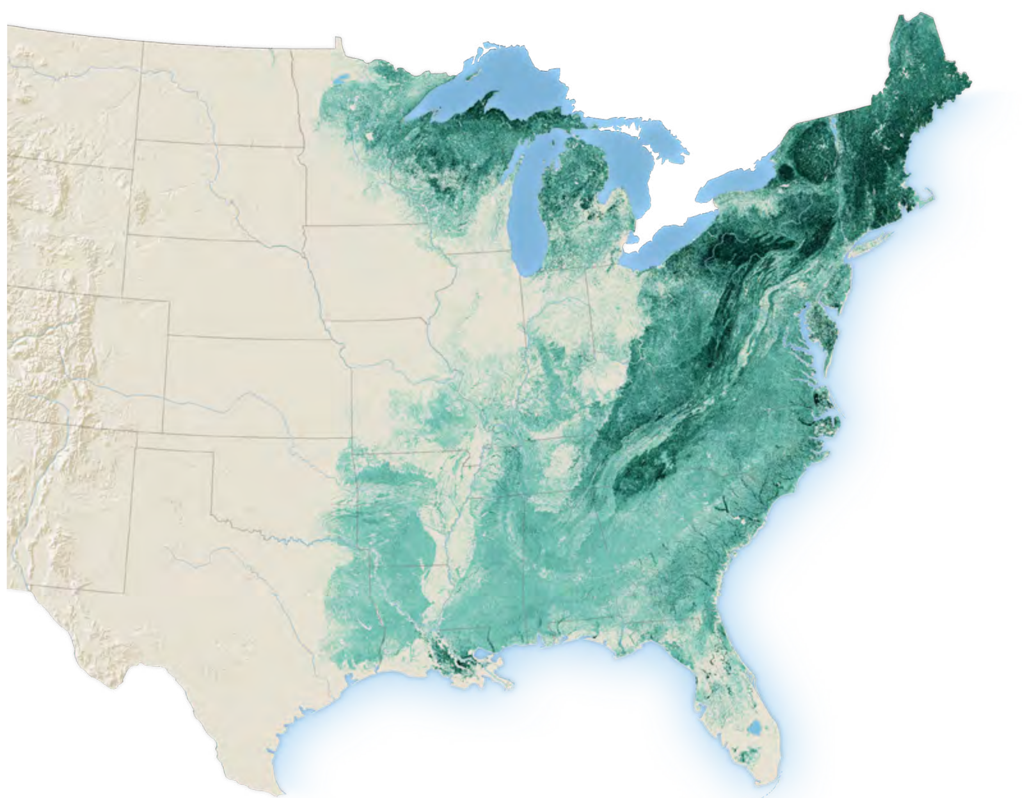
Sugar maple *(Acer saccharum)*

Red alder *(Alnus rubra)*

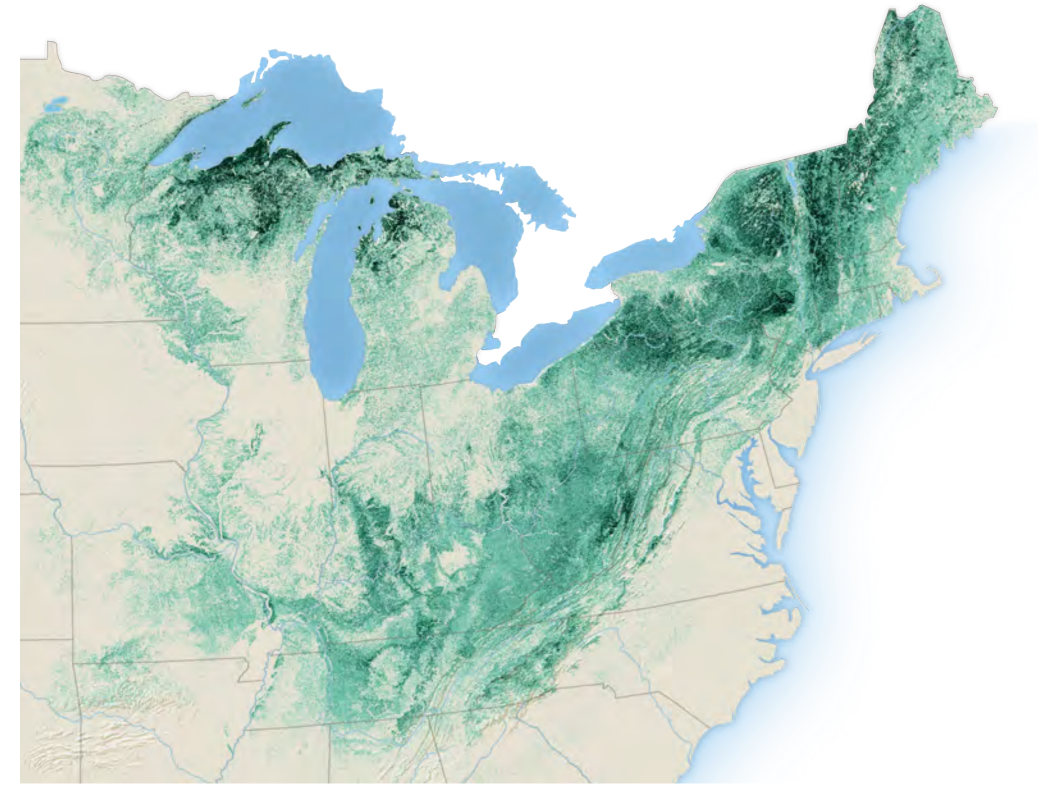
BALSAM FIR *(Abies balsamea)* grows best in areas with cool temperatures and abundant moisture, on a wide range of soils that originated via glaciation. Balsam fir is also referred to as balsam, Canadian balsam, or eastern fir. Wildlife rely extensively on this tree for food and shelter. Moose, for example, 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.



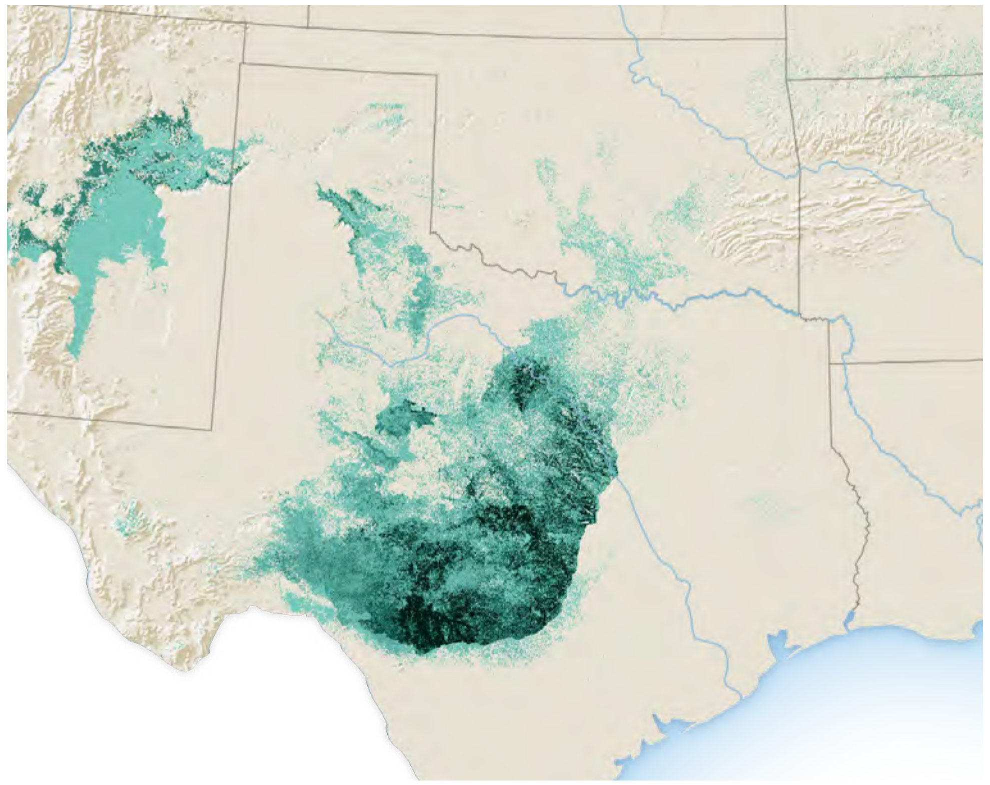
HIGH
RELATIVE ABUNDANCE
LOW

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.

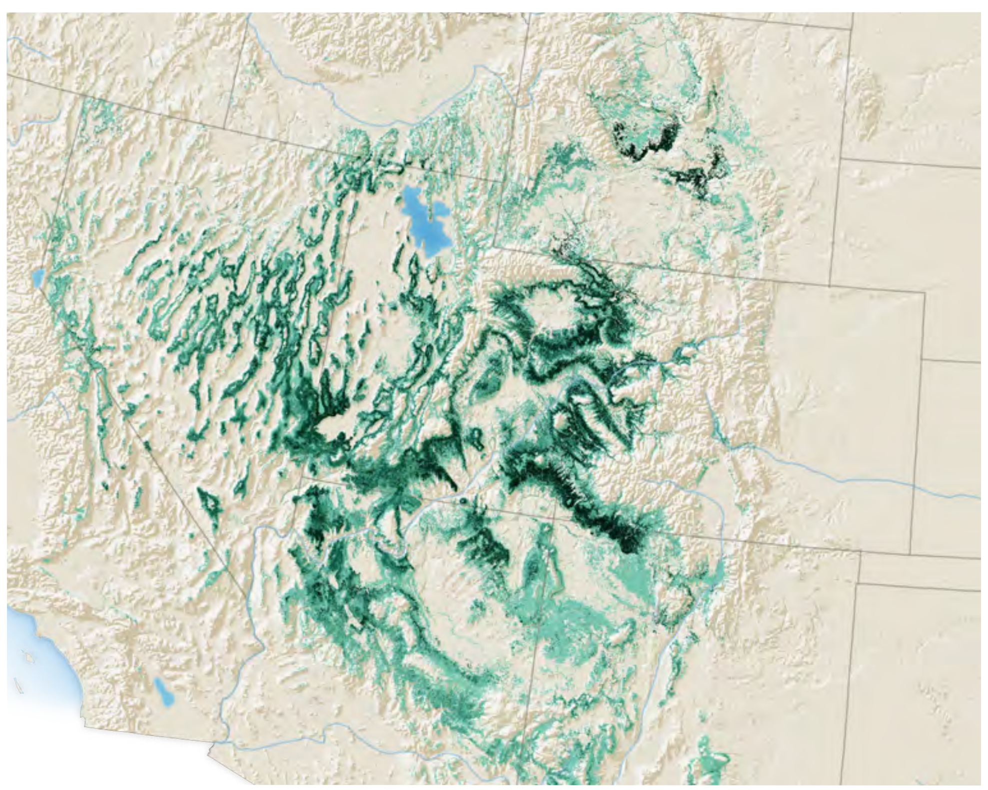
Ashe juniper *(Juniperus ashei)*

Utah juniper *(Juniperus osteosperma)*

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.



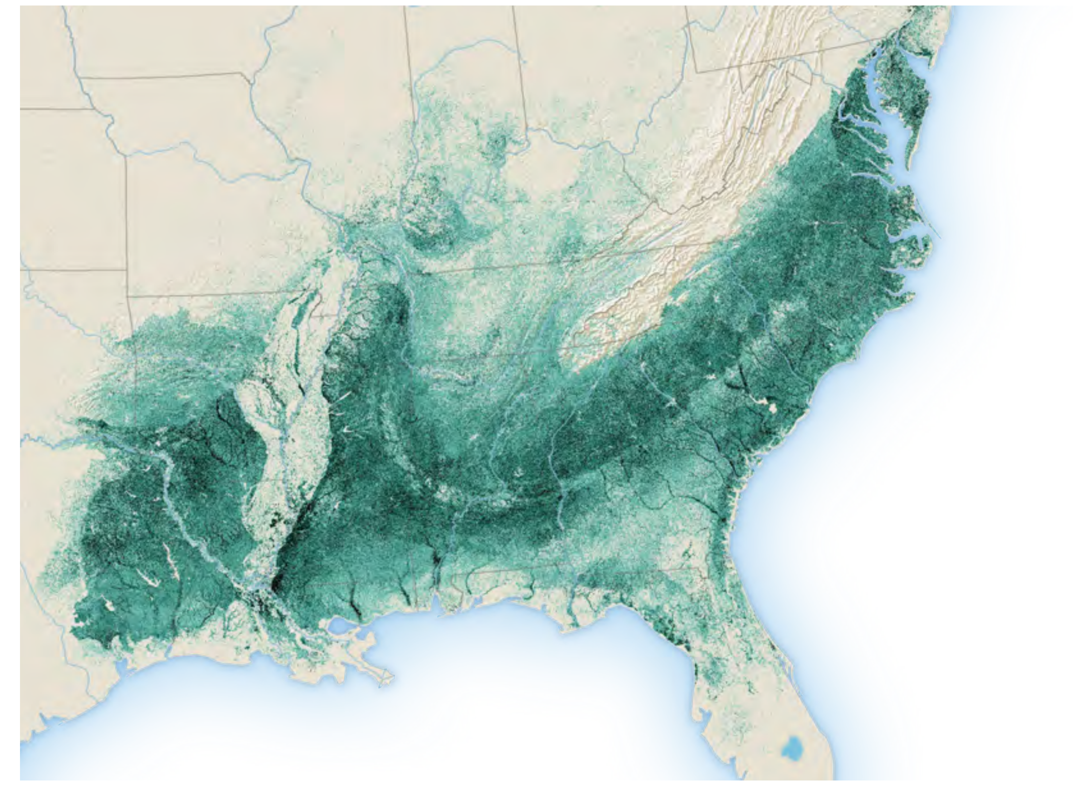
UTAH JUNIPER *(Juniperus osteosperma)* is native to the Southwestern United States. It thrives on very dry sites, with hot, dry summers and cold, wet winters. Utah juniper typically grows on alluvial fans and rocky hillsides with shallow, alkaline soils at elevations ranging from 4,000 to 8,500 feet.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



Sweetgum *(Liquidambar styraciflua)*

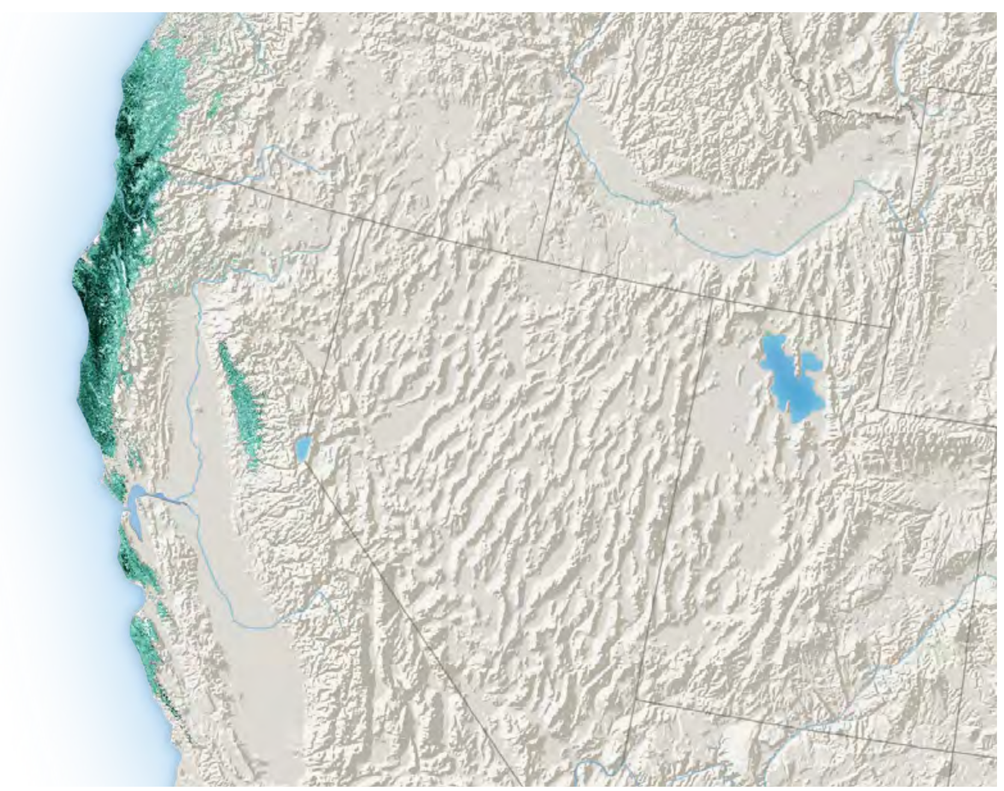
Tanoak *(Lithocarpus densiflorus)*

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.



HIGH
RELATIVE ABUNDANCE
LOW

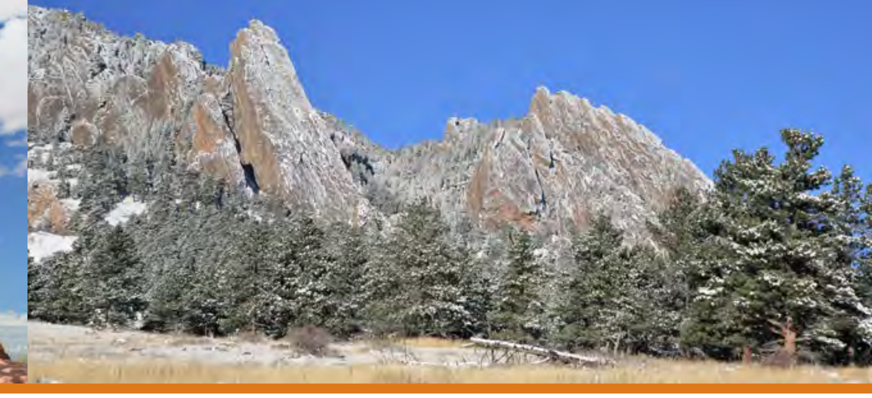
TANOAK *(Lithocarpus densiflorus)*, or tanbark-oak, grows in the humid region along the Pacific coast, with annual precipitation ranging from 40 to 100 inches, most of it coming in winter. It grows well on a variety of soils, from deep, well-drained loams to shallow soils that are less suitable for conifers. Historically, tanoak's large acorns have provided an important food source for Native American communities in the region.



Lodgepole pine *(Pinus contorta)*

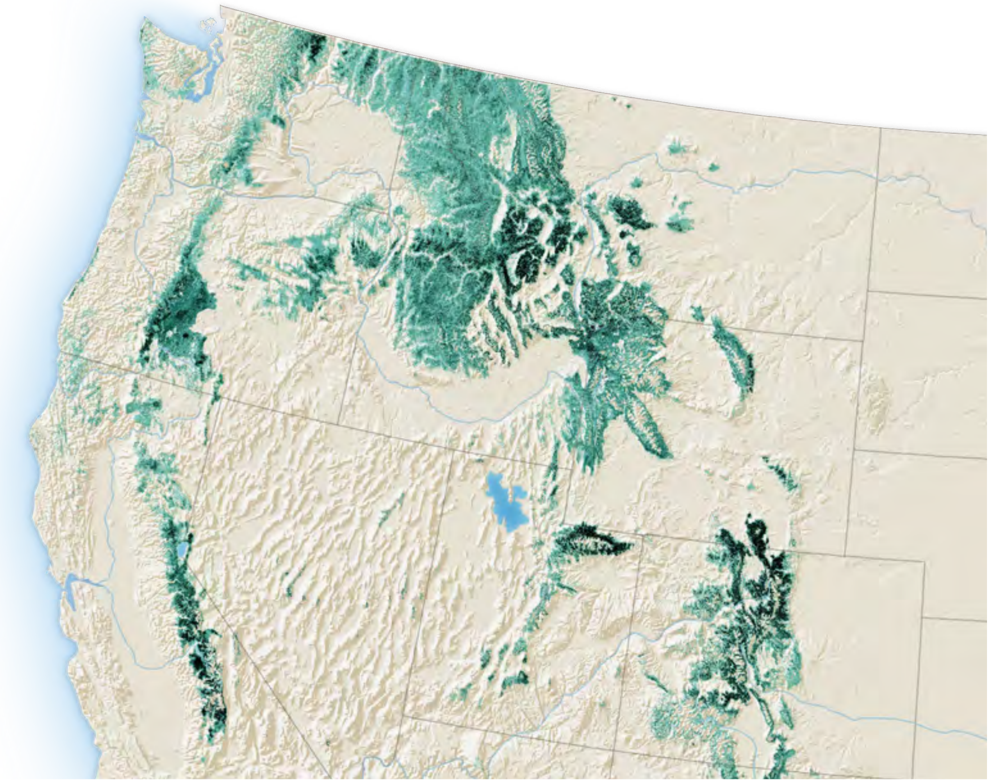
Shortleaf pine *(Pinus echinata)*

Common or two-needle pinyon *(Pinus edulis)*

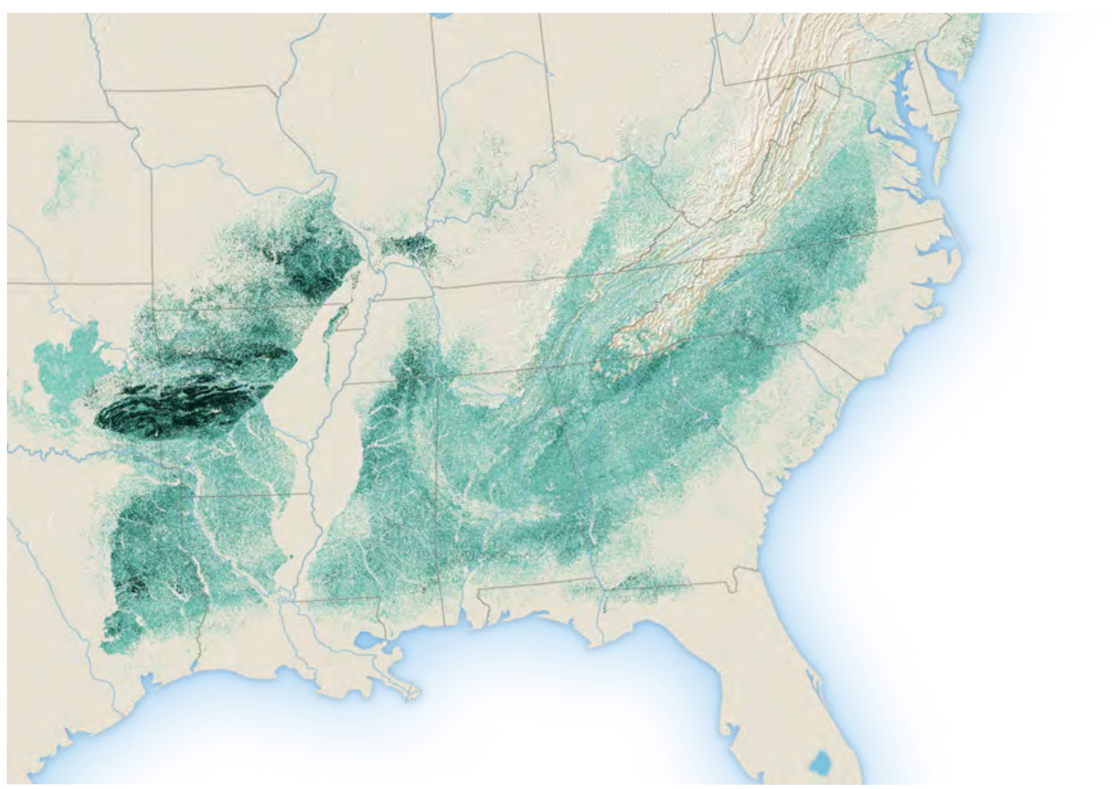


Ponderosa pine *(Pinus ponderosa)*

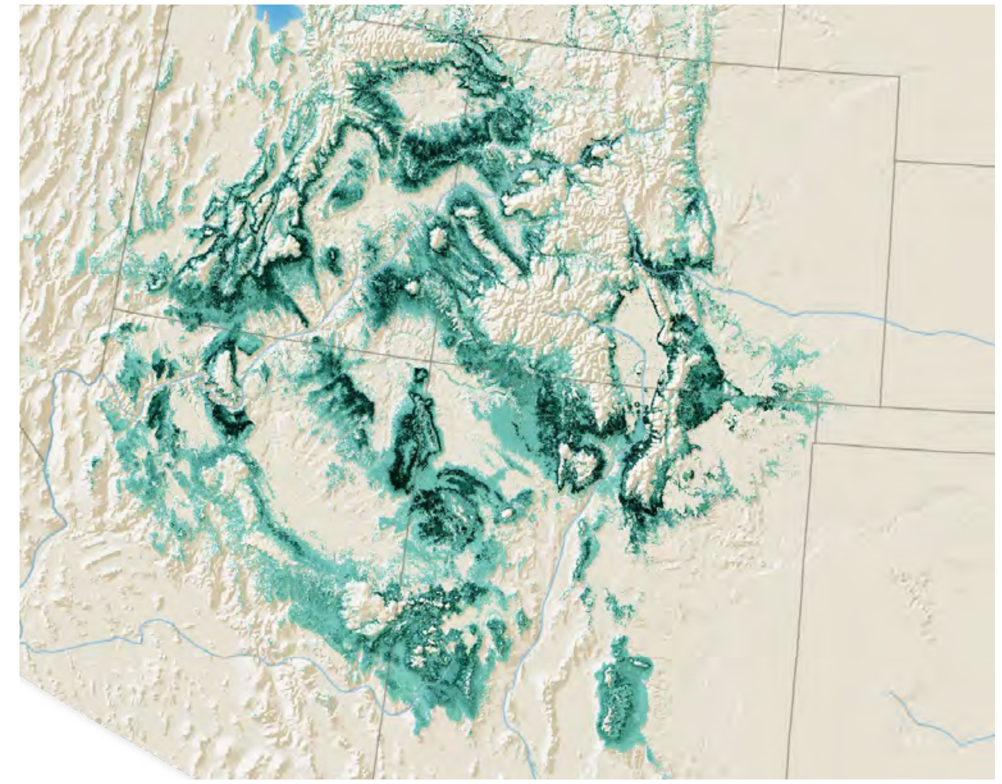
LODGEPOLE PINE *(Pinus contorta)* grows in a variety of climatic conditions, from the coasts of the Pacific Northwest to the inland environs of the northern Rocky Mountains. It grows best on moist soils derived from granites and shales, and it generally favors northern and eastern slopes. Along the coasts, 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.



HIGH
RELATIVE ABUNDANCE
LOW

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.

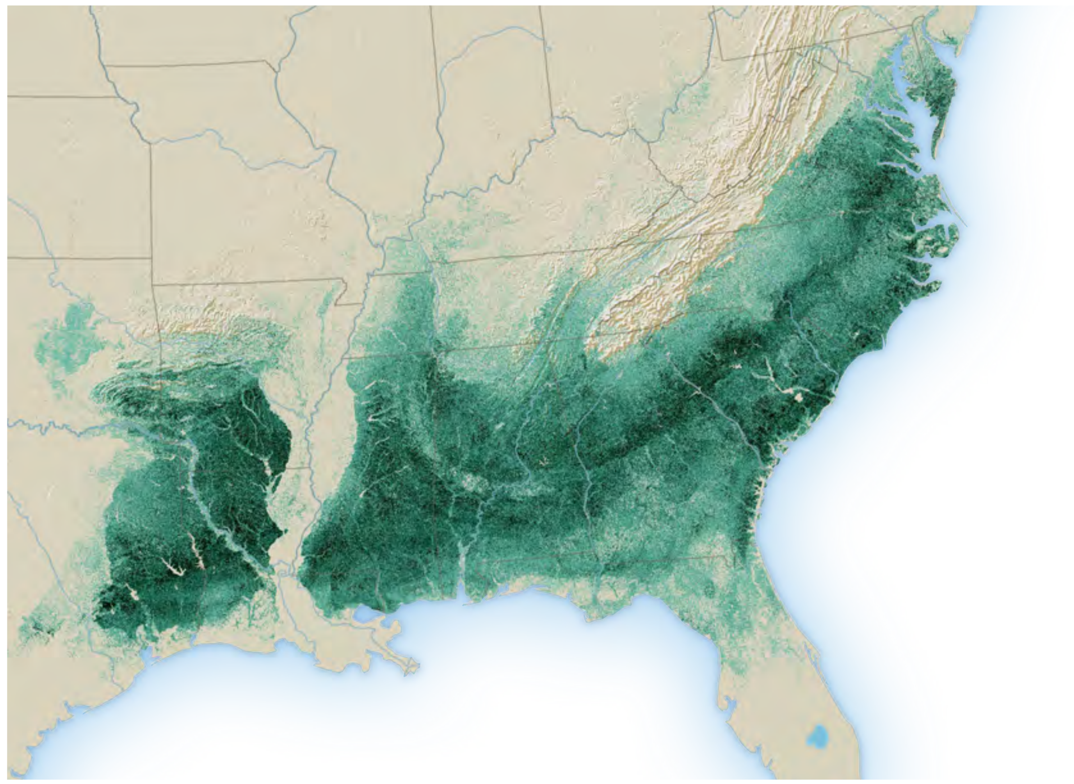
Loblolly pine *(Pinus taeda)*

Quaking aspen *(Populus tremuloides)*

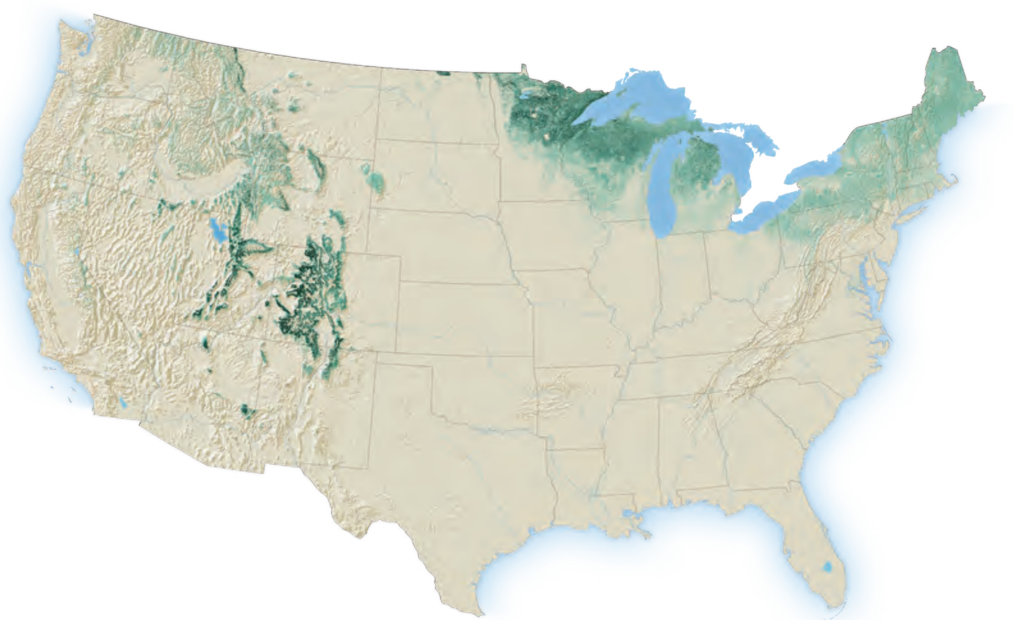
Honey mesquite *(Prosopis glandulosa)*

Douglas-fir *(Pseudotsuga menziesii)*

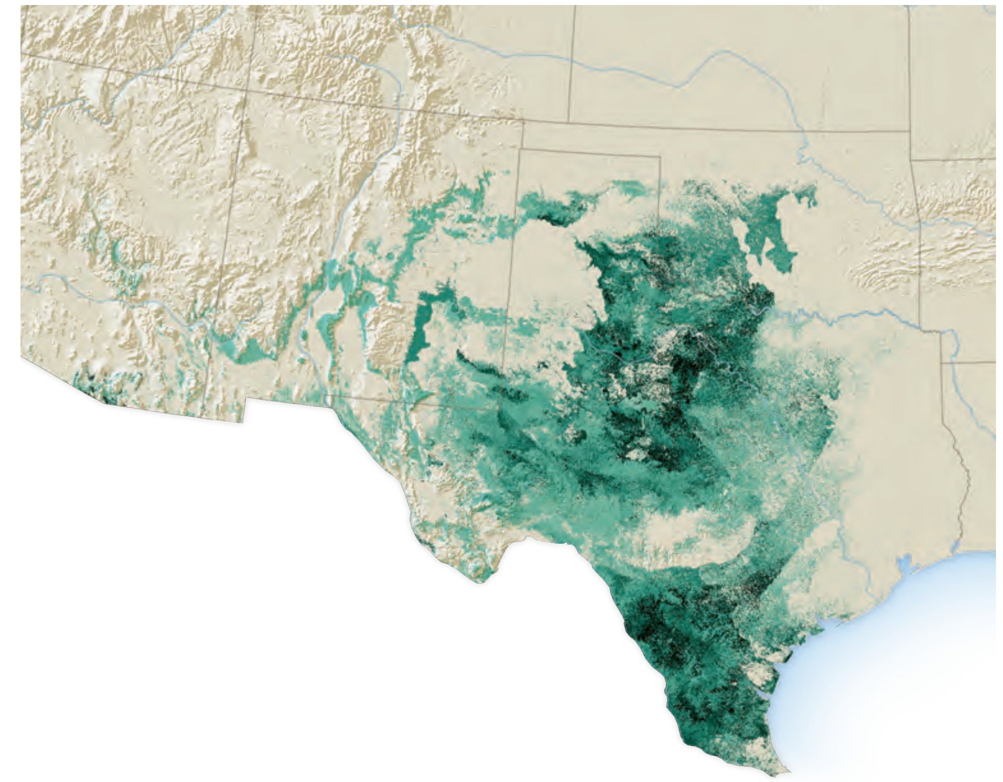
LOBLOLLY PINE *(Pinus taeda)* grows primarily in humid climates, with long hot summers and mild winters. The main limiting factor to its range is likely low winter temperatures in the North and lack of adequate precipitation in the West. Sometimes referred to as oldfield pine, this species grows over 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.

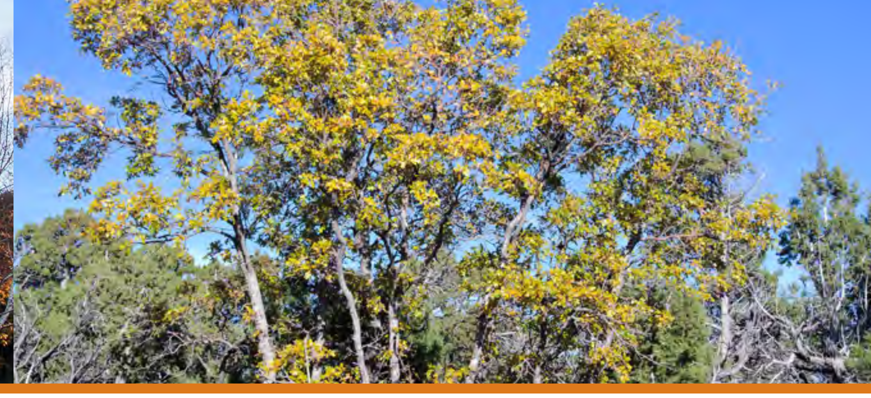


HONEY MESQUITE *(Prosopis glandulosa)* grows on a wide variety of soils across the Chihuahuan Desert and into the southern edge of the Great Plains. It generally is found in areas below 4,500 feet in elevation and receiving fewer than 30 inches of precipitation annually. Previously, honey mesquite was 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.



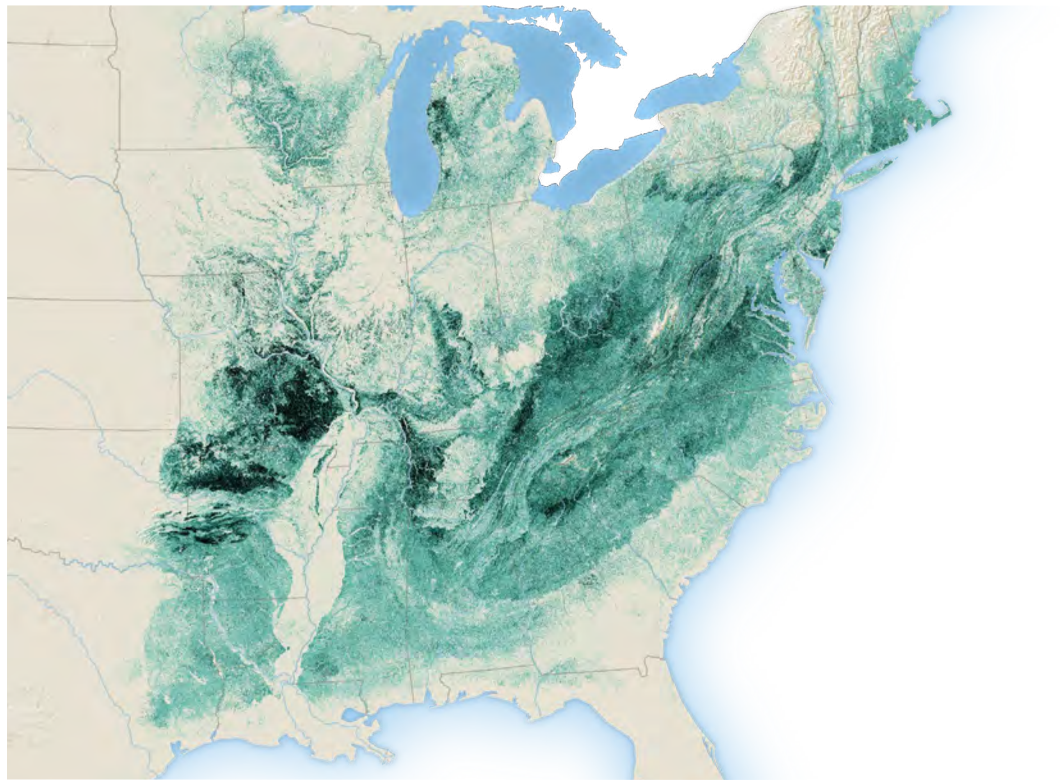
DOUGLAS-FIR *(Pseudotsuga menziesii)* grows under a range of climatic conditions in the United States, from the mild, wet winters and cool, dry summers of the Pacific Northwest to the more extreme conditions of the Sierra Nevada. It grows best on well-aerated, deep, mildly acidic soils. Douglas-fir is 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)*

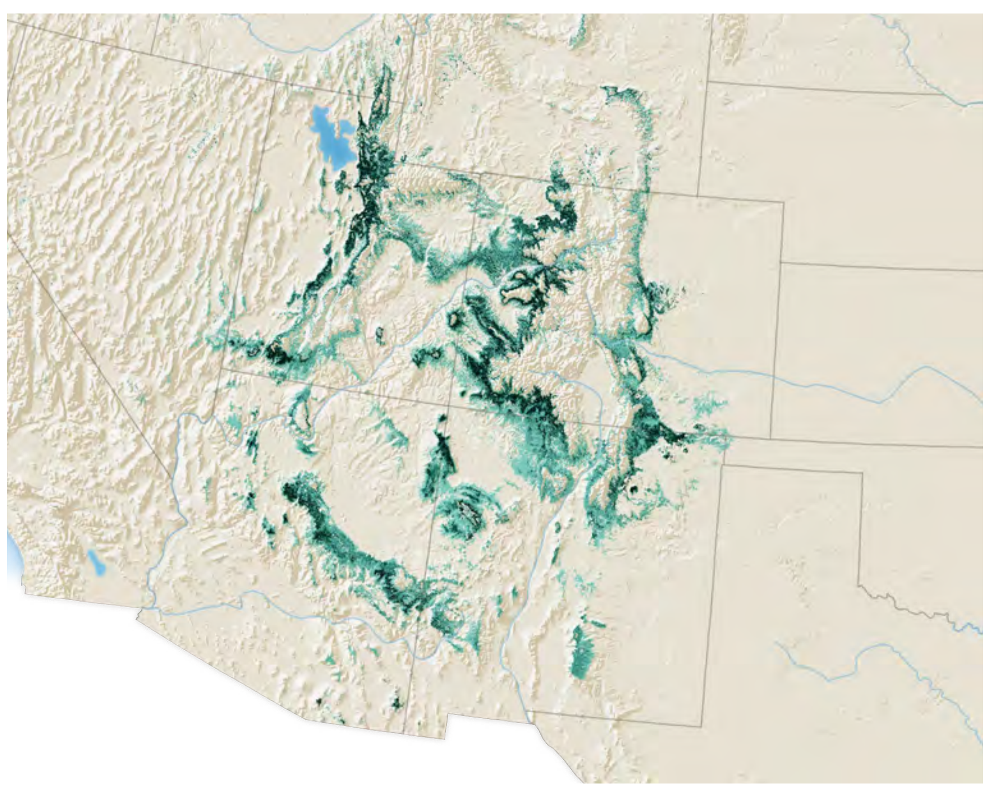


Gambel oak *(Quercus gambelii)*

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.



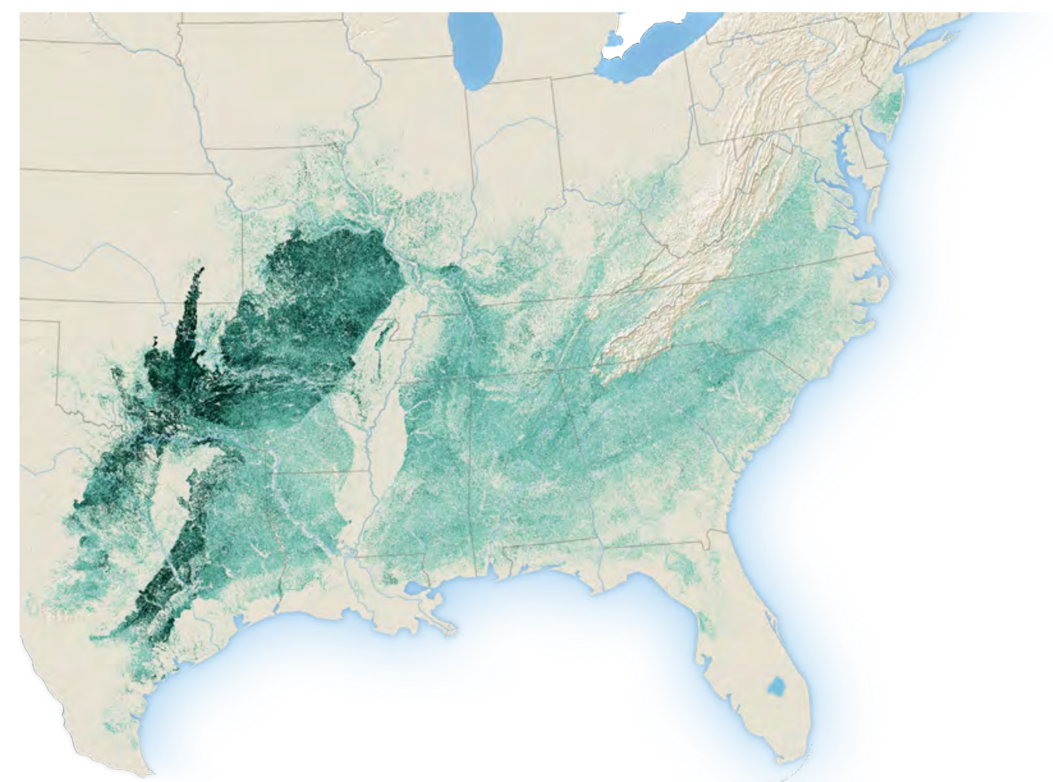
Chestnut oak *(Quercus prinus)*

Post oak *(Quercus stellata)*

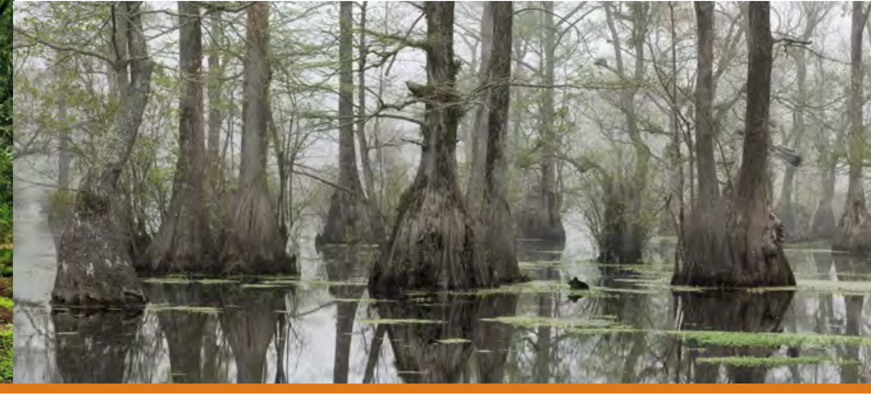
CHESTNUT OAK *(Quercus prinus)*, sometimes called rock oak, grows in a humid climate throughout its range, except for a super-humid region in the Appalachian Mountains. Average annual precipitation over most of its range is from 40 to 48 inches. It is most commonly found on dry upland sites in shallow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

HIGH
RELATIVE ABUNDANCE
LOW

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, in well-drained, sandy soils. Post oak is a commonly used shade tree in urban parks.



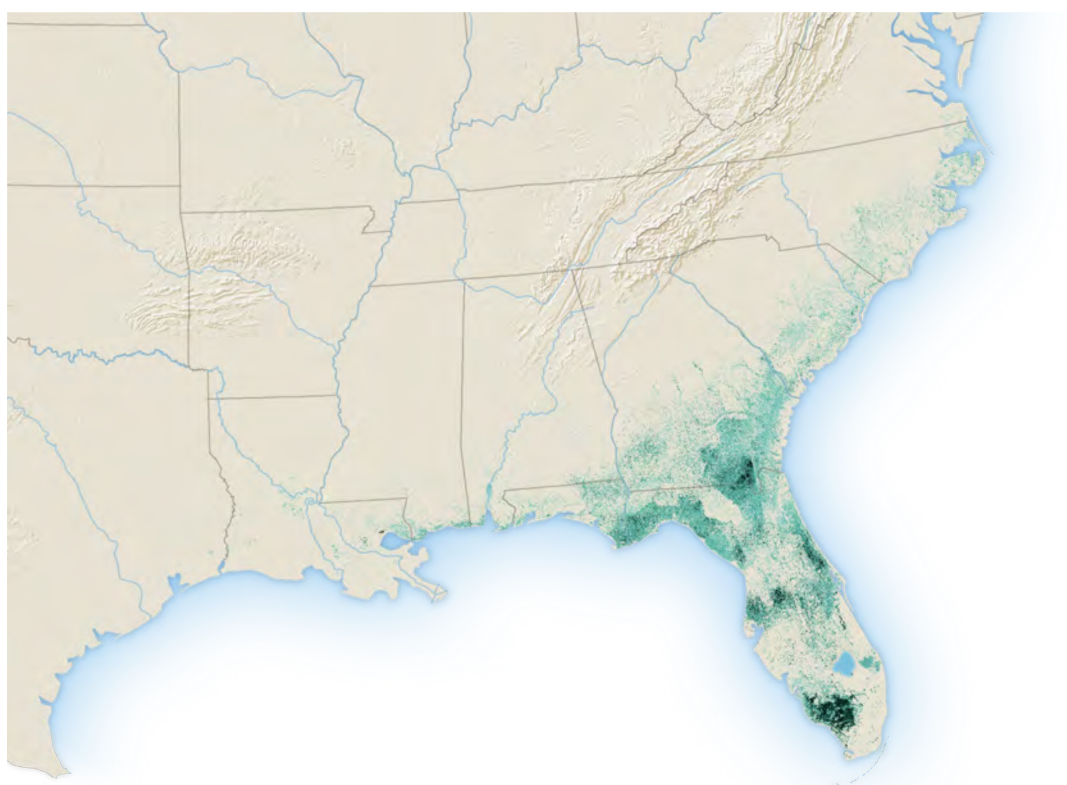
Redwood *(Sequoia sempervirens)*



Pondcypress *(Taxodium ascendens)*

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 south-eastern 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.



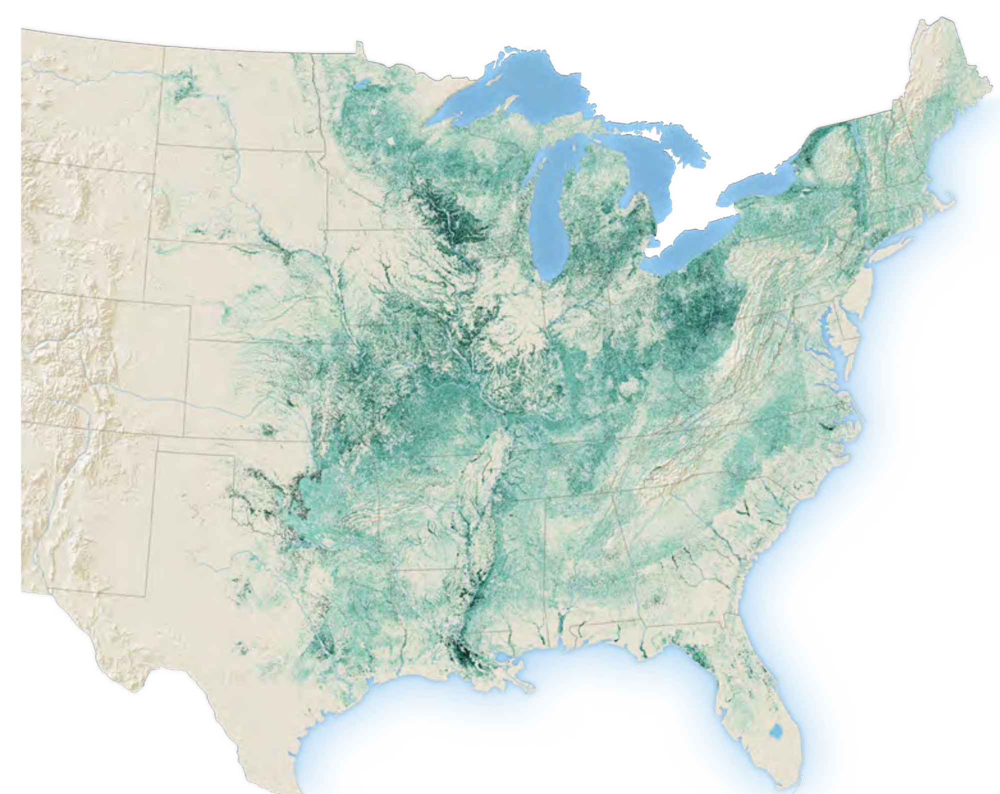
Western hemlock *(Tsuga heterophylla)*

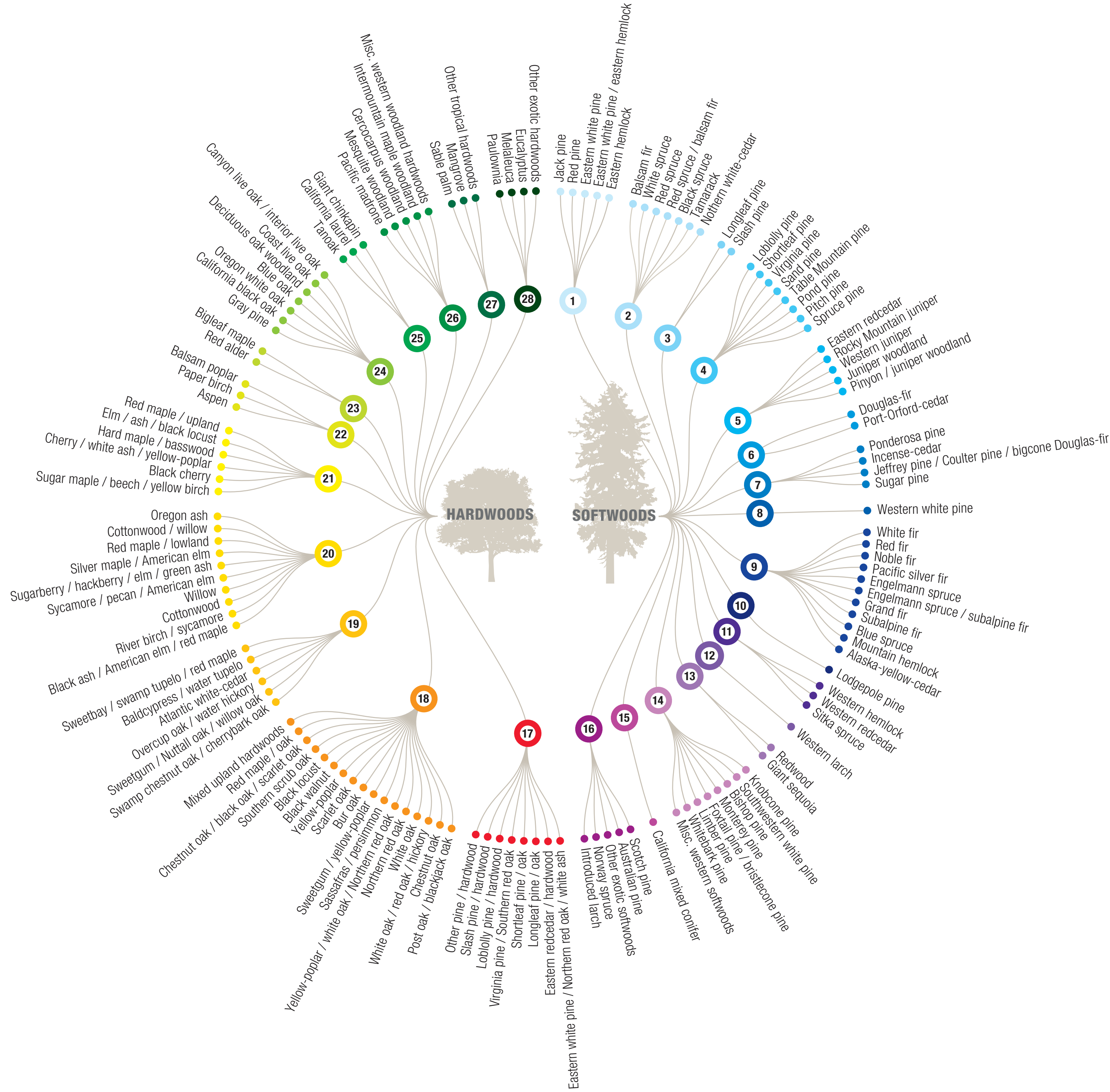
American elm *(Ulmus americana)*

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.

HIGH
RELATIVE ABUNDANCE
LOW

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 cold 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

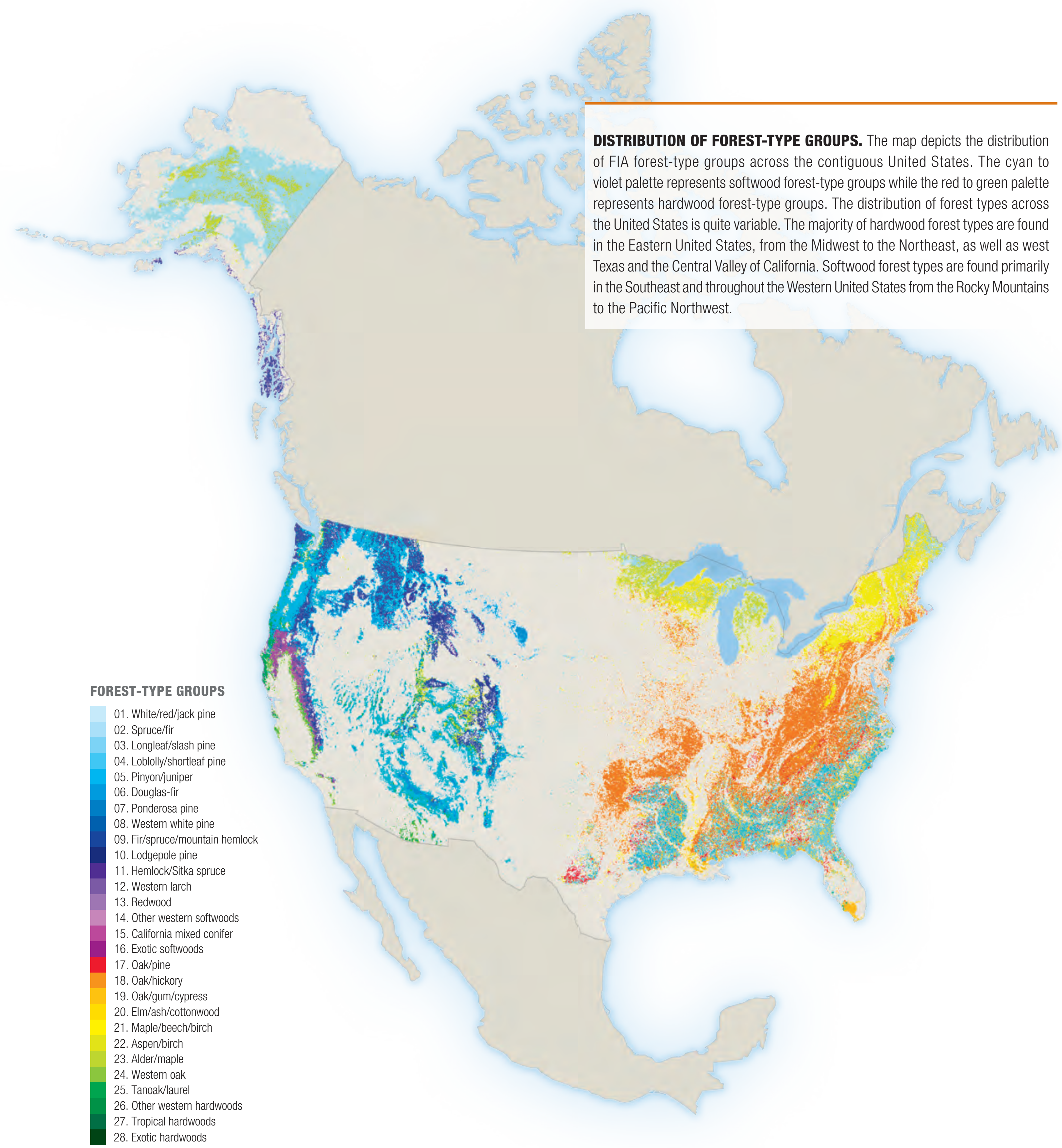
Forest communities are made up of distinct assemblages of plant species. These communities are distributed quite variably across the landscape.

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 and Alaska, here arranged as a circle. Starting in the center, all forests can first be divided into hardwood (e.g., oak) and softwood (e.g., pine) clusters. Within each of these major clusters, forests can be further subdivided into 28 different forest-type groups. Finally, forest-type groups can be broken down into 140 individual forest types.



DISTRIBUTION OF FOREST-TYPE GROUPS. The map depicts the distribution of FIA forest-type groups across the contiguous United States. The cyan to violet palette represents softwood forest-type groups while the red to green palette represents hardwood 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.

What Else Lives in the Forest?

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 mocking-bird, 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, these 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.

FORESTS SUPPORT WILDLIFE. 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 frog), birds (Clark's nutcracker), reptiles (eastern indigo snake), fish (sockeye salmon), and mammals (mountain lion).

Small-diameter or early succession forests include seedlings, saplings, scrub-shrub, and open areas, attracting birds like American woodcock.

Medium-diameter or pole timber forests can be used by beavers as the foundation for their dams.

Large-diameter or mature forests tend to be dark and moist, providing ideal habitat for gastropods like banana slugs.

PROPORTION OF FOREST LAND IN SMALL STAND-SIZE CLASS. Commonly called saplings, these trees are smaller than 5 inches diameter at breast height (d.b.h., 4.5 feet above ground) and typically occur in young, regenerating forests.

PROPORTION OF FOREST LAND IN LARGE STAND-SIZE CLASS. Commonly called sawtimber, these trees have a diameter at breast height of 9 inches or larger for softwoods, 11 inches or larger for hardwoods, and typically occur in older, maturing forests.

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.

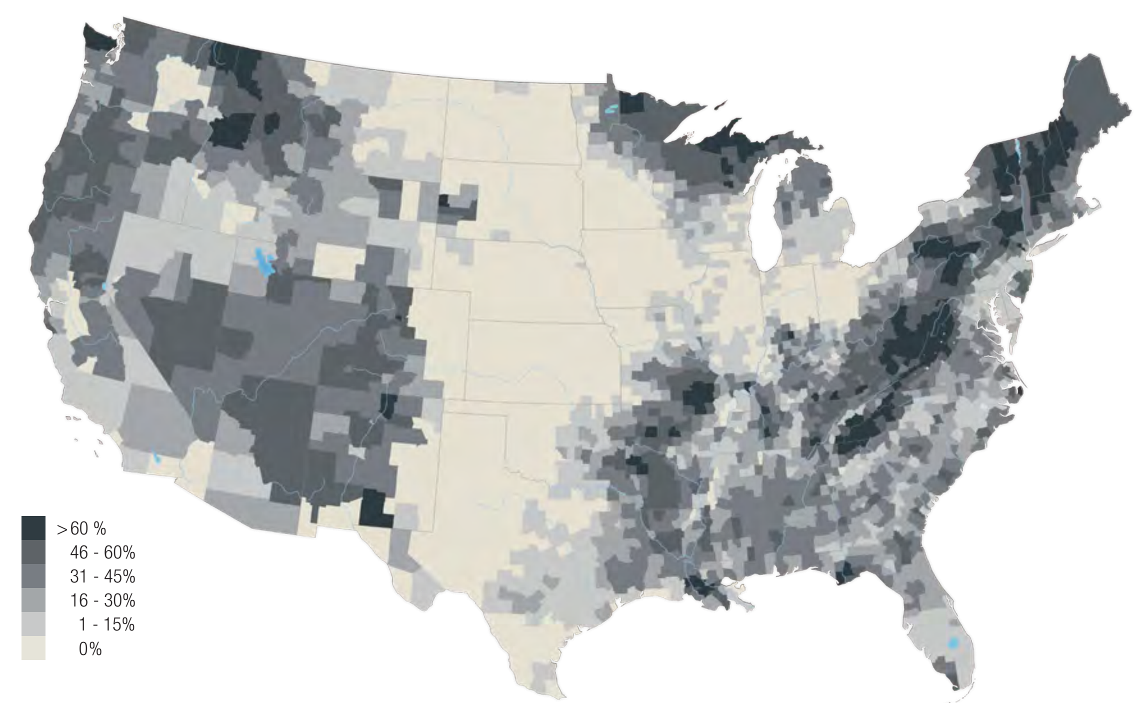
As a forest passes through various developmental stages, the structure and composition of trees and other plants change, along with the animal communities that live within the forest.

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.

CORE FOREST AS A PROPORTION OF TOTAL FOREST AREA BY COUNTY. Forest fragmentation occurs when previously contiguous forest areas are broken up, resulting in smaller patch sizes, less connection to other forest areas, and less total forest area in the surrounding landscape matrix. This may happen as a result of relatively permanent loss of forest. Here, we defined "core forest" with two conditions:

1. Forest cover from the National Land Cover Database (deciduous, evergreen, and mixed forest, and woody wetlands) is surrounded completely by 10 acres of forest.
2. A larger 1,500-acre landscape neighborhood surrounding the area of interest is at least 50 percent forested.



WATER Wood duck *(Aix sponsa)*

SHRUB Northern cardinal *(Cardinalis cardinalis)*

MIDSTORY Cooper's hawk *(Accipiter cooperii)*

CANOPY Baltimore oriole *(Icterus galbula)*

TRUNK Acorn woodpecker *(Melanerpes formicivorus)*

FLOOR Ruffed grouse *(Bonasa umbellus)*

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.

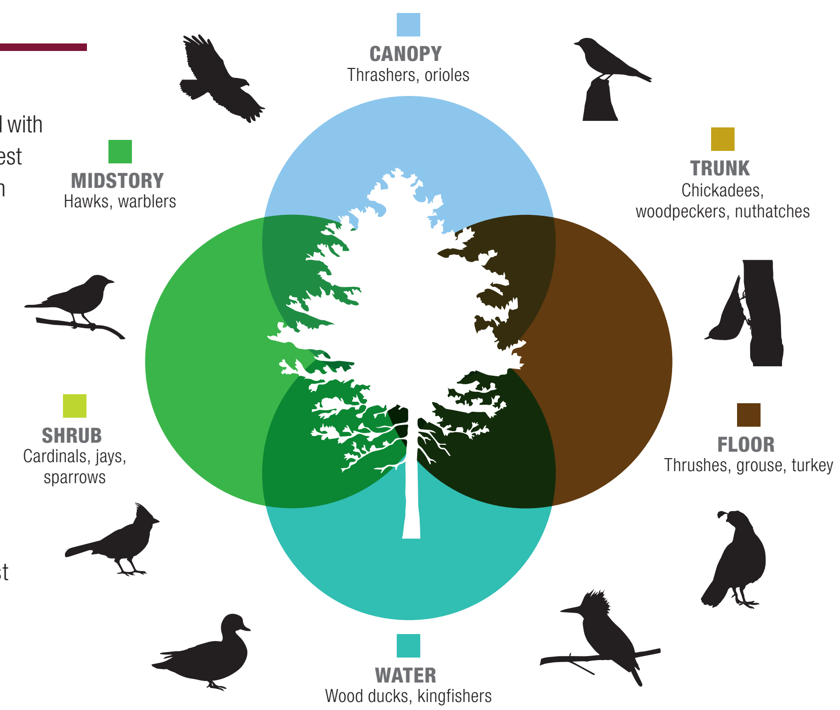
Forest attributes of composition and structure are important to forest bird species at varying degrees and during different seasons. These attributes include tree and understory vegetation species, tree diameter, canopy and understory height and density, and abundance of standing dead trees and downed 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 midstory to upper canopy habitats, particularly during migration in the spring; 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 nesters. This graphic 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.

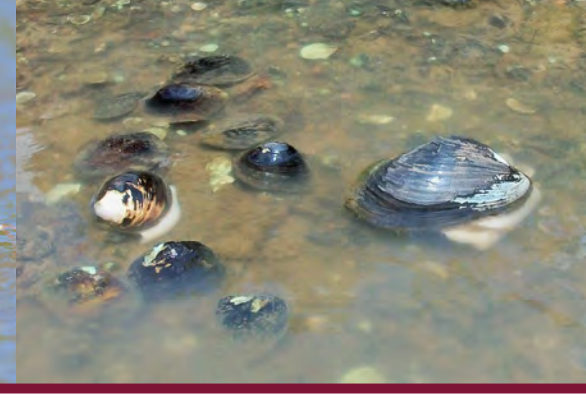


NUMBER OF FOREST-BREEDING BIRD SPECIES BY SUBWATERSHED. Patterns correspond with forest density, except for forests in southern pines, the Great Plains, and Pacific Northwest coast. Richness for all birds (including nonforest species—not shown) is highest along Atlantic, Gulf, and Pacific coasts.

GEOGRAPHIC BREEDING RANGE OF FLAMMULATED OWL AND ASSOCIATED FOREST HABITAT. Like many owl species, the flammulated owl *(Psiloscops flammeolus)* nests in cavities of live trees or in large standing dead trees or snags. Throughout most of their breeding range of western North America, flammulated owls inhabit mid-elevation montane forests of ponderosa pine *(Pinus ponderosa)* and Jeffrey pine *(Pinus jeffreyi)*. Potential flammulated owl breeding habitat is present on about half of this forest acreage, where there are trees of a large size and open cover.

Spotted gar *(Lepisosteus oculatus)*

Mayfly *(Ephemeroptera)*



Texas pigtoe *(Fusconaia askewi)*

Marbled salamander *(Ambystoma opacum)*

Pacific giant salamander *(Dicamptodon tenebrosus)*

Eastern brook trout *(Salvelinus fontinalis)*

Forest Fish and Aquatic Species

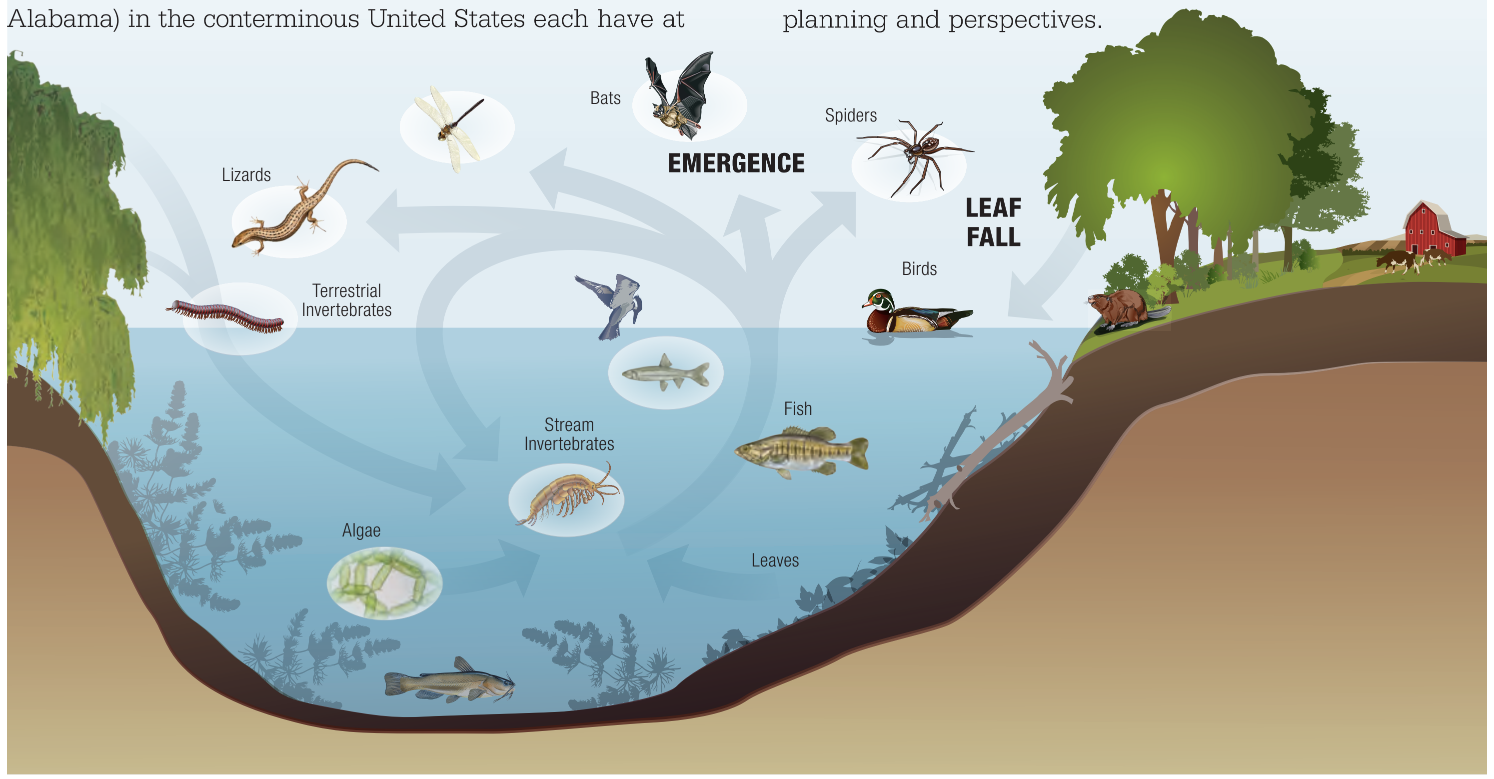
Freshwater streams in the United States are home to 801 known fish species, 322 crayfish, 300 freshwater mussels, 600 snail species, and more than 3,000 species of stoneflies, mayflies, caddisflies, dragon and damselflies, and stygobites, making the United States the seventh-ranked country worldwide 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.

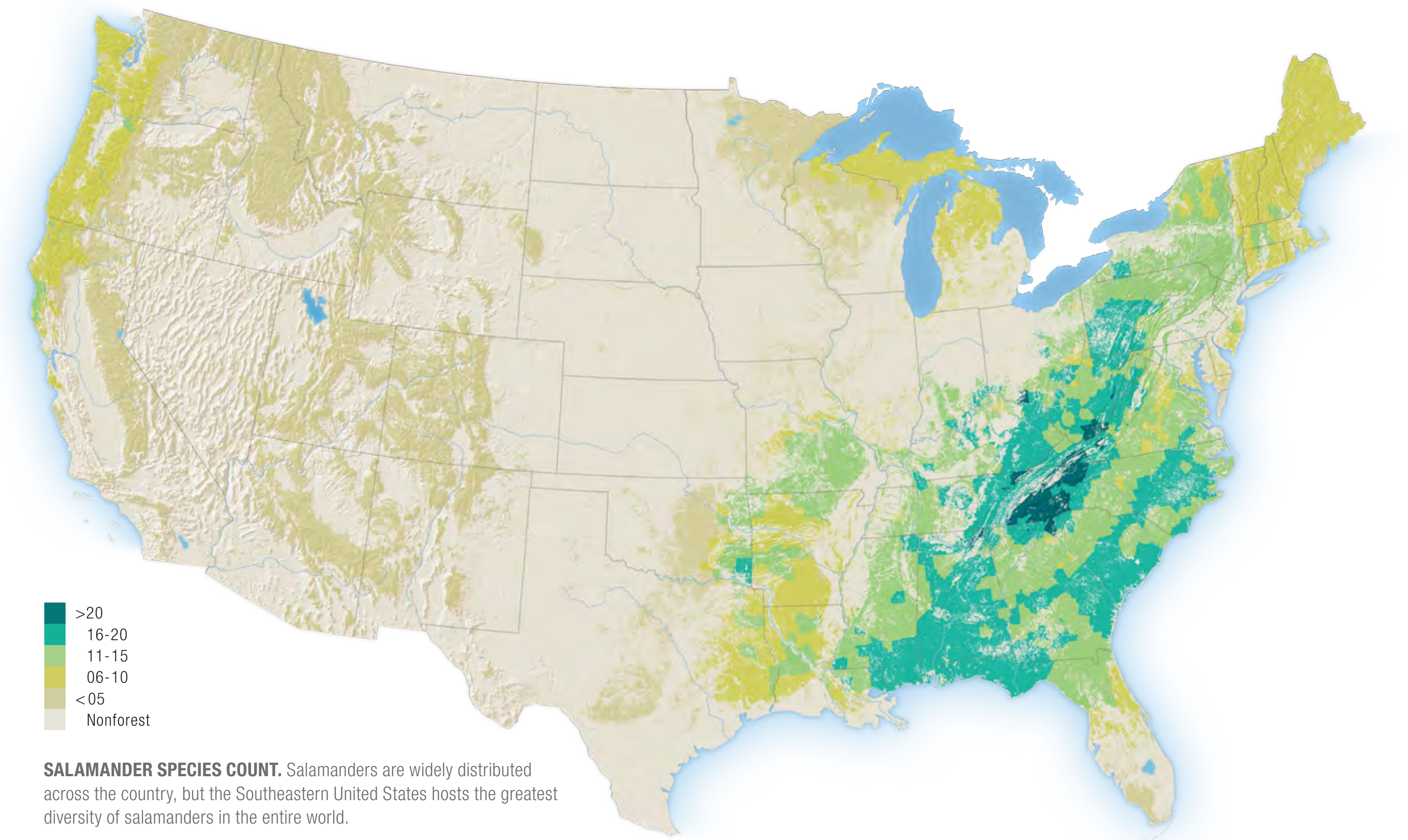
The nutrients in fish carcasses and animal waste enrich the soil, providing resources for growing trees and other plants. In turn, fallen trees and other structural components of the forest, such as tree roots and canopy cover, provide important habitat features in streams and lakes. Healthy fisheries, 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.

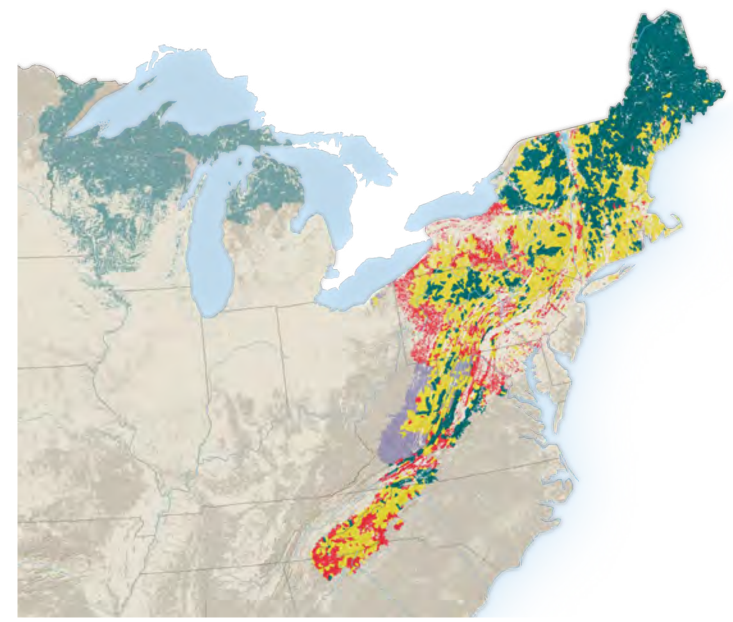


RIPARIAN ZONE. The definition of a riparian zone varies across jurisdictions, but, fundamentally, riparian zones are interfaces where terrestrial and aquatic ecosystems interact in many ways. Trees provide shade, altering stream temperature and sunlight availability for aquatic plants. Falling leaves 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.



SALAMANDER SPECIES COUNT. Salamanders are widely distributed across the country, but the Southeastern United States hosts the greatest diversity of salamanders in the entire world.

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.



Red fox *(Vulpes vulpes)*

White-tailed deer *(Odocoileus virginianus)*

American pine marten *(Martes americana)*

Snowshoe hare *(Lepus americanus)*

Indiana bat *(Myotis sodalis)*

Bobcat *(Lynx rufus)*

Forest Mammals

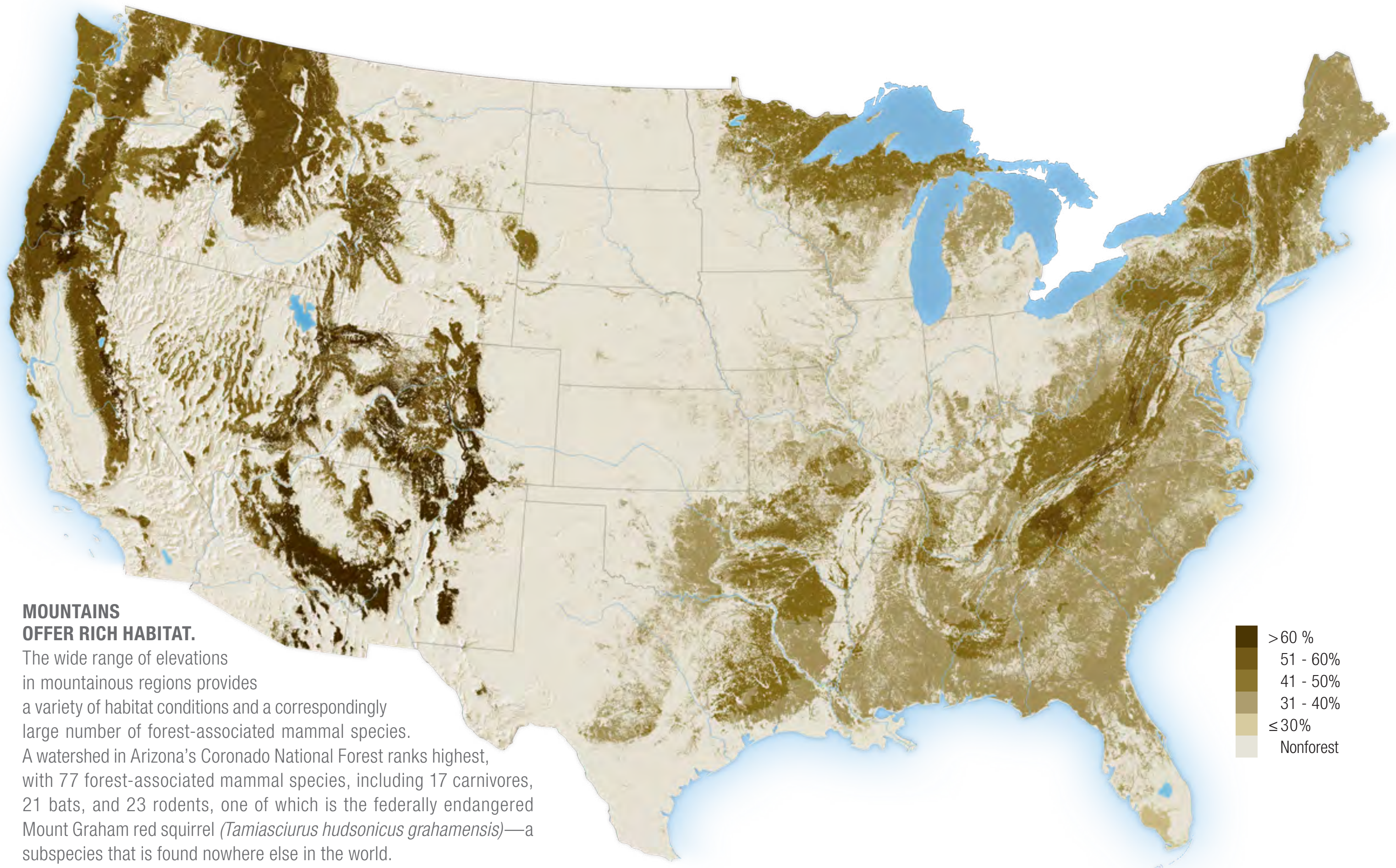
When people think about forest wildlife, some sort of mammal usually comes to mind, whether it's a large animal like a bear or a wolf, or a backyard creature like a squirrel or a mouse. Forest mammals are charismatic symbols of wilderness in the United States, and they are important to humans in myriad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



MOUNTAINS OFFER RICH HABITAT. The wide range of elevations in mountainous regions provides a variety of habitat conditions and a correspondingly large number of forest-associated mammal species. A watershed in Arizona's Coronado National Forest ranks highest, with 77 forest-associated mammal species, including 17 carnivores, 21 bats, and 23 rodents, one of which is the federally endangered Mount Graham red squirrel *(Tamiasciurus hudsonicus grahamensis)*—a subspecies that is found nowhere else in the world.

GEOGRAPHIC BREEDING RANGE OF AMERICAN BLACK BEAR AND ASSOCIATED FOREST HABITAT. As a habitat generalist, black bears historically populated most North American forests. In the United States, overexploitation and habitat fragmentation have removed them from large portions of their historical range and significantly altered their distribution. Evidence indicates that modern populations within the remaining habitat, however, are stable or even increasing.

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 site 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.


Mountain pine beetle *(Dendroctonus ponderosae)*


Western tent caterpillar *(Malacosoma californicum)*


Fruiting body of annosum root disease *(Heterobasidion annosum)*


Gypsy moth *(Lymantria dispar)*


Emerald ash borer *(Agrilus planipennis)*


White pine blister rust *(Cronartium ribicola)*

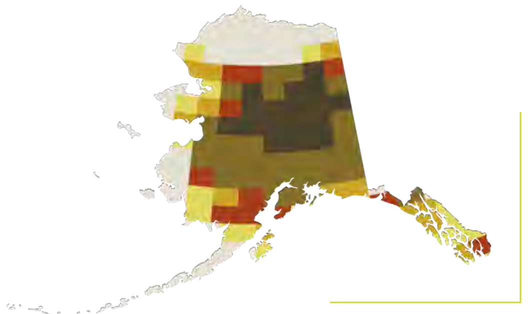
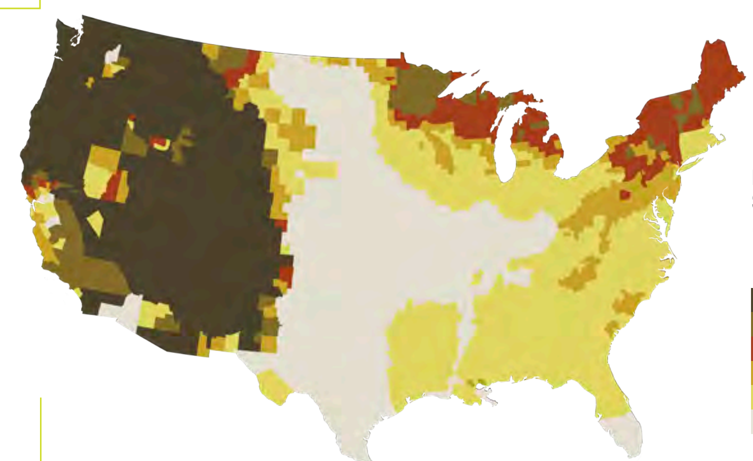
Native and Nonnative Insects and Diseases

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.

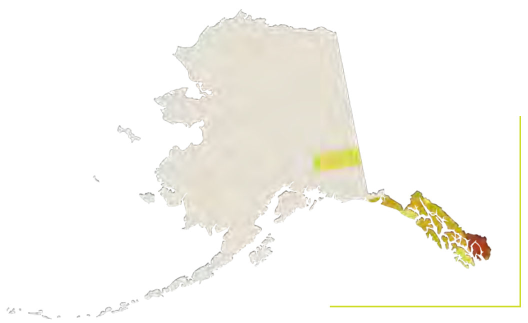
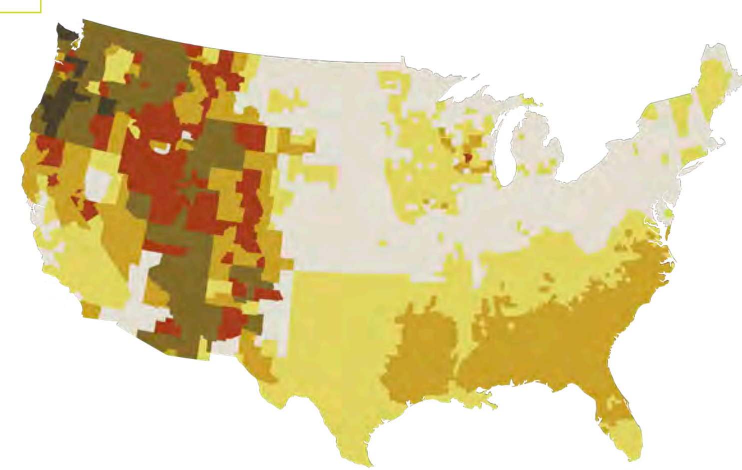
Our Forest Health Protection program at the U.S. Department of Agriculture (USDA), Forest Service routinely reports on almost 50 major forest pests and pathogens whose impact is significant and is of local and national interest. The accompanying maps present some of the results of these surveys.

NATIVE INSECTS AND DISEASES. 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 recycling. 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.

NUMBER OF MAJOR NATIVE INSECT SPECIES BY COUNTY.
(Alaska: USGS 1:250,000 Quadrangles)

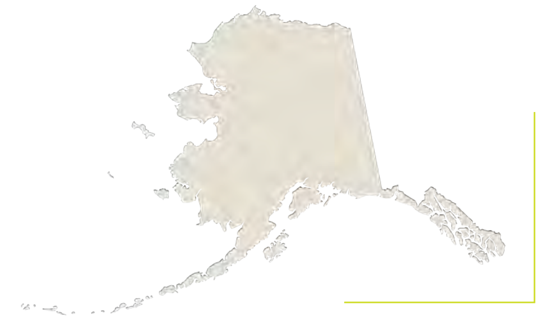
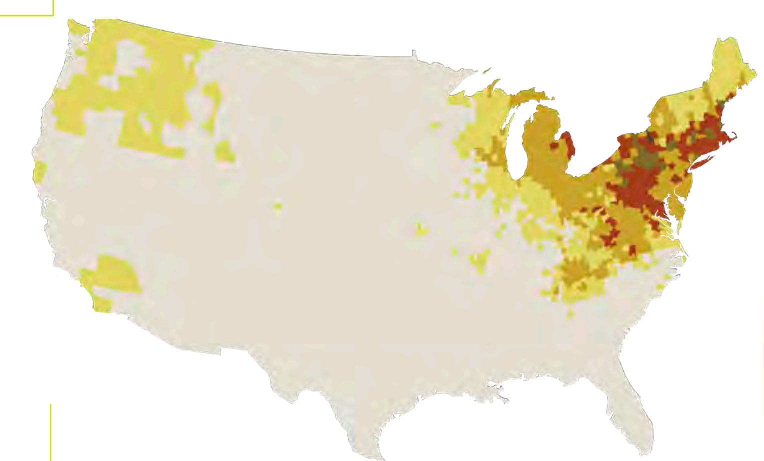
≥ 5
4
3
2
1
0

NUMBER OF MAJOR NATIVE DISEASE SPECIES BY COUNTY.
(Alaska: USGS 1:250,000 Quadrangles)

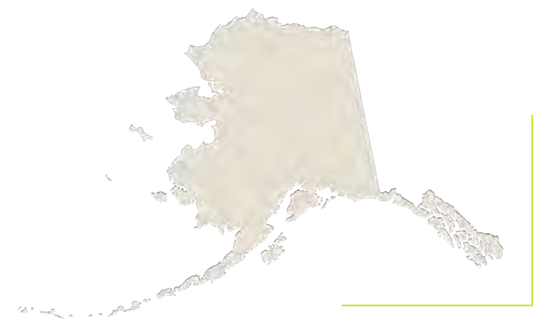
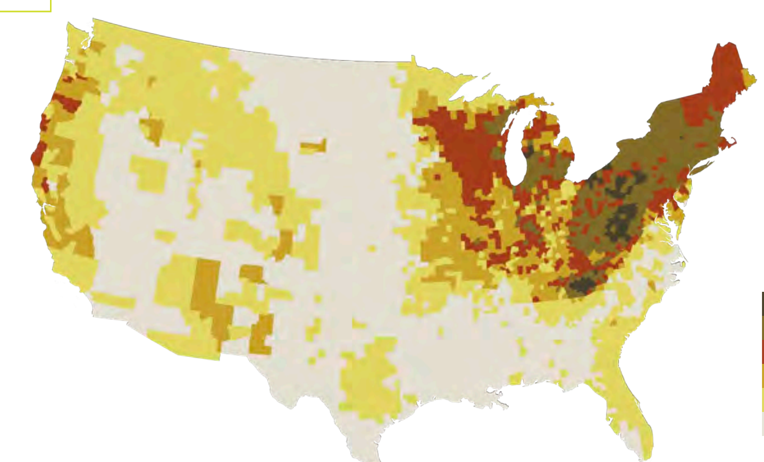
5
4
3
2
1
0

NONNATIVE INSECTS AND DISEASES. 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.

NUMBER OF MAJOR NONNATIVE INSECT SPECIES BY COUNTY.
(Alaska: USGS 1:250,000 Quadrangles)

5
4
3
2
1
0

NUMBER OF MAJOR NONNATIVE DISEASE SPECIES BY COUNTY.
(Alaska: USGS 1:250,000 Quadrangles)

≥ 5
4
3
2
1
0

Surface fire

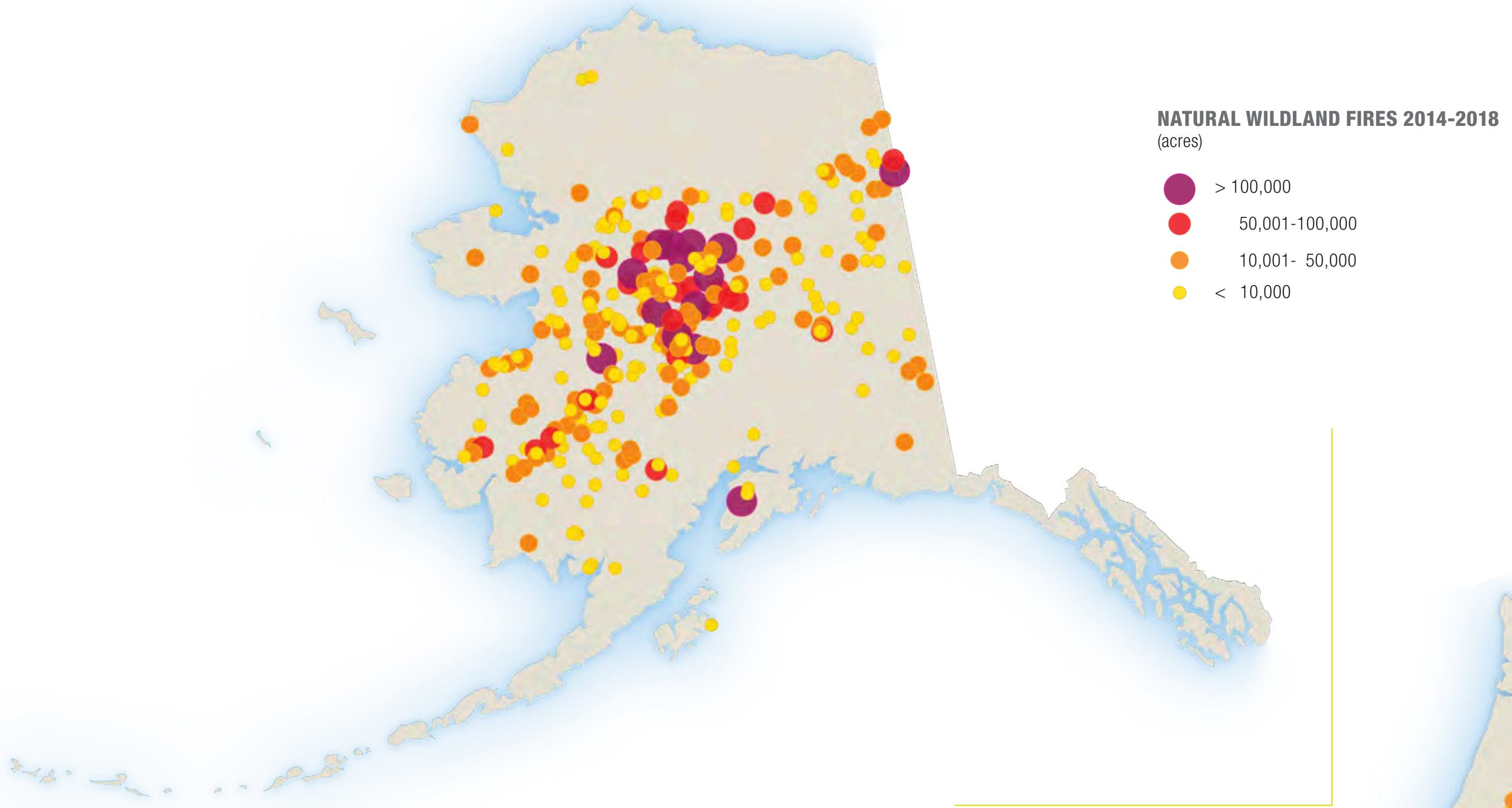
Surface fire

Understory fire

Understory fire

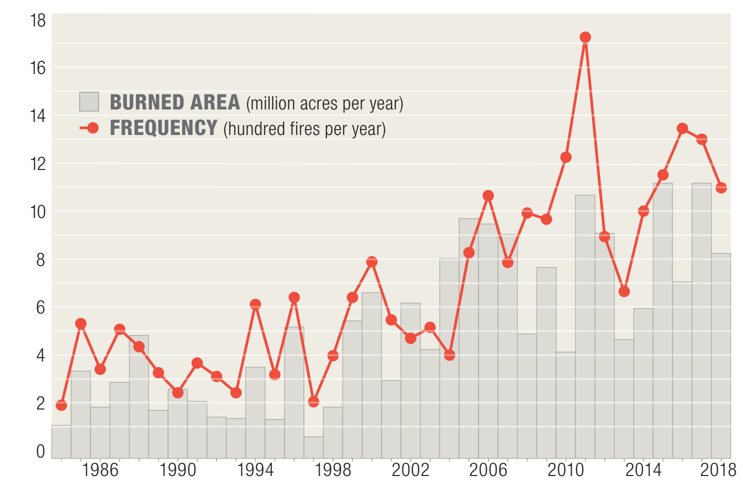
Crown fire

Crown fire



MONITORING TRENDS IN BURN SEVERITY (MTBS) DATA ARE CAPTURED THROUGH SATELLITE IMAGERY. The Forest Service uses data to create maps that support local-, State-, and national-level analyses of burn severity (extent and intensity) and to assess the effectiveness of land management decisions. This map of fire size and location shows that small wildfires occur much more commonly than large fires and that there are more large fires in the Western United States, including Alaska. The map was developed using data from the MTBS project and shows all fires mapped on forest lands and grasslands between 2014 and 2018.

TOTAL BURNED AREA AND FIRE FREQUENCY INCREASES AND DECREASES IN CYCLES. The Monitoring Trends in Burn Severity (MTBS) project produced data depicting both the number of fires and burned area annually for the period 1984 through the present. These data indicate high levels of interannual variability with generally increasing fire frequency and burned area through the period.



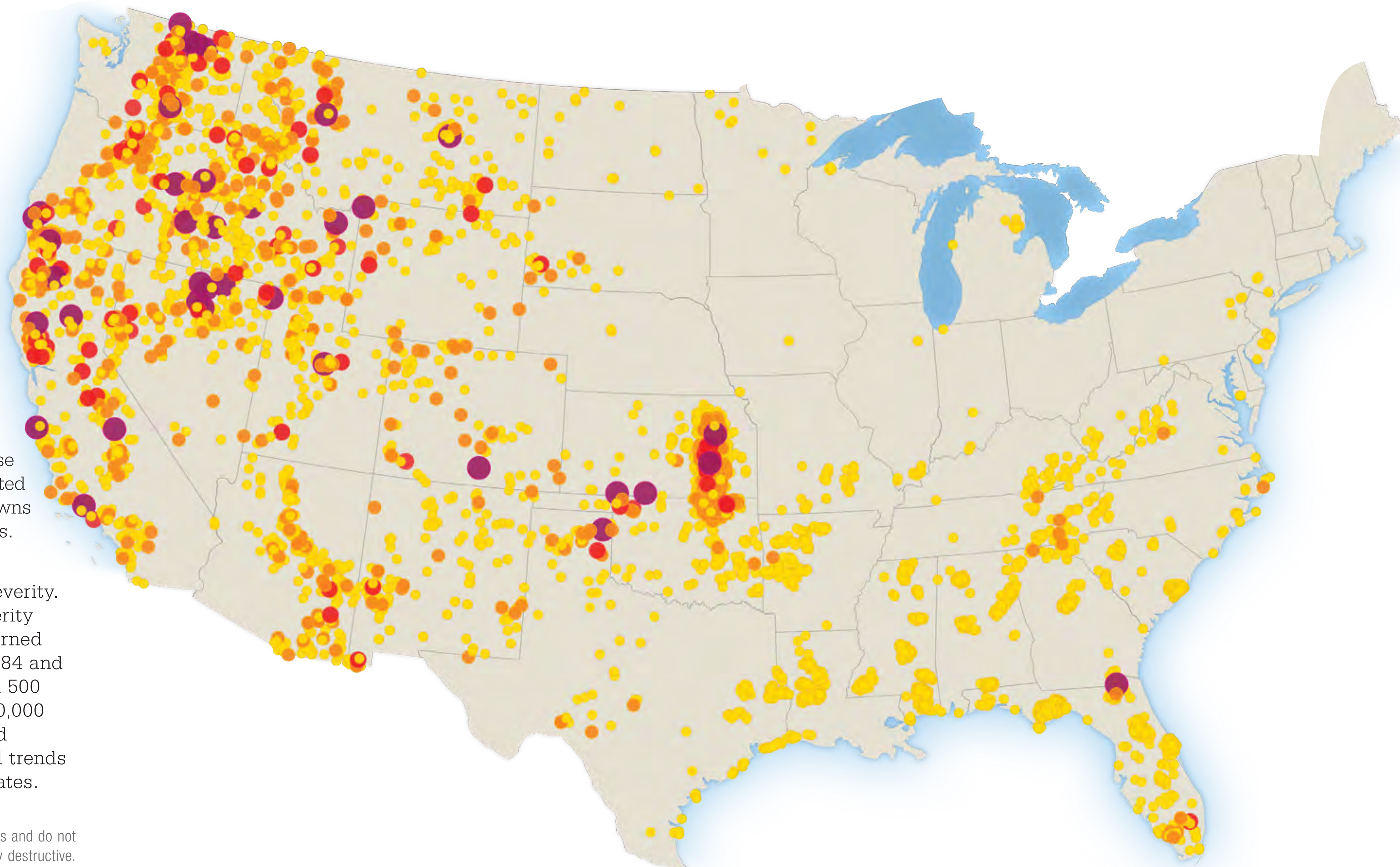
Wildland Fire as a Natural Disturbance

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.

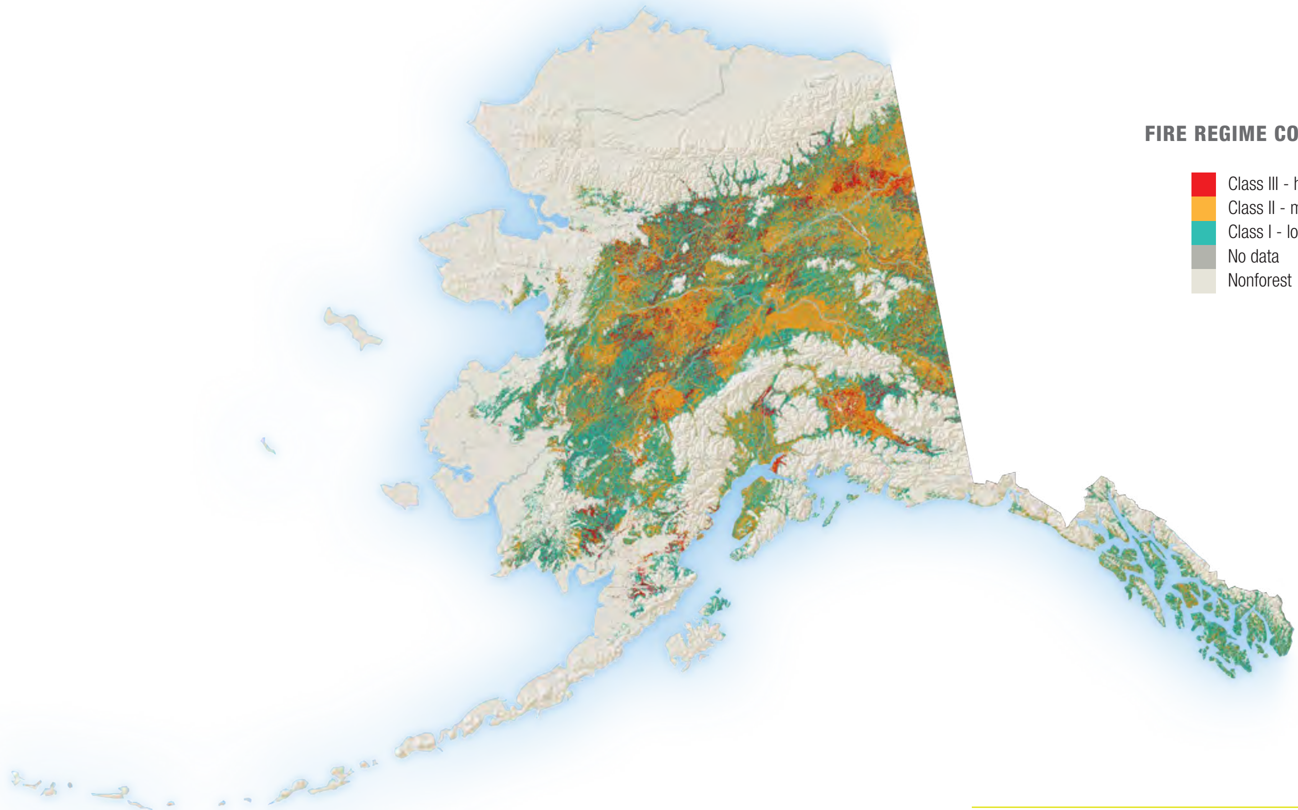
All these fire types occur in every region of the United States but with varying frequency and severity. Our interagency Monitoring Trends in Burn Severity (MTBS) project used satellite imagery to map burned area boundaries and severity for all fires from 1984 and beyond greater than 1,000 acres in the 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 (a dead fuel) and vegetation (a 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 dominant vegetation. CROWN FIRES create a solid wall of flame from the surface through the canopy fuel layers and can be very destructive.

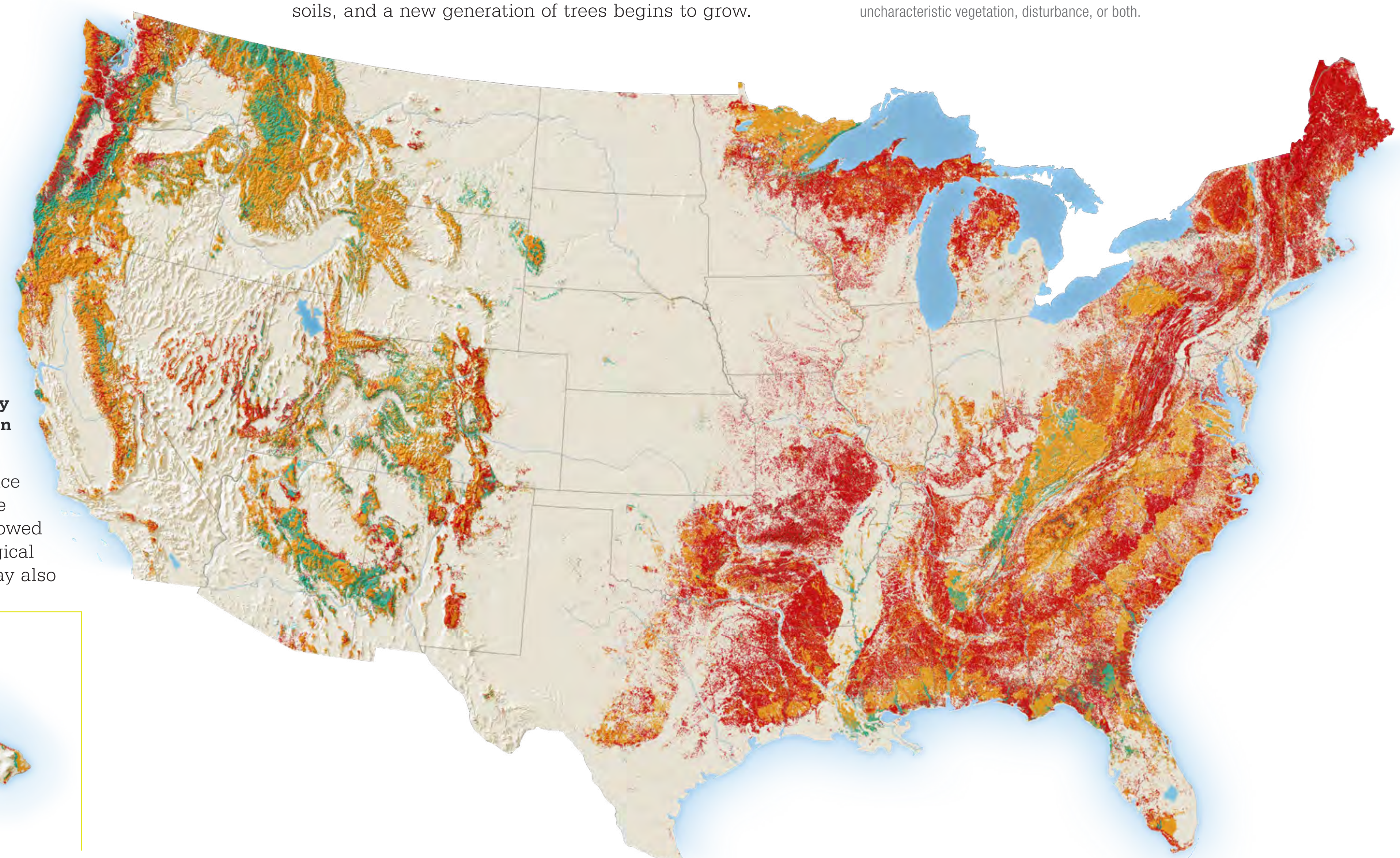




FIRE REGIME CONDITION CLASSES (FRCC)

- Class III - high departure/risk sites
- Class II - moderate departure/risk sites
- Class I - low departure/risk sites
- No data
- Nonforest



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 wildland fires 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.

HISTORY AND EVOLUTION A growing body of research shows that a century or more of fire suppression and exclusion has negatively impacted many ecosystems. These problems underscore the need for assessment tools to help fire managers interpret landscape condition and departure from the historical fire regime. This map shows fire regime groups, which were developed by the LANDFIRE project (www.landfire.gov) and characterize historical fire regimes within landscapes based on interactions between vegetation dynamics, fire spread, fire effects, and spatial context.

FIRE REGIME CONDITION CLASSES ARE GENERALIZED WILDFIRE RISK. They indicate departures from historical conditions in two categories: fire regime and vegetation. Noteworthy changes include fire frequency and severity, fuel composition, stand age, insect- and disease-induced tree mortality, and drought. Class I = low departure/risk sites within the natural or historic range of variation. Class II = moderate departure/risk sites departing slightly from the natural regime. Class III = high departure/risk sites with uncharacteristic vegetation, disturbance, or both.

PHOTOS: Many activities are associated with a modern fire management strategy that suppresses some fires, uses naturally occurring fires, and ignites fires. All of these approaches are applied to achieve management objectives consistent with the condition of the ecosystem involved, as well as the consideration of nearby communities.

Delimber

Tracker-feller-buncher

Logging truck

Debarked log deck

Dimensioning lumber

Limber mill

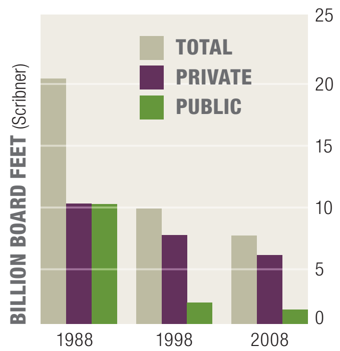
Providing Quality Wood Products While Sustaining Our Forests

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.

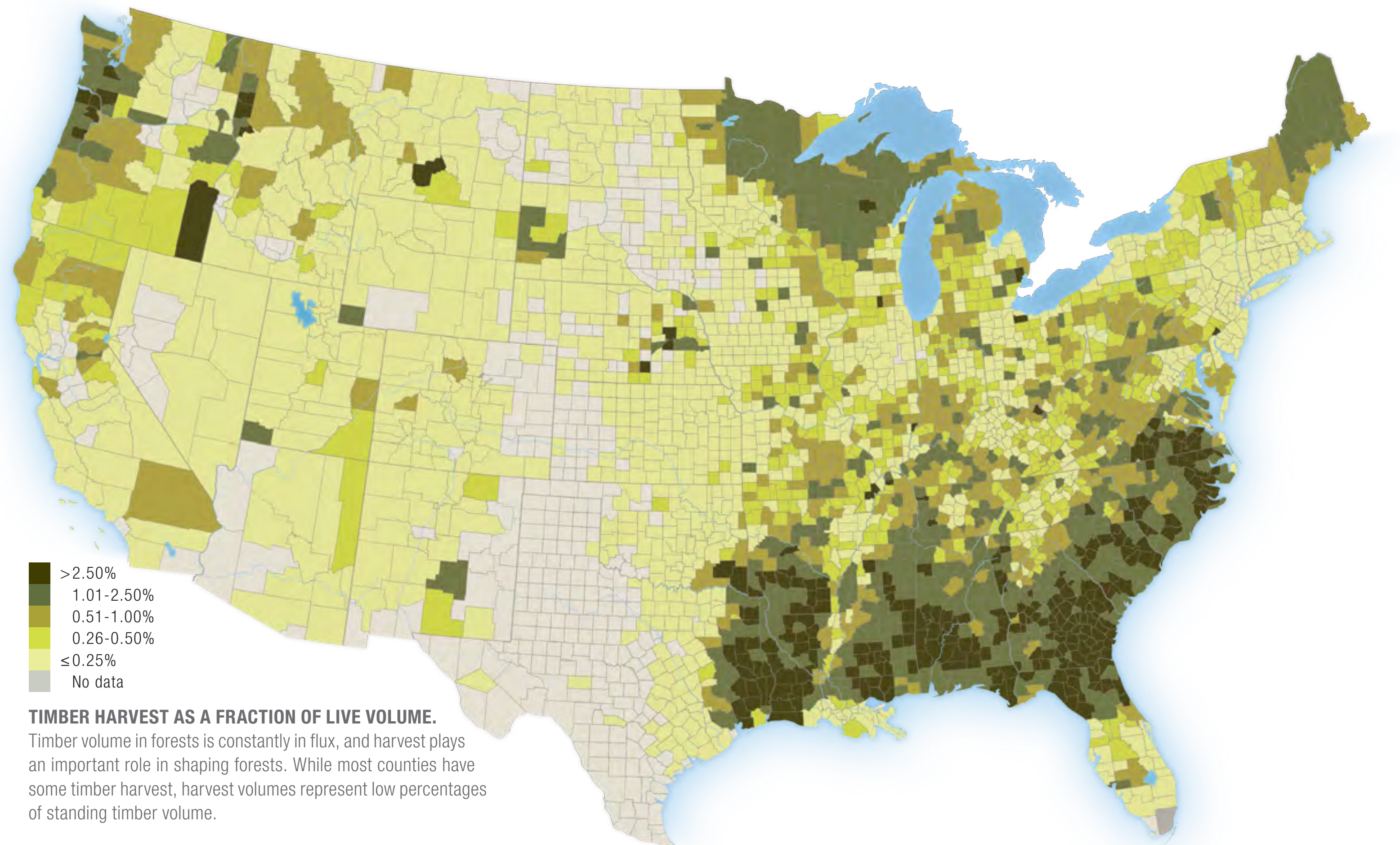
Harvesting timber (i.e., cutting trees) for wood products is an important forest management activity that shapes the forest. By selectively removing both live and dead trees from the forest, forest managers are better able to prescribe forest attributes and shape forests to meet the needs of current 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.

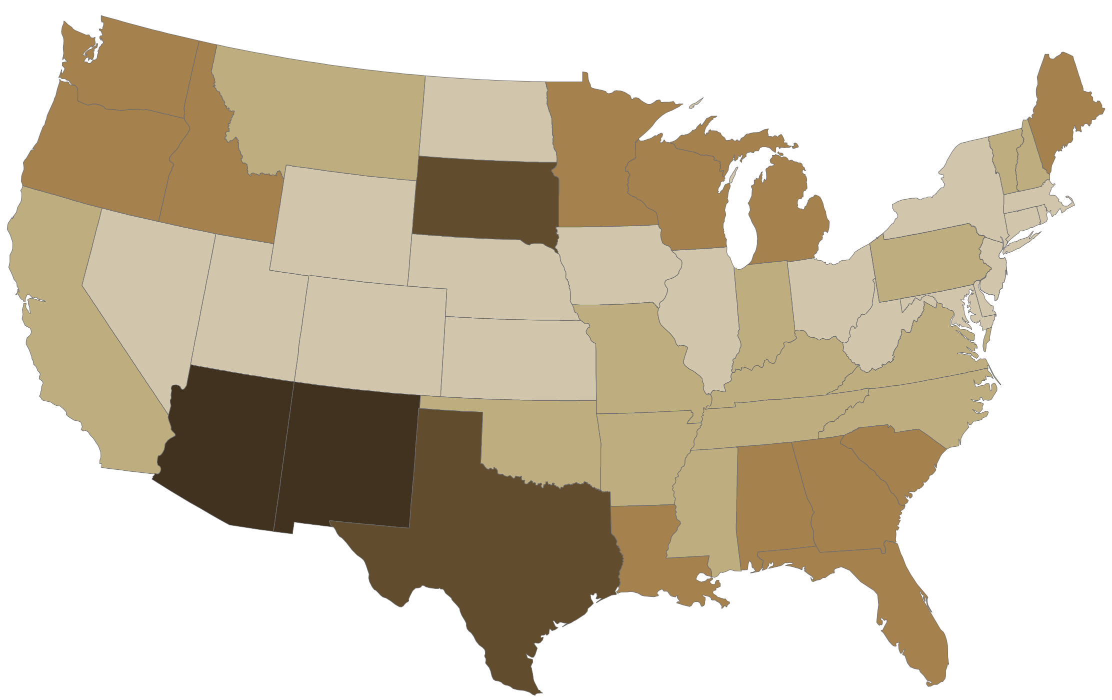
Trees are a renewable resource because they grow back after being harvested. Amongst a host of forest management goals and objectives, sustaining our forests includes carefully managing them so the sum of harvest and mortality levels does not exceed growth—this helps maintain the timber resource and 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 harvest levels dramatically decreased, but also the ownership mix of timber harvest has shifted increasingly from public to private lands.



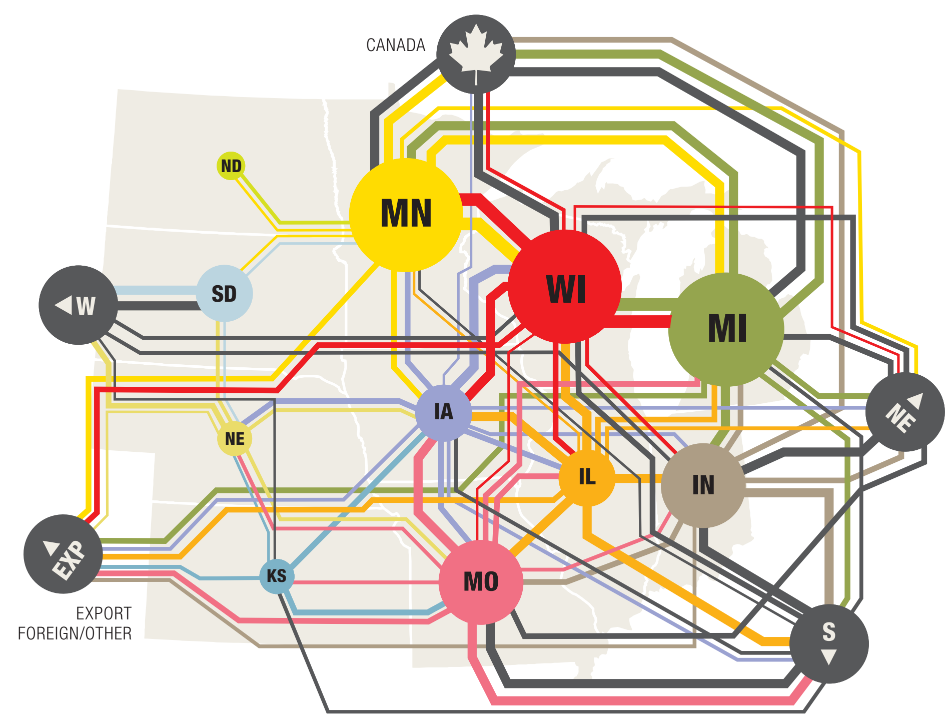
TIMBER HARVEST AS A FRACTION OF LIVE VOLUME. Timber volume in forests is constantly in flux, and harvest plays an important role in shaping forests. While most counties have some timber harvest, harvest volumes represent low percentages of standing timber volume.



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.

- >80%
- 61-80%
- 41-60%
- 21-40%
- ≤20%

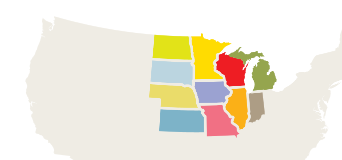
PHOTOS: Timber products from forest to marketplace. Timber is harvested from the forest, considering management objectives that may include but are not limited to improving forest health, maintaining wildlife habitat, and providing wood fiber for products. After being harvested, logs are processed and forwarded to log trucks. Log trucks deliver logs to manufacturing facilities, such as sawmills, where the logs are scaled, sorted, sawn, planed, and often kiln-dried to produce lumber that can be brought to market.



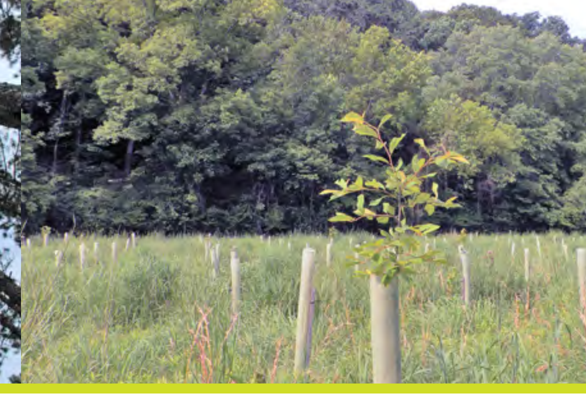
WOOD MOVEMENT IN THE UPPER MIDWEST. Timber is often processed and used far from where it was harvested. The depiction of timber flow in the Upper Midwest illustrates harvest levels and the movement of logs to mills. Clearly, timber is moving all over the region, and some logs are even shipped overseas. 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.

TOTAL HARVEST VOLUME: > 100,000; < 10,000

TIMBER FLOW (thousand cubic feet)
- > 10,000
- 1,001-10,000
- 101-1,000
- 11-100
- ≤ 10





Tree species reforestation, Douglas-fir

Meadow restoration, watershed maintenance, habitat improvements, ponderosa pine

Thinning and noxious weed removal to maintain healthy canopy cover, red pine

Tree species reforestation, American chestnut

Trail and road maintenance, loblolly pine

Prescribed burning, slash pine

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.

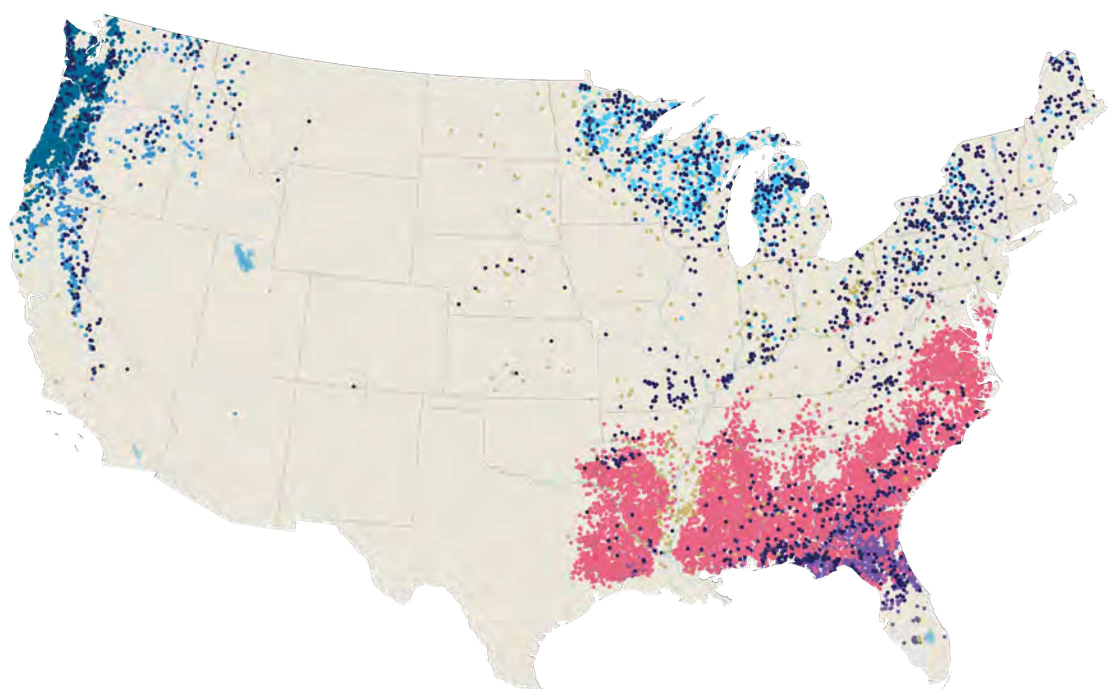
Trees do not live forever, and attention to establishing the next generation is critical. Forests regenerate two ways, naturally and artificially. Natural regeneration relies upon seeds, seedlings, and sprouts from the harvested or adjacent forest. Artificial regeneration, primarily planting, results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

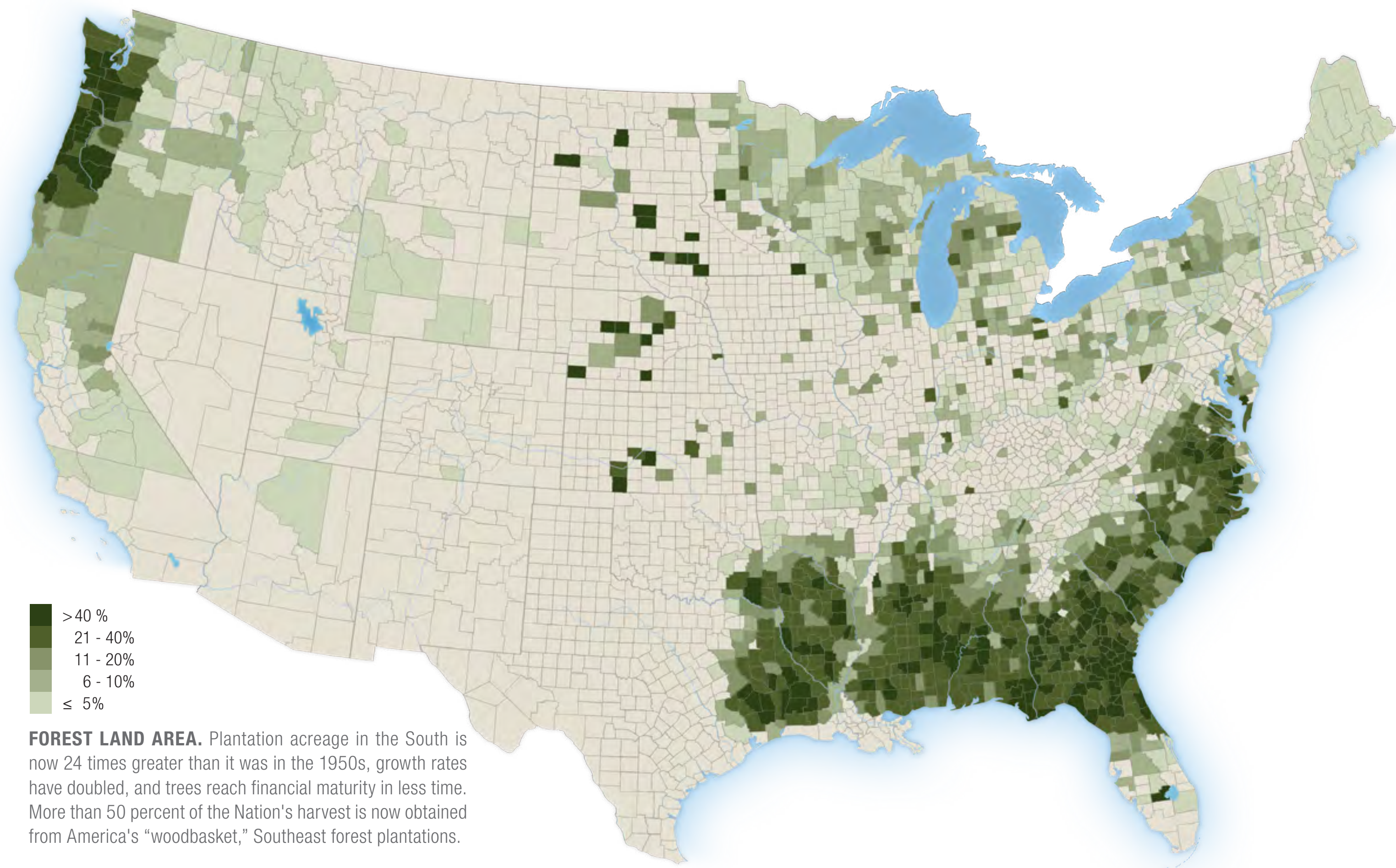
Thirty percent of the world's forests are primarily used for production of wood and nonwood forest products. The area of planted forests is increasing and now accounts for 7 percent of total forest area globally. In the United States, planted forests account for about 9 percent of all forests (or 13 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.

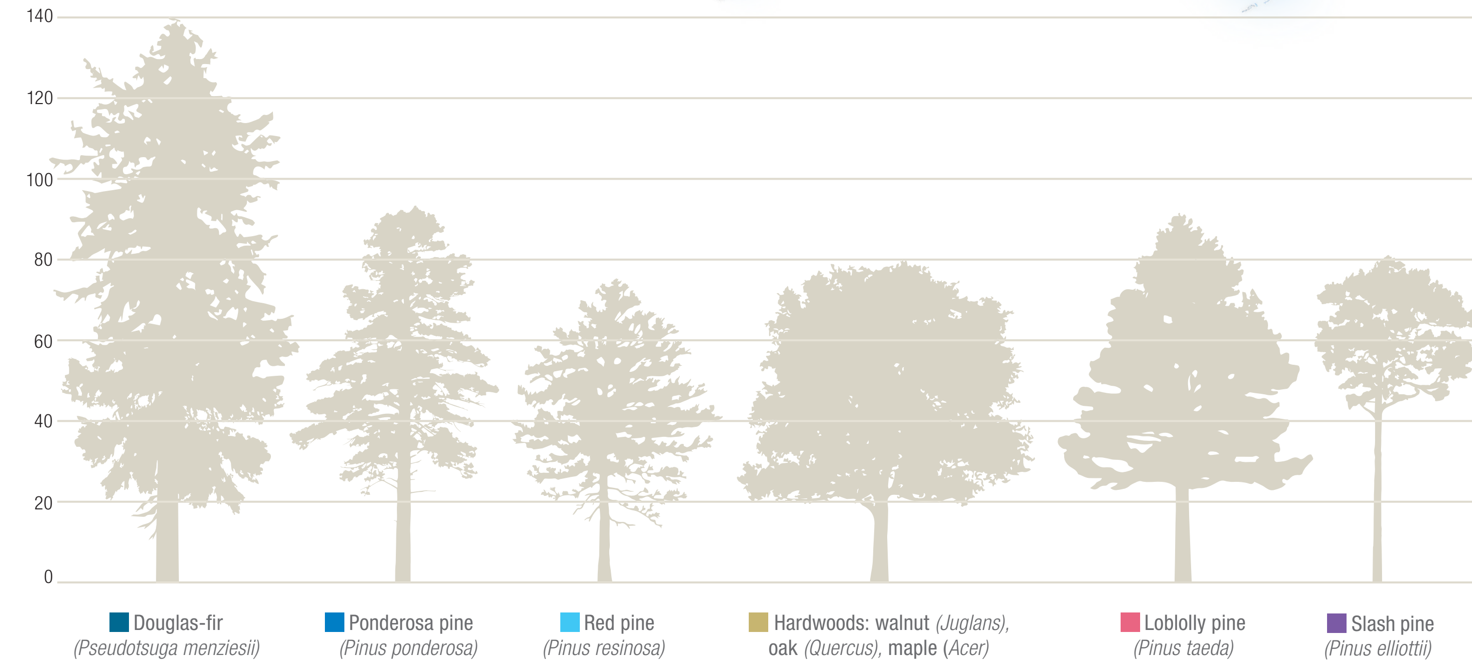


PLANTED FOREST STANDS. Planted forests in the United States are primarily initiated by the planting of small seedlings grown in nurseries and planted as bare-root stock or containerized seedlings. The most common planted species are loblolly pine and slash pine in the South, red pine in the North, ponderosa 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 managed to provide particular kinds of wildlife habitat. Nursery 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.

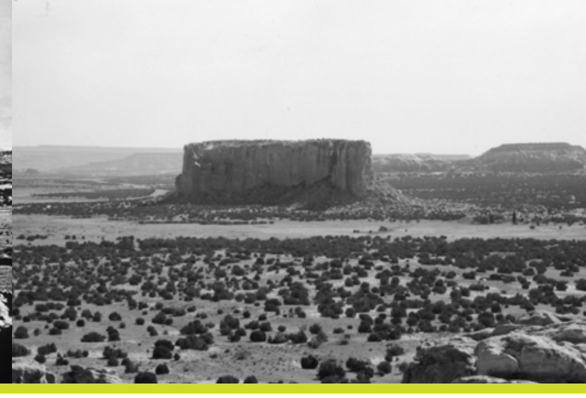


FOREST LAND AREA. Plantation acreage in the South is now 24 times greater than it was in the 1950s, growth rates have doubled, and trees reach financial maturity in less time. More than 50 percent of the Nation's harvest is now obtained from America's "woodbasket," Southeast forest plantations.



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 minimizing 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 longleaf pine and shortleaf pine are gaining attention as managers attempt to save these species.

Acoma Pueblo, New Mexico 1899



Acoma Pueblo, New Mexico 1977

Ross Hole, Montana 1895

Ross Hole, Montana 1980

Mountaintop coal mining, Magoffin County, Kentucky 2008

Mountaintop coal mining, Magoffin County, Kentucky 2013

Our Changing Forests

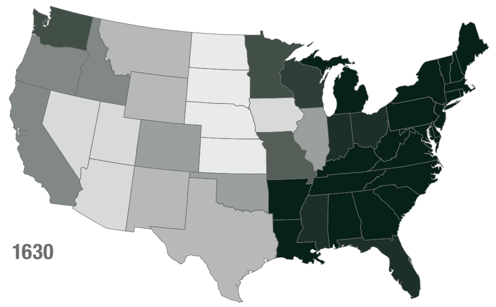
Human activities affect the area of land covered by forests and the condition of those forests. For centuries, forests have been cleared for agriculture, industrial uses, and urban development. In the past 80 years, however, forests have returned in areas through active reforestation, suppression of 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.

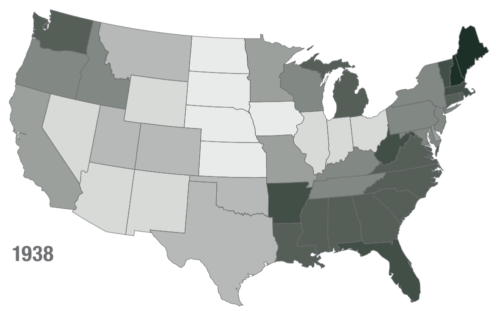
Before the arrival of Europeans, Native Americans used forests as a source of building material, fuel for heat and cooking, and a place for hunting and gathering food. For example, there is evidence that Native Americans used fire to alter the extent and composition of forests in ways that assisted with 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 1600s, 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 through tree-planting 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.

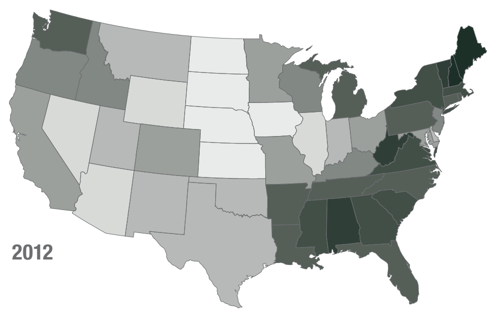
Field-based inventories of forest land are used to quantify the status and trend of the Nation's forest land line in the Forest Service's Resource Planning Act (RPA) assessment. The most recent RPA report shows that, in the United States, forest land area continues to expand. The report also highlights the regional differences in forest land area, ownership, biomass distribution, and wood utilization.



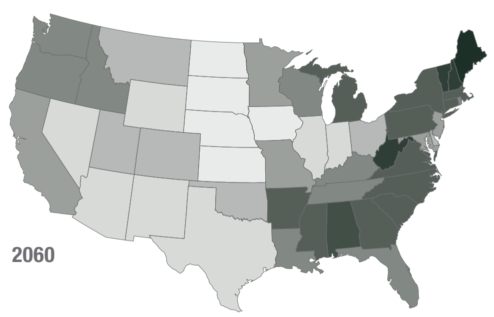
1630



1938

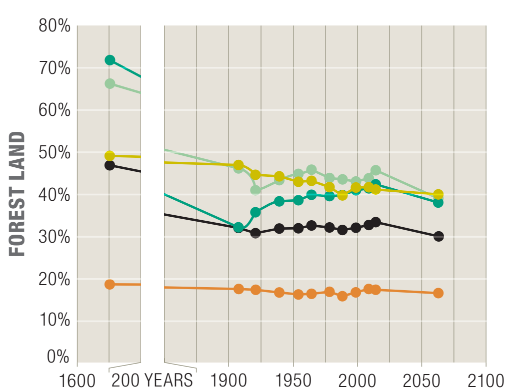


2012



2060

>90%
81 - 90%
71 - 80%
61 - 70%
51 - 60%
41 - 50%
31 - 40%
21 - 30%
11 - 20%
≤ 10%



PACIFIC COAST
ROCKY MOUNTAIN
SOUTH
NORTH
LOWER 48

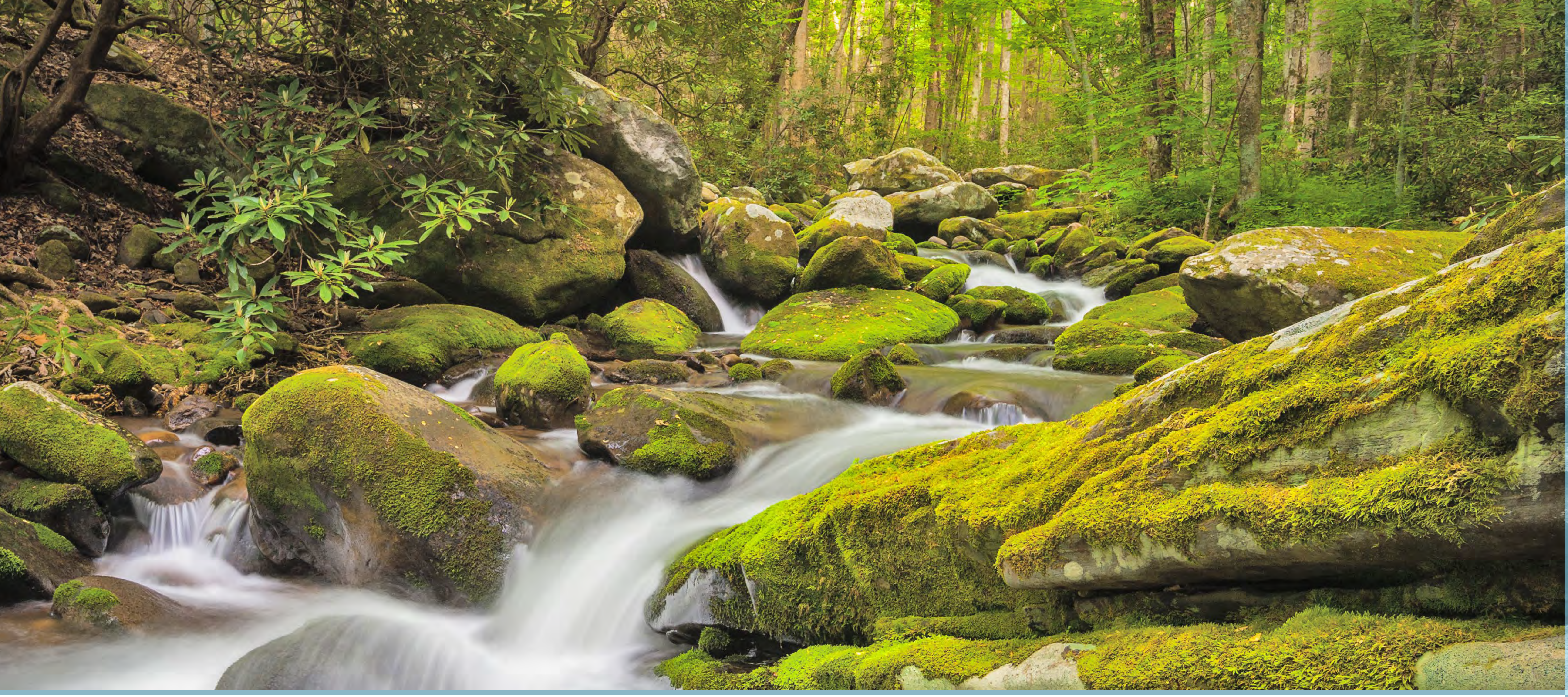
TRENDS IN FOREST LAND. Over the past 380 years, the amount of forest land in the conterminous United States has been variable. For the first 300 years of this history, the trend in all regions of the country was negative, with the largest declines in the Northern region. Over the past 80 years, however, 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 26 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, once 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 2016 Landsat satellite imagery while Alaska and Hawaii were created using circa 2011 imagery. The database for Puerto Rico was created using circa 2001 imagery.

Open water
Perennial ice/snow
Developed, open space
Developed, low intensity
Developed, medium intensity
Developed, high intensity
Barren land
Forest, deciduous
Forest, evergreen
Forest, mixed
Dwarf scrub
Shrub/scrub
Grassland/herbaceous
Sedge/herbaceous
Lichens
Moss
Pasture/hay
Cultivated crops
Woody wetlands
Emergent herbaceous wetlands

PHOTOS: Forest land expands and contracts for a variety of reasons. The expansion of woodlands in Acoma Pueblo, NM, and Ross Hole, MT, is due to fire exclusion and reduced logging and grazing. In contrast, Magoffin County, KY, lost forest land to mountaintop coal mining.



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





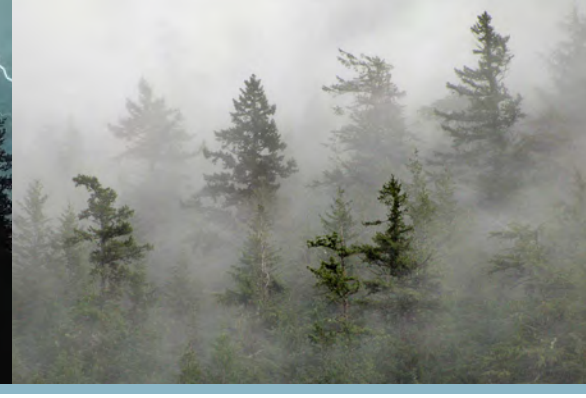
trees result in $2.0 billion per year in reduced building energy consumption.

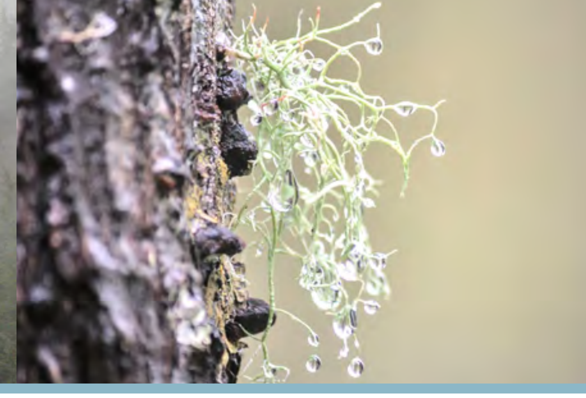
Many nature-based recreational opportunities are often associated with forests. Whether in national forests, city parks, or private woodlots, forests are places where we go to seek refuge from daily stresses and to picnic, hike, bike, hunt, fish, and generally relax in a natural setting.

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.

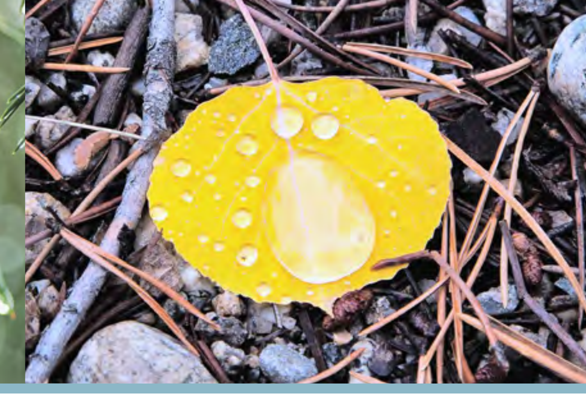
FORESTS PROVIDE VALUABLE GOODS AND SERVICES. The Millennium Ecosystem Assessment offered three categories of direct goods and services. Many of these are "public goods," meaning the benefits are shared with more than just the landowner. First, we obtain many products from forests (e.g., food, fiber, 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.

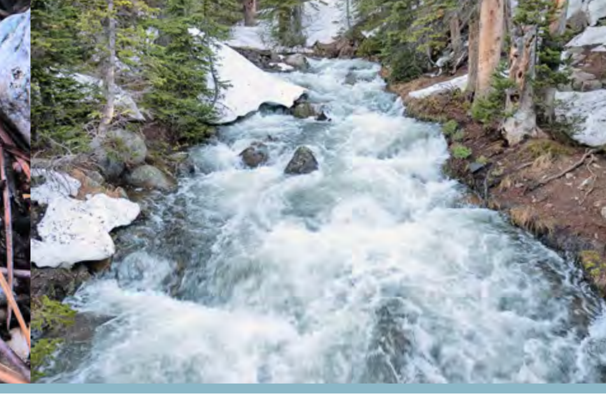

Rainfall on forest


Leaf interception


Stemflow


Throughfall


Infiltration / forest floor

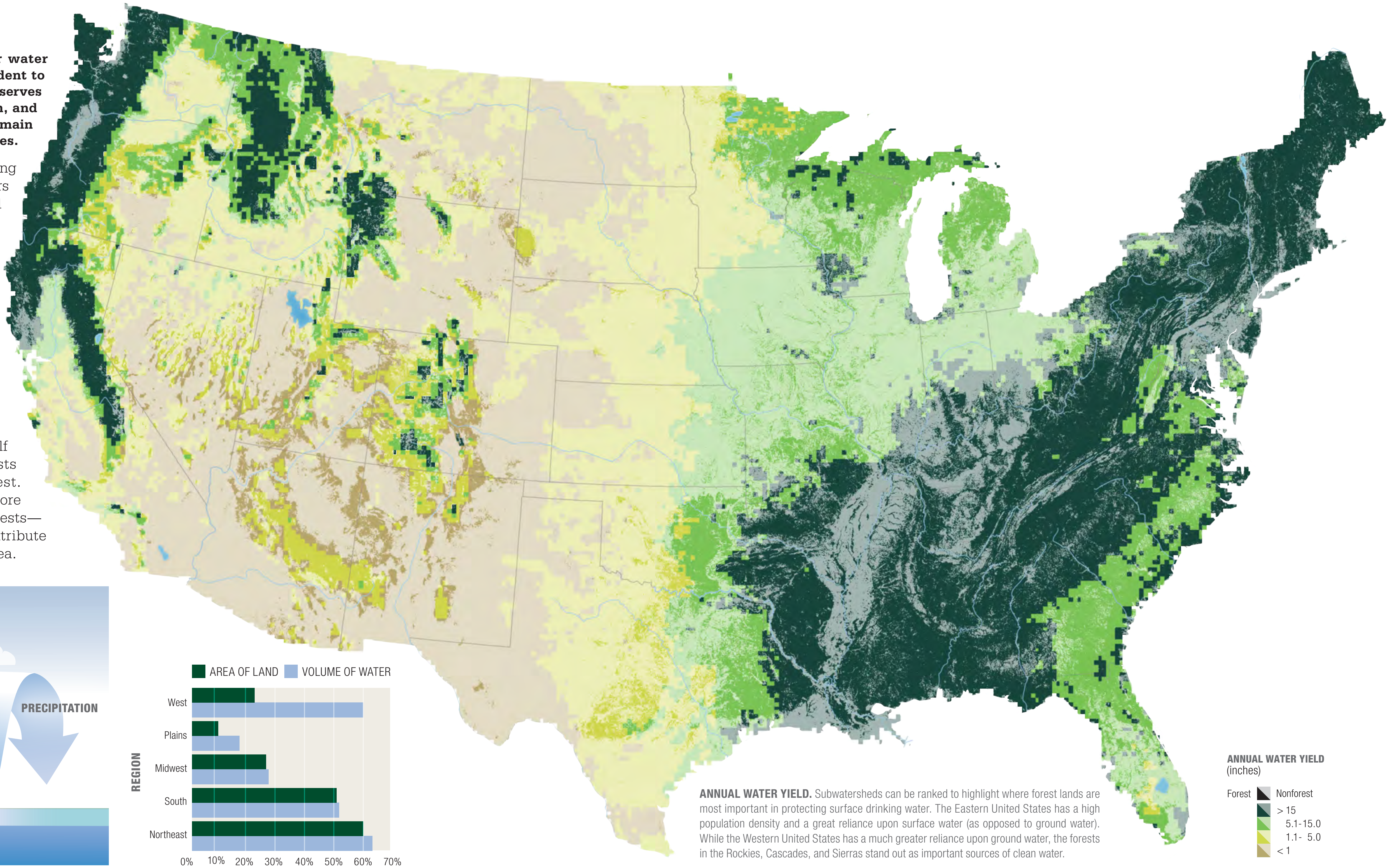

Streamflow

Clean Water

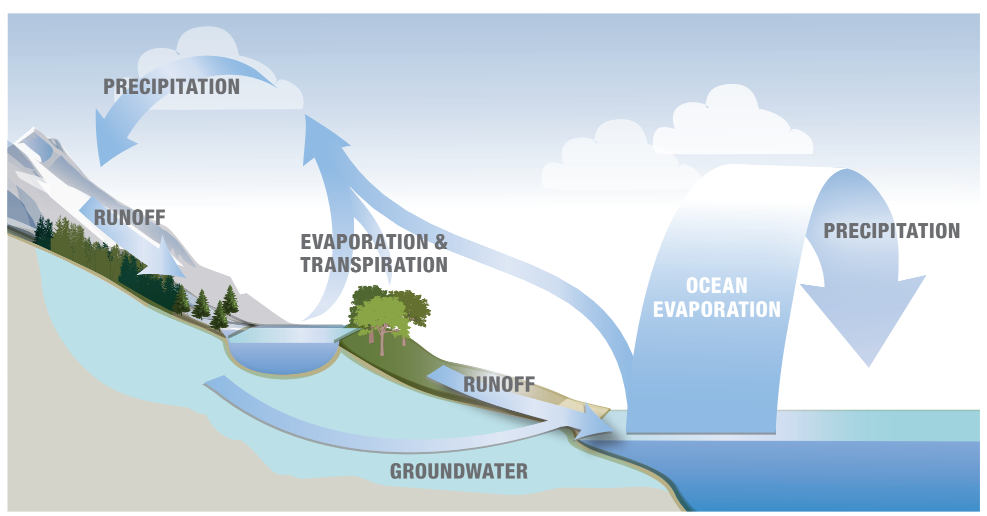
Forests have long been recognized as critically important for water supply. While the Forest Reserve Act of 1891 allowed the President to establish forest reserves, the Organic Act of 1897 provided that reserves would be established for forest protection, watershed protection, and timber production. 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 29 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.



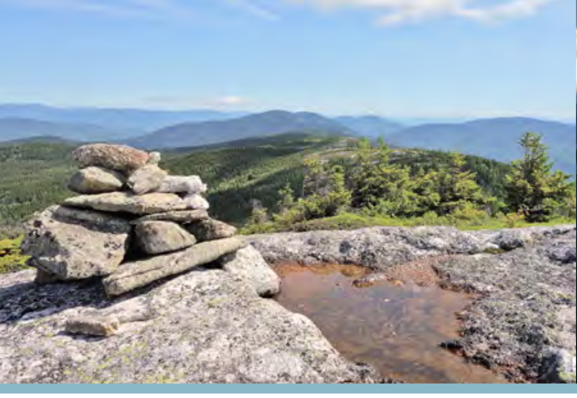
ANNUAL WATER YIELD. Subwatersheds can be ranked to highlight where forest lands are most important in protecting surface drinking water. The Eastern United States has a high population density and a great reliance upon surface water (as opposed to ground water). While the Western United States has a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



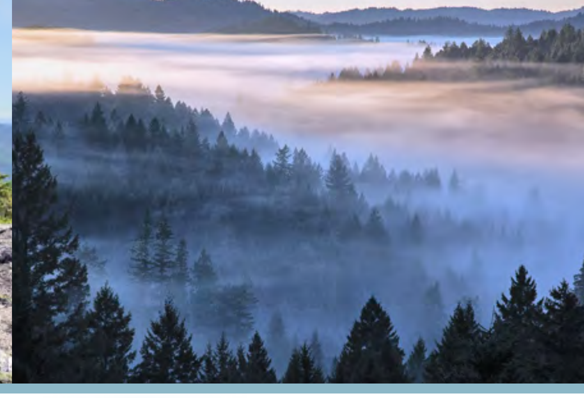
WATER IS CONNECTED BY THE HYDROLOGIC CYCLE. Water moves between the atmosphere, landscapes, rivers and lakes, and oceans in processes and pathways known as the hydrologic cycle. Forests influence the cycle in profound ways. Through evapotranspiration, trees use water from the soil and facilitate evaporation 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.

PHOTOS: Forests interact with rainfall in many ways before it reaches streams. Leaves catch raindrops, and some evaporate back into the atmosphere. Some rain runs down the trunk of the tree. Other raindrops fall through the forest canopy. Once on the forest floor, the rain seeps into the soil before it emerges again as streamflow.



1990, Caribou-Speckled Mountain Wilderness, New Hampshire, USFS



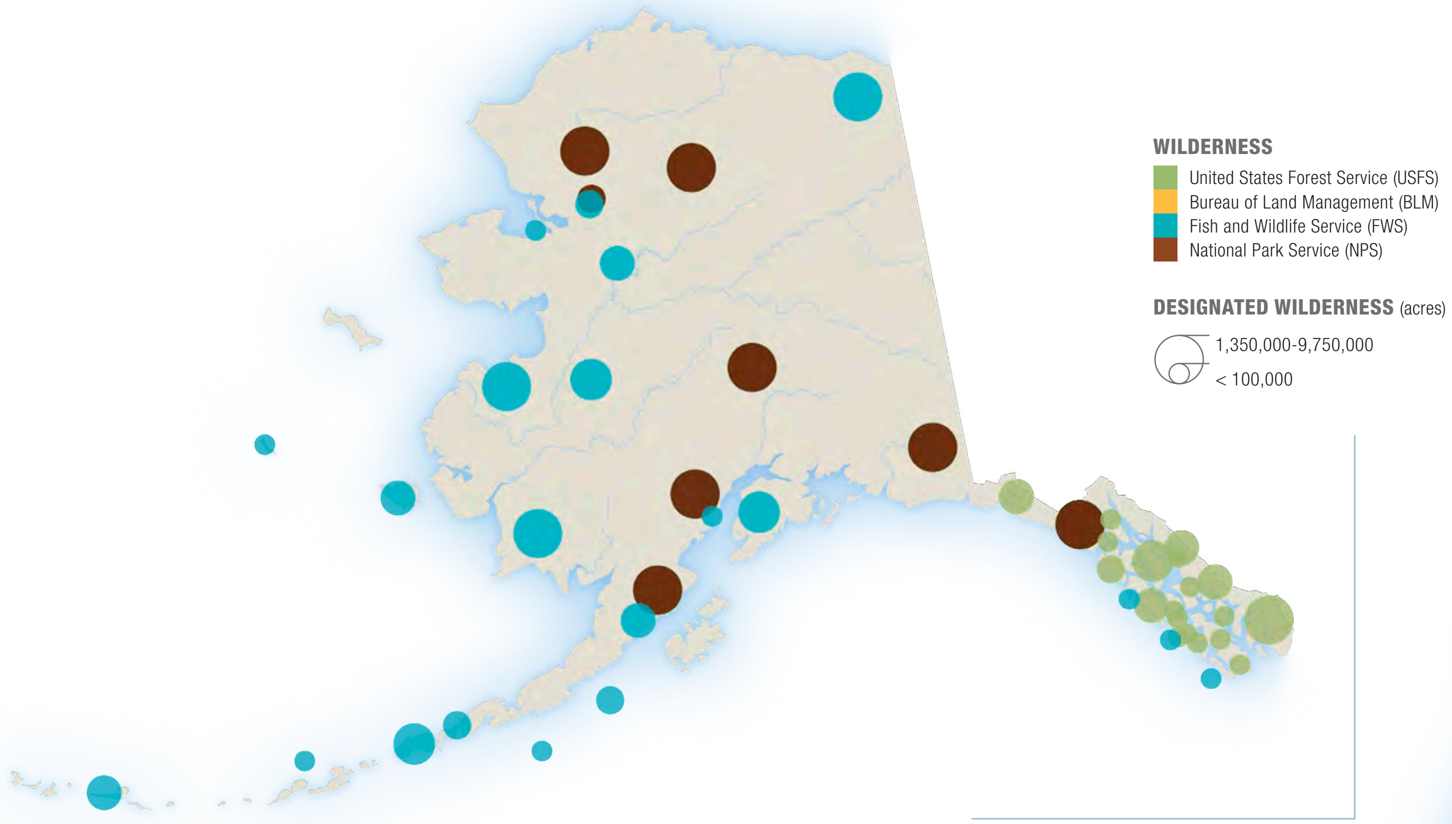
2006, Kings Range Wilderness, California, BLM

1970, Wichita Mountains Wilderness, Oklahoma, FWS

1980, Wrangell-St. Elias Wilderness, Alaska, NPS

1970, Pelican Island Wilderness, Florida, FWS

1924, Gila Wilderness, New Mexico, USFS



Wilderness

Designated wilderness in the United States 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.

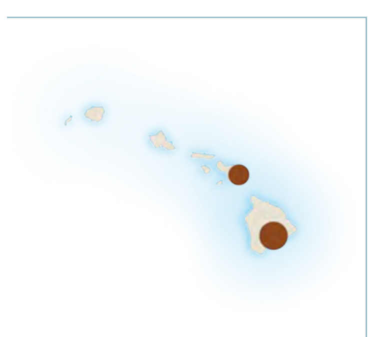
The goal of wilderness is to set aside landscapes "for the use and enjoyment of the American people in such manner as will leave them unimpaired for future use and enjoyment as wilderness…"

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 condition… 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).

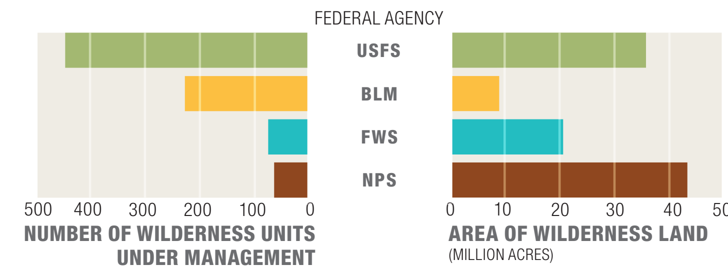


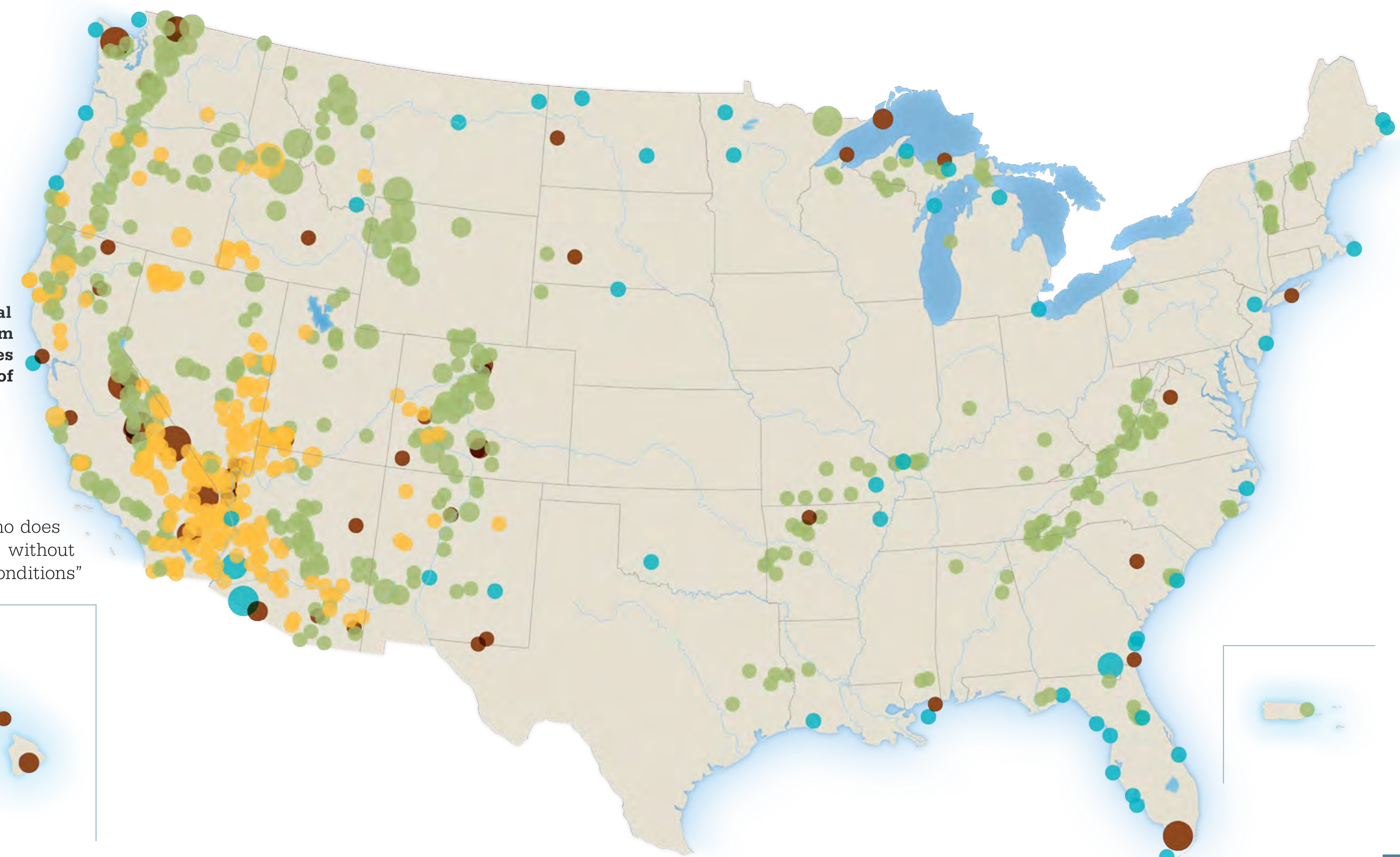
PHOTOS: Wilderness areas are designated by the Congress to protect a wide variety of values. While many wildernesses are famous for their beautiful landscapes, they also serve as critical wildlife habitat, laboratories on the natural world, and opportunities to preserve our important cultural heritage. They range in size from massive mountain reserves to a single island.

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."

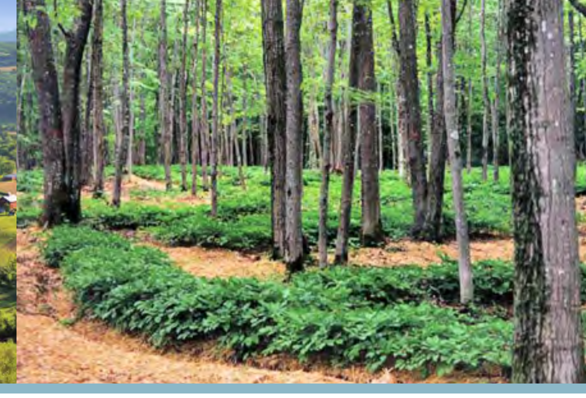
DESIGNATED WILDERNESS PROTECTS A BROAD RANGE OF ECOSYSTEMS FROM HIGH MOUNTAIN PEAKS TO DESERTS TO WETLANDS. Alaska has 52 percent of the Nation's total wilderness acreage. The largest wilderness is Wrangell-St. Elias Wilderness in Alaska at approximately 9 million acres; Pelican Island Wilderness in Florida is the smallest at 6 acres. The distribution of wilderness by agency is broadly reflective of the pattern of lands administered by these agencies.





Silvopasture

Riparian forest buffers



Forest farming

Special applications

Alley cropping

Windbreaks

Agroforestry

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.

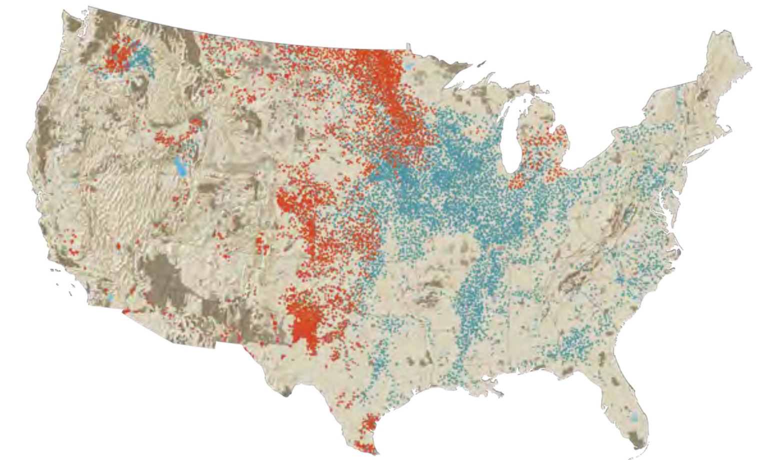
Agroforestry is the intentional integration of trees and shrubs into crop and animal production systems to create environmental, economic, and social benefits. Farmers have implemented these practices in the United States and around the world for centuries.

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.

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 onsite impacts to soil quality and crop productivity and off-site 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 vegetative cover.

EROSION SITES
(100,000 tons per year)
- Wind
- Water
- Federal land

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.

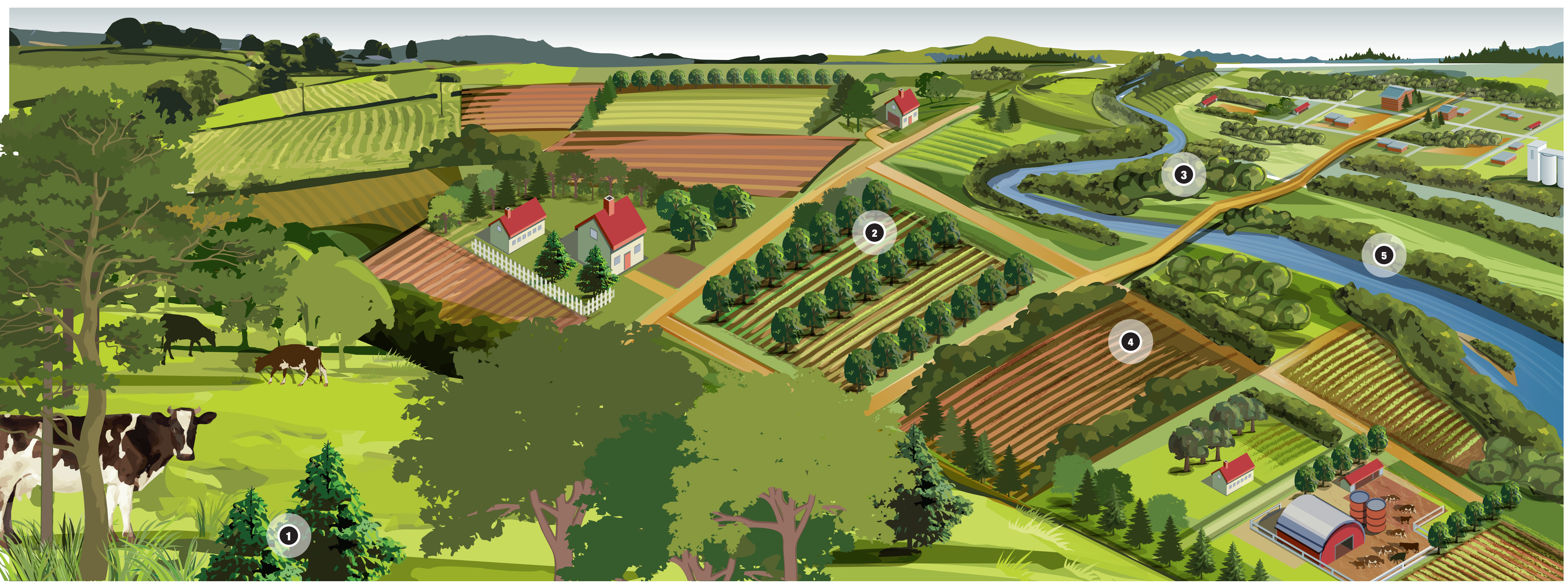
2. ALLEY CROPPING SYSTEMS. In this practice, widely spaced rows of high-value trees create alleyways for agricultural crops that benefit both the trees and crops, create annual and long-term income, and provide conservation benefits.

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 windspeed and improve crop yields, reduce soil erosion, improve water efficiency, protect livestock, and conserve energy.

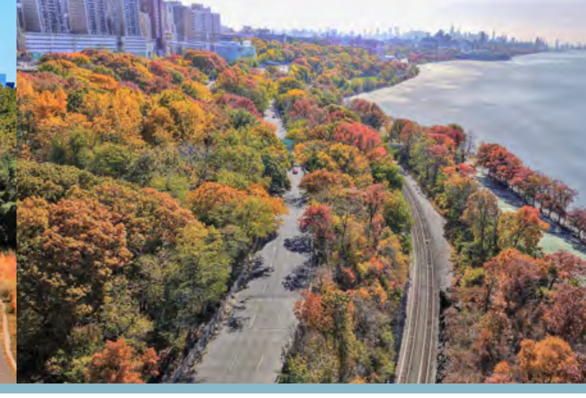
5. RIPARIAN FOREST BUFFERS. Trees, shrubs, and grasses planted alongside streams reduce water pollution and bank erosion, protect aquatic environments, and enhance wildlife habitat.

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.




Residential district, Fort Collins, Colorado


Cedar Lake Trail runs from the west suburbs to downtown Minneapolis, Minnesota


Henry Hudson Parkway to Manhattan, New York


Gathering under a live oak, Audubon Riverview Park, New Orleans, Louisiana


Community tree planting, New York City


Transit Mall, Portland, Oregon

Urban Forests Provide Benefits Where We Live

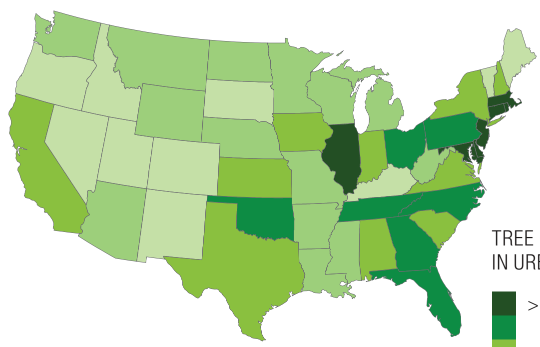
More than 80 percent of Americans now reside in urban areas. Trees found within these areas provide numerous benefits to society that affect human health and well-being. These benefits are valued in the billions of dollars annually across the United States. As urban lands continue to expand, managing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

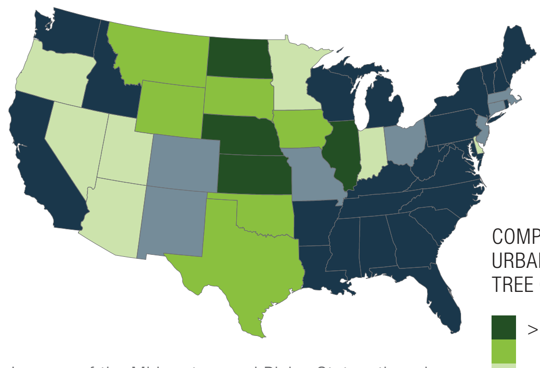
Urban and community areas—including cities, their suburbs, and towns—in the conterminous United States occupy 121 million acres of land, which is larger than California, and house more than 80 percent of the U.S. population. This area increased by 18 million acres between 2000 and 2010, an area larger 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.

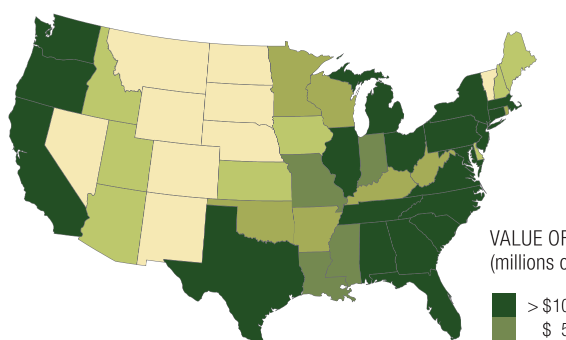
BENEFITS OF URBAN TREE CANOPY COVER



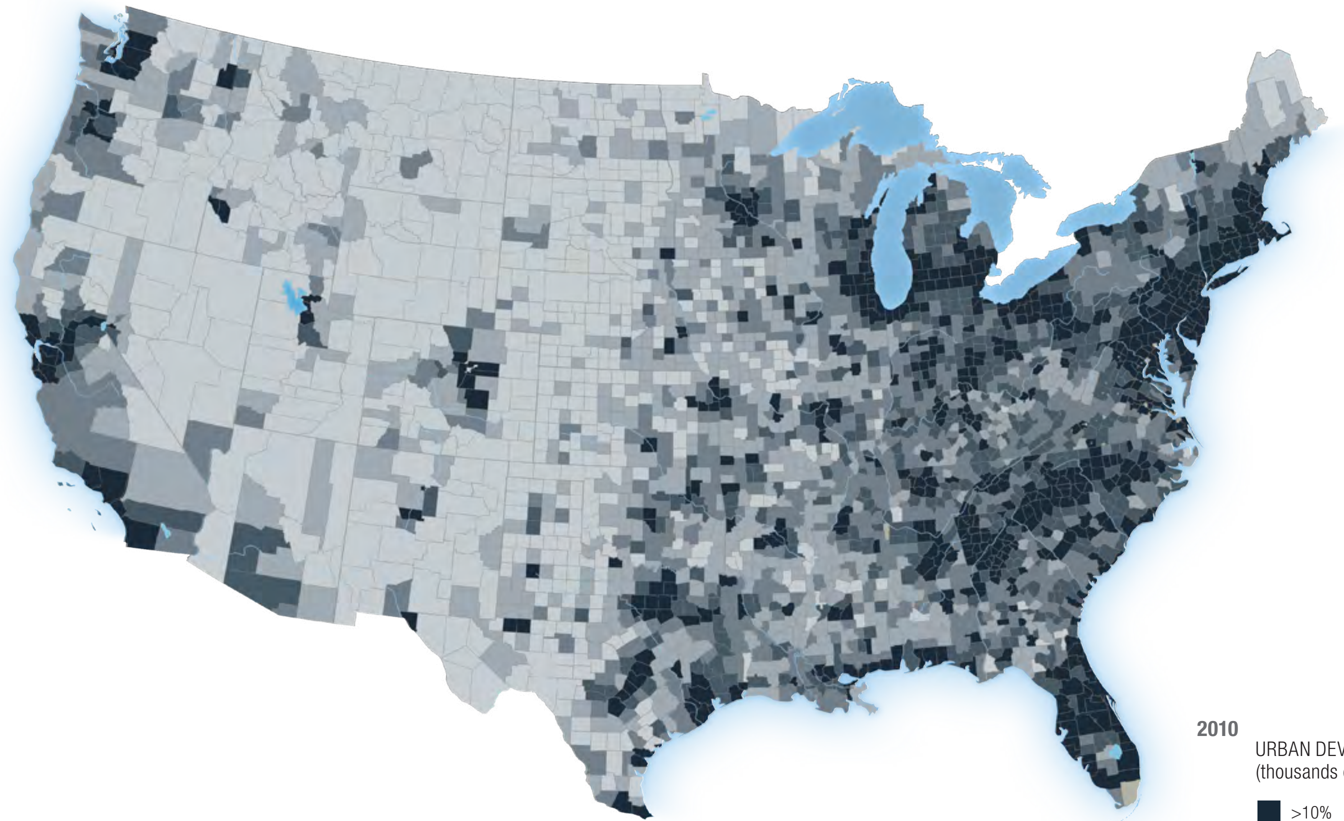
Urban and community tree cover provides greater than 10 percent of the States' total tree cover in several States.



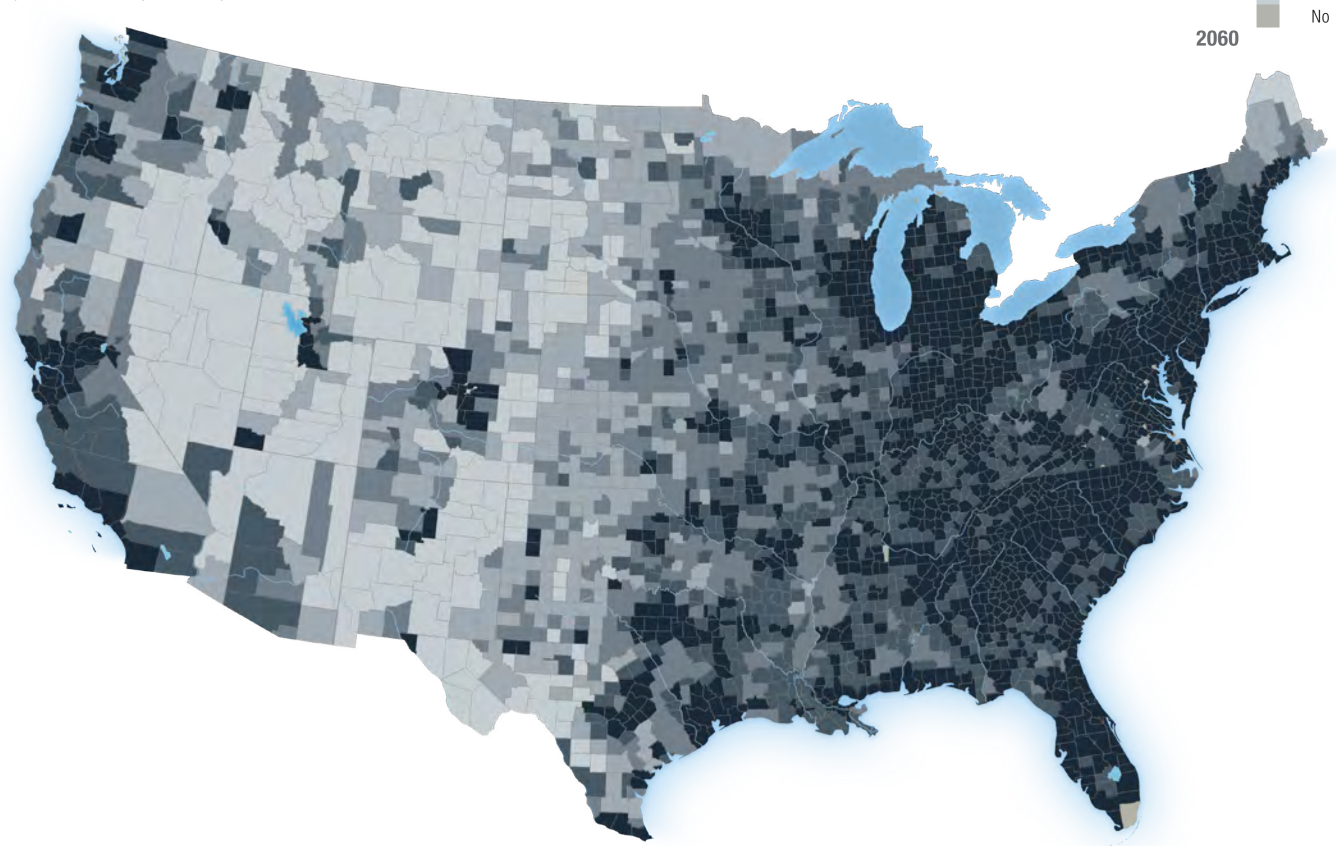
In many of the Midwestern and Plains States, there is a greater proportion of treed land in urban and community areas than in rural landscapes.



The contribution of these urban forests to pollution removal adds up to billions of dollars.



PERCENTAGE OF URBAN COUNTY LAND 2010, 2060 Just under 5 percent of land in the United States was classified as urban or developed in 2010. This amount is expected to jump to 8.5 percent by 2060 as urban areas expand to accommodate the Nation's growing population, making urban forests even more important than they are today.

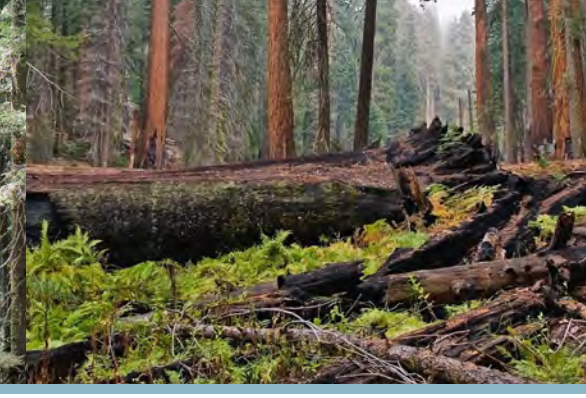


Vehicle emissions: 1,821 million metric tons of CO_2 Eq. (MMT) annually

Electrical power generation: 1,753 MMT annually

Refrigeration and air conditioning: 129 MMT annually

Aboveground live carbon: 54,960 MMT



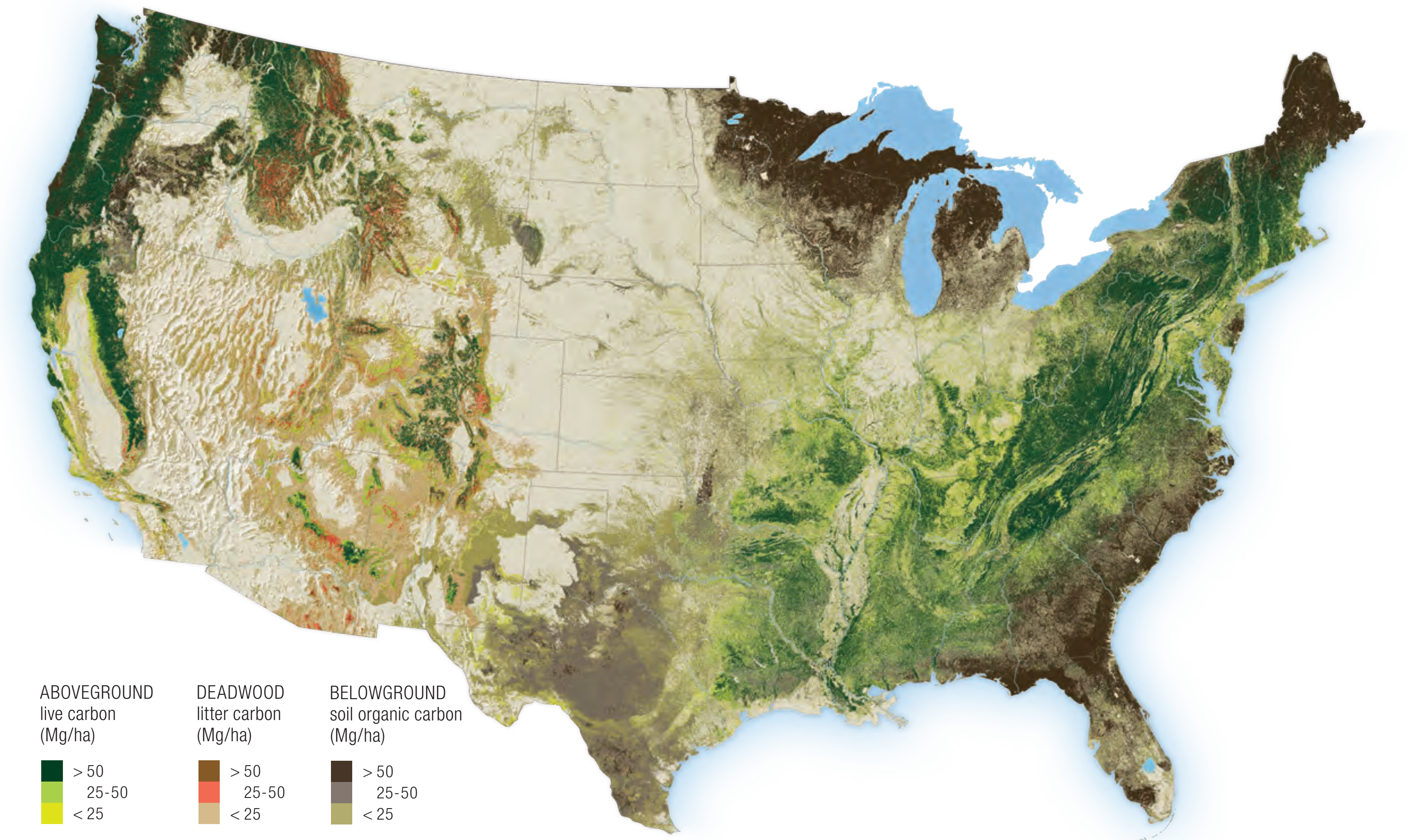
Deadwood and litter carbon: 23,530 MMT

Belowground live and soil organic carbon: 127,000 MMT

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.



ABOVEGROUND live carbon (Mg/ha)
- > 50
- 25-50
- < 25

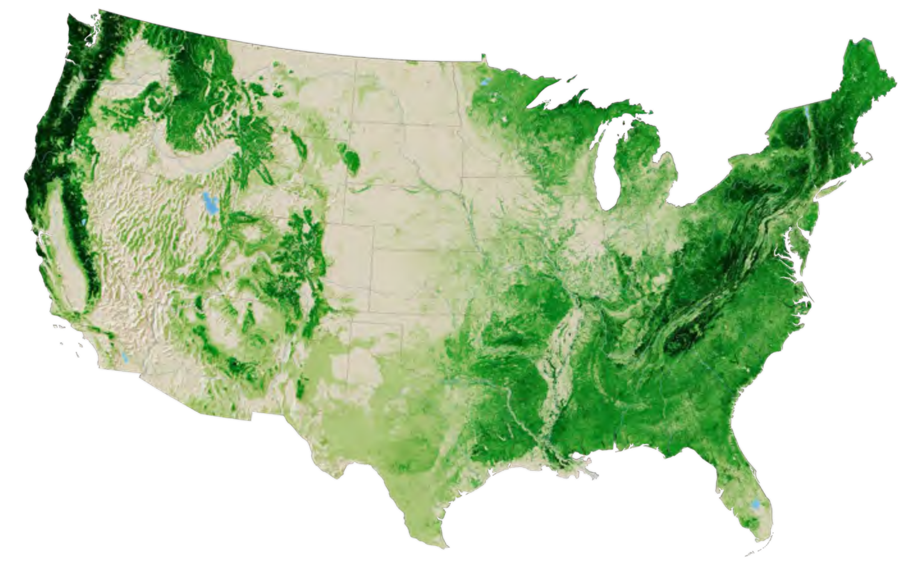
DEADWOOD litter carbon (Mg/ha)
- > 50
- 25-50
- < 25

BELOWGROUND soil organic carbon (Mg/ha)
- > 50
- 25-50
- < 25

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) living biomass (aboveground, belowground, and understory), (2) deadwood and forest floor (including standing dead, down dead, and forest floor), and (3) soil organic carbon.

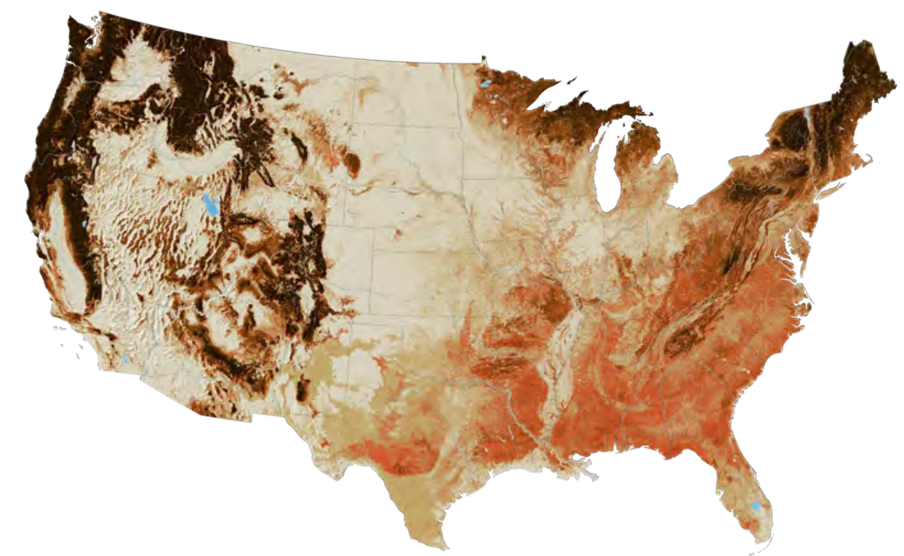
ABOVEGROUND LIVE CARBON STOCKS. Aboveground live biomass in forests often consists of both live trees and understory vegetation, thus a diverse array of flora that constitutes the largest portion of total forest carbon stocks in many areas of the United States.

ABOVEGROUND live carbon (Mg/ha)
- > 75
- 51-75
- 26-50
- 11-25
- 5-10



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.

DEADWOOD litter carbon (Mg/ha)
- > 25
- 21-25
- 11-20
- 6-10
- 1-5



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.

BELOWGROUND soil organic carbon (Mg/ha)
- > 60
- 41-60
- 21-40
- 11-20
- 1-10

Interior decor

Construction

Charcoal

Shampoo

Diapers

Television screen

Wood Products in Everyday Life

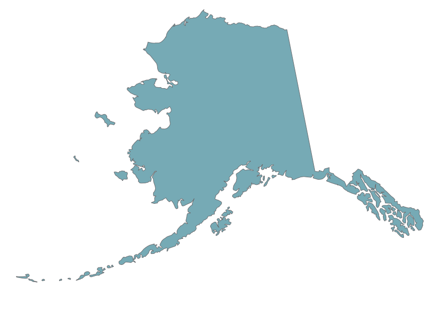
Nothing can better illustrate our Nation's dependence on wood than examining how often wood is used for a surprising number of purposes. From firewood, to paper, to building materials, to energy utilities, to furniture, even televisions and food flavorings and fragrances, Americans use a lot of wood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

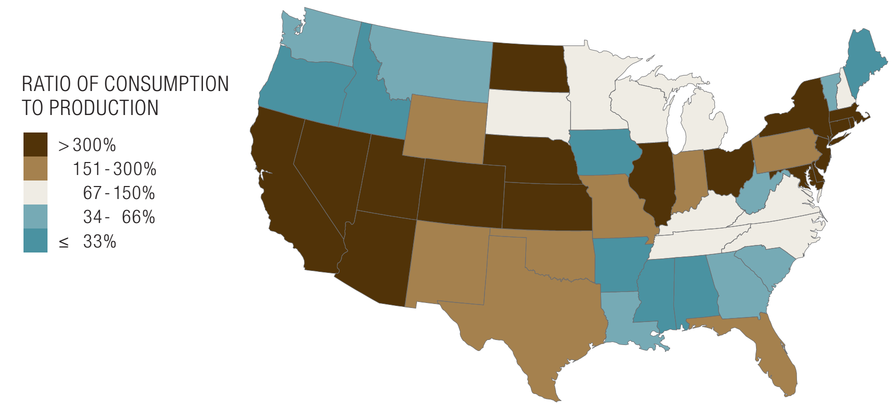
On average, we have been building more than 1 million new single-family homes each year for more than 40 years. The last 10 years, however, have been a very dynamic period for wood use in the United States. With the Great Recession of 2007–2009 and collapse of new home building, the number of homes built 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.

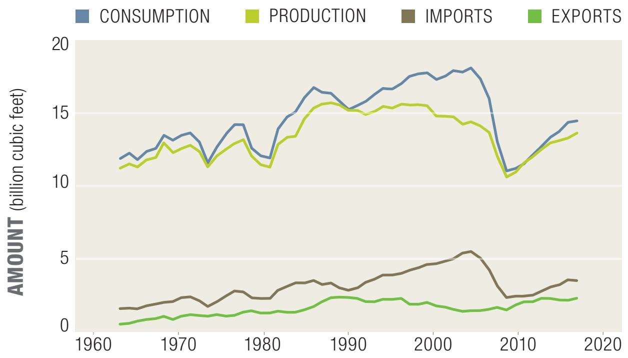
Wood is a major input in construction, and this is especially the case with residential homes, which are commonly framed with dimensional lumber and have many wood finishes throughout their interior. Wood products used in construction are a product of harvesting timber and managing our forests. To put 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.



PRODUCTION, CONSUMPTION, AND IMPORTS AND EXPORTS OF WOOD PRODUCTS AT THE STATE LEVEL. Based on United States per capita wood products consumption, it is clear that many States produce (harvest) more wood than they consume, while others consume significantly more wood than they produce. Nationwide, the United States as a whole is a net consumer of wood products, with nearly 2 billion cubic feet of the wood and paper we use annually coming from outside the country.



PRODUCTION, CONSUMPTION, AND IMPORTS AND EXPORTS OF WOOD PRODUCTS AT THE NATIONAL LEVEL. Domestic production and consumption of wood products are linked directly to imports and exports of wood products. When consumption exceeds production, imports must exceed exports. The margin between imports and exports grew from 1990 until the housing market collapse and the Great Recession of 2007–2009, which brought U.S. consumption much closer to the level of U.S. production.



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 toiletries 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 several food and cosmetic ingredients, and even liquid-crystal-display (LCD) television screens, also use wood in their manufacturing processes.

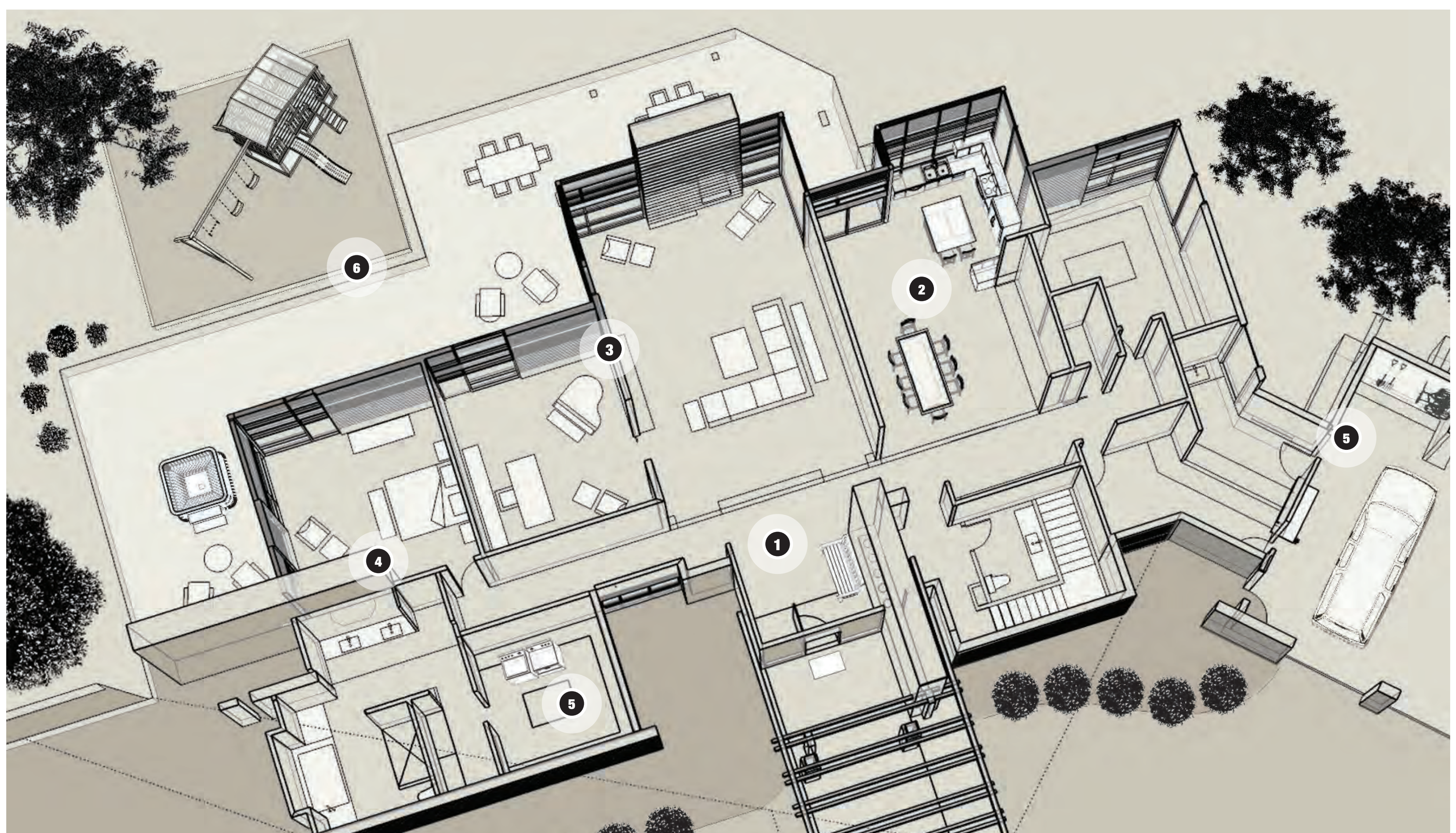
■ Solid wood products may be the most iconic and recognizable of the wood products we use, including products such as lumber, log homes, dining room tables, flooring, and picture frames.

■ 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.

HOUSE ■ Roof, plywood sheathing, wainscoting, window frames, door jams, floors, staircase, log homes. ■ Carpet backing. ■ Electricity, linoleum, rubber door mat.

1. ENTRYWAY ■ Door, bench, coat rack, umbrella handle, clogs. ■ Coats, sandals. **DECOR** ■ Picture frames, grandfather clock, bonsai trees, decorative foliage, wreath, Christmas tree. ■ Textiles. ■ Candles.



2. DINING ROOM ■ Dining table, chairs, china cabinet or hutch, salad bowl, serverware. **KITCHEN** ■ Cutting board, rolling pin, toothpicks. **FOOD** Nuts, fruits, berries, mushrooms, maple syrup, honey, vanilla, allspice, annatto, bay leaves, cinnamon, cloves, mace, nutmeg, sassafras oil. ■ Cork, cartons, cardboard food boxes, sugar/flour bags, paper towels, napkins, coffee filters, tea bags, wax paper, candy wrappers. ■ Liquid smoke, crackers, grated cheese.

3. LIVING/FAMILY ROOM ■ Entertainment center, coffee table, rocking chair, firewood. ■ LCD screens, upholstery backing, magazines, newspaper. **HOME OFFICE/STUDIO** ■ Desk, chair, bookcase, musical instruments, pencils. ■ Printer paper, corkboard.

4. MASTER BEDROOM ■ Bedframe, dresser, bedside table, mirror frame, cedar chest. ■ Rayon clothing, linens. **KIDS ROOM** ■ Wooden toys, art easel. ■ Disposable diapers, books, coloring book. ■ Crayons. **BATHROOM** ■ Vanity, toilet seat, hamper, toilet paper, facial tissue. ■ Shampoo, aspirin, toothpaste, shaving cream, lipstick, perfume, combs, hairspray, bandage strips, cough syrup, pine scent air freshener.

5. WORKSHOP / BASEMENT / LAUNDRY/UTILITY / GARAGE ■ Workbench, shelves, pellets. ■ Shovel, rake, and tool handles, boat shells, baseball bats, hockey sticks. ■ Football helmet, tires, hose.

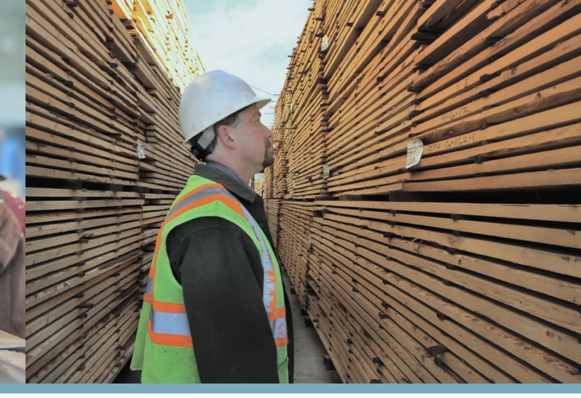
6. YARD ■ Porch, deck, fence, lattice, sauna, hot tub, play set, birdhouse, telephone poles, trees, shrubs, wicker, bark, mulch, smoked wood chip. ■ Charcoal for grill.

Log thinning

Helicopter logging

Lumber mill

Milling



Lumber inspection

Pulp and paper

Forest Industries Keep America Working

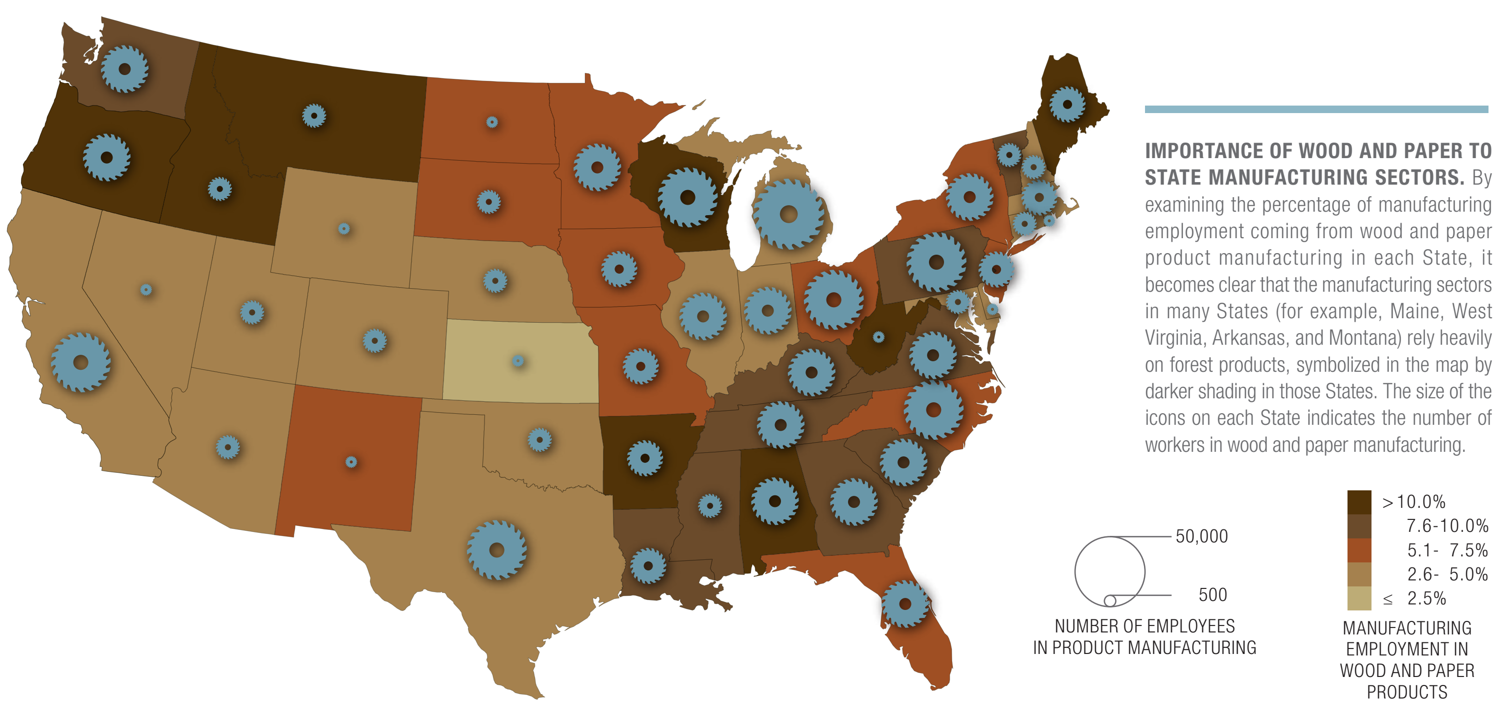
Forest industries are a major contributor to the U.S. economy and provide jobs from forests to showrooms. The economic benefits of the industry are felt throughout the Nation, but each region of the country relies on different components of the industry to varying degrees—from softwood lumber and plywood production in the West to hardwood manufacturing in the East.

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 statistics and financial experts working in office settings. Forestry 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.

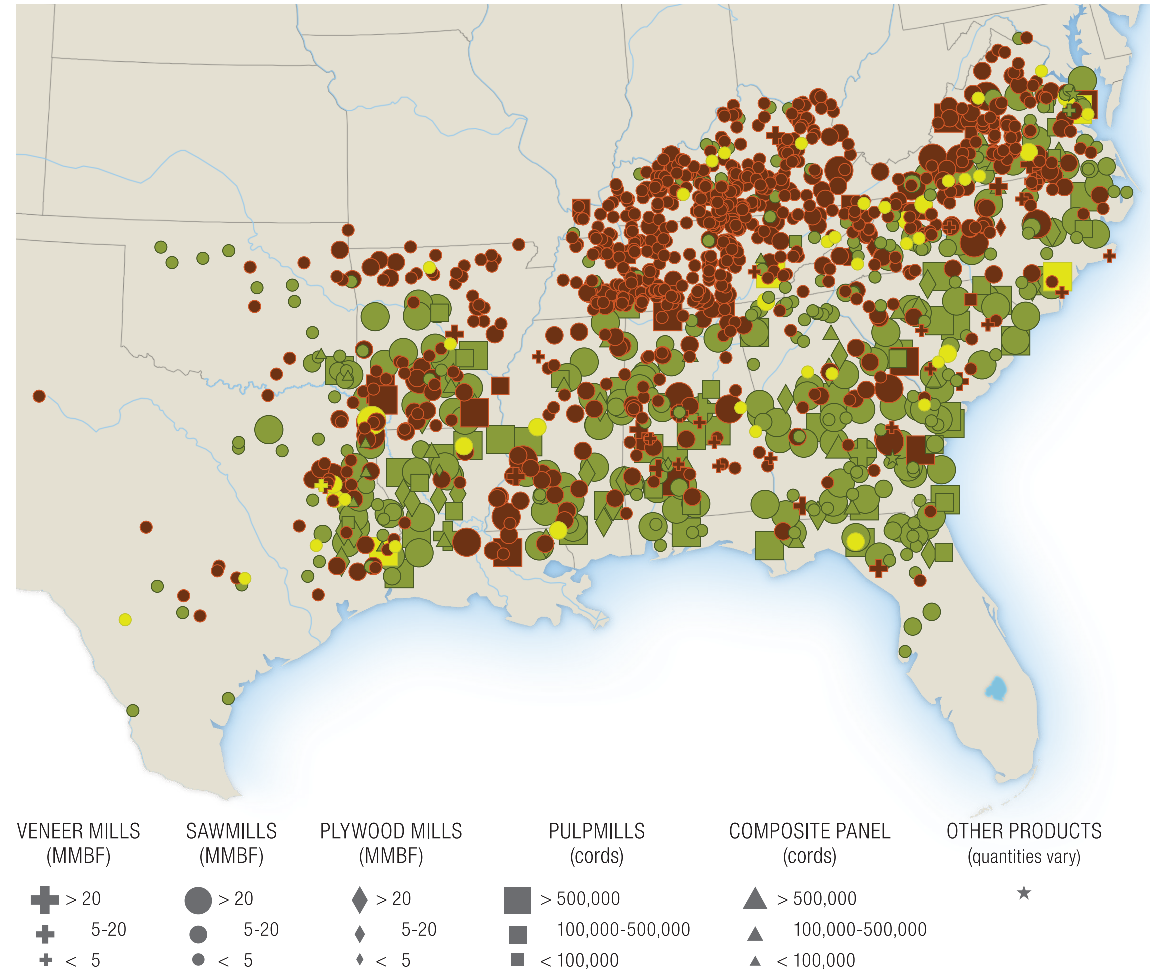
For the purpose of measuring employment in the industry through time, the forest industry is defined as the sum of employment in three sectors: forestry and logging, wood product manufacturing, and paper manufacturing. This is a somewhat narrow definition of the industry; it does not include forestry 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 these States in terms of contribution to those States' manufacturing sectors.

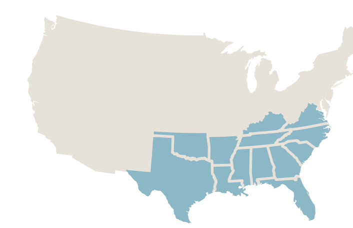
While the forest products industry remains an integral part of the Nation's economy and vital to many local economies, the industry was particularly hard hit by the dramatic downturn in the housing sector and the associated Great Recession of 2007–2009. The 75-percent drop in housing starts from 2005 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.



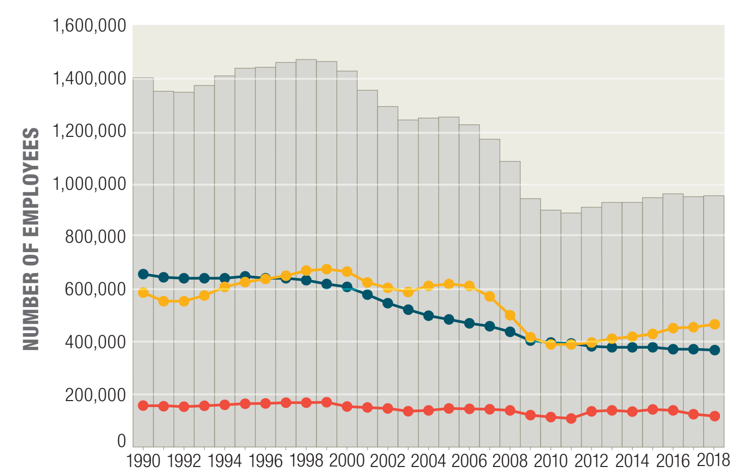
IMPORTANCE OF WOOD AND PAPER TO STATE MANUFACTURING SECTORS. By examining the percentage of manufacturing employment coming from wood and paper product manufacturing in each State, it becomes clear that the manufacturing sectors in many States (for example, Maine, West Virginia, Arkansas, and Montana)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



PRIMARY WOOD-USING MILLS OF THE SOUTHERN UNITED STATES, 2009. Mills that process timber to make wood products provide a major source of employment for forest industry workers in the South. Both hardwood and softwood mills are prevalent throughout the Southern States, with a few mills that process both hardwoods and softwoods. This map shows the myriad locations, types, and sizes of mills in the region. Some symbols are shifted slightly to ease map interpretation.



MILLIONS OF BOARD FEET OF TIMBER (MMBF). 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.** Pulpwood is 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, 1990–2018. The U.S. forest products industry—defined as the three sectors including forestry and logging, wood product manufacturing, and paper manufacturing—employed more than 1.2 million workers annually from 1990 through 2006. 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 2009 through 2011. Significant improvements in housing markets during 2011 and 2012, however, generated optimism for industry stakeholders going forward.

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 unit to the landing. A stroke-boom-delimber operator is one of the workers involved in processing and merchandizing logs. Employees in wood and paper manufacturing work in increasingly automated facilities, monitoring their production lines for safety, quality, and efficiency, often from a central control room.

What is the Future of Our Forests?

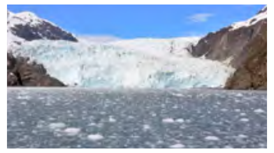
Forests will change due to complex interacting stresses, an increasing population, and a changing climate (see Chapter 3), as well as shifting demands for the goods and services that our forests provide (see Chapter 4).

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.




FORESTS ARE ALWAYS CHANGING. Forests change due to both natural and human factors. Wildfire and flooding cause dramatic changes in forested ecosystems, whereas other factors create more subtle changes. In contrast, some forests can be actively managed for more than a century and still maintain a natural character. Regardless of the situation, private landowners and public land managers, as well as the public, will have a large role in determining how future forests look.

Conservation and preservation rights

Recreation rights

Timber harvest and sale rights

Wild or released game hunting rights

Belowground resource rights

Owners of rights can sell or give away those rights

Who Owns the Forest?

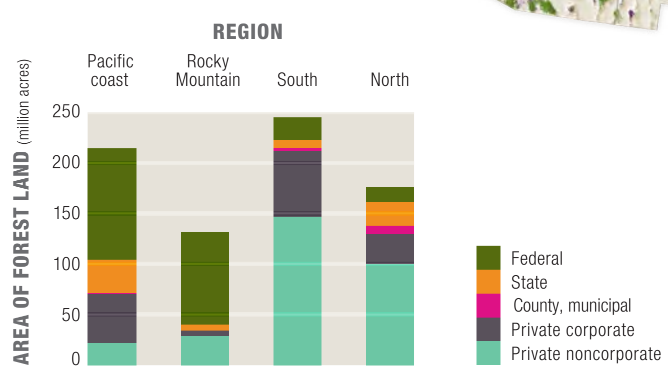
The future of a forest lies largely in the hands of those who own it. The owners' objectives, needs, knowledge, and resources, within biophysical capabilities, social norms, and political regulations, will determine not only what land remains in forest cover but also what part of the forest is managed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

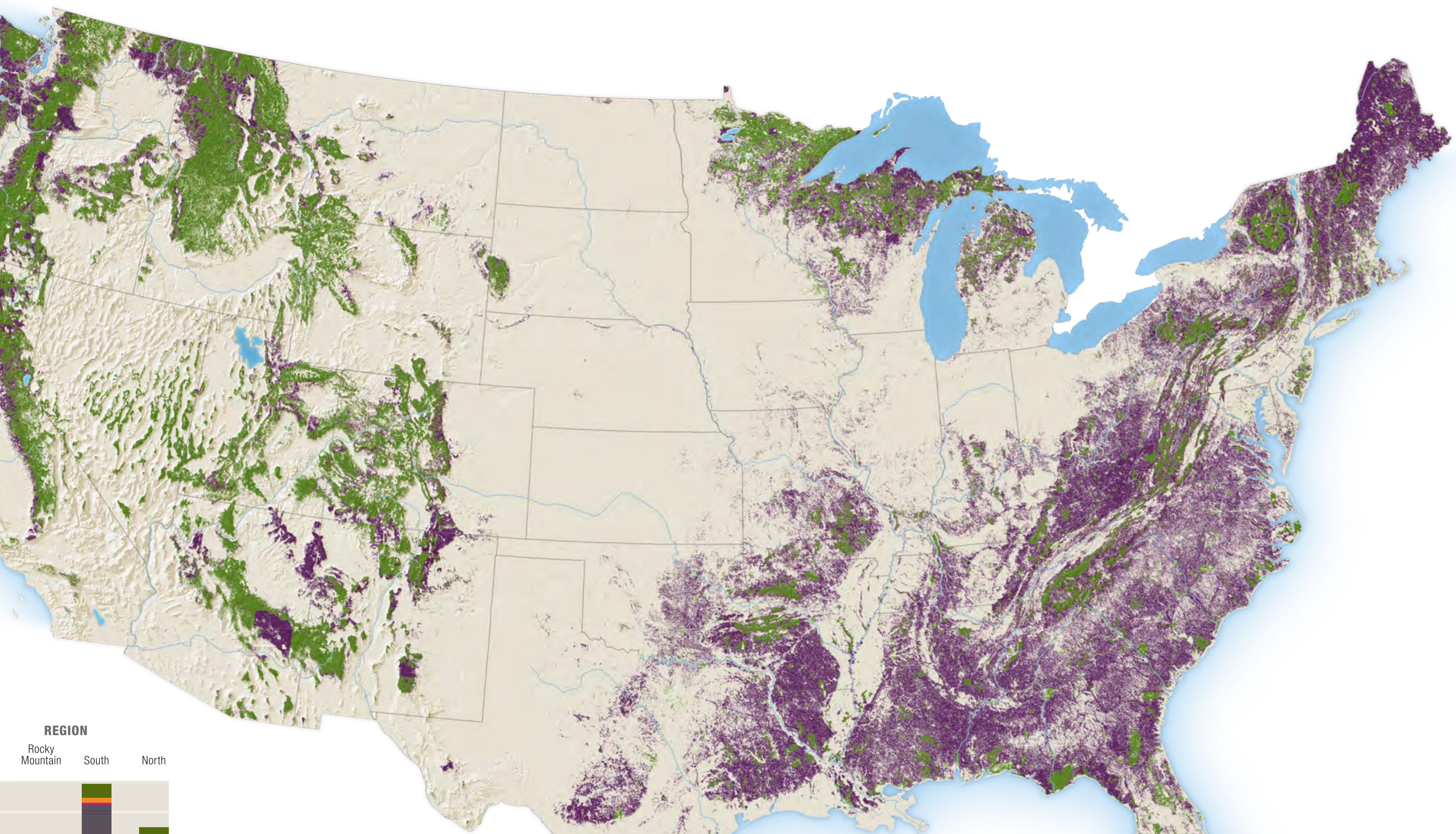
Forest ownership patterns vary significantly across the United States. In general, private forests are dominant in the East, and public ownership is dominant in the West, but many types of ownerships are interspersed throughout the country. The locations of specific ownerships are a result of settlement 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.

BUNDLE OF RIGHTS. Land ownership can be thought of as a bundle of rights. Landowners have tremendous freedom on how they manage their property, with some important constraints. Wildlife, for example, is held in trust for the benefit of present and future generations by State and Federal governments. Rights to manage and extract aboveground resources, such as timber, are generally controlled by the landowner. Rights to belowground resources, such as minerals, can be held by someone else entirely. Owners of rights can sell or give away those rights. Conservation easements are one example of where an owner can sell the rights to develop an individual piece of property.



FOREST OWNERSHIP BY REGION. The area of forest land can be reported by broad forest ownership groups. Forest ownership patterns vary significantly across the country. In the Western United States, public ownership dominates. In the eastern part of the country, it is private ownership that dominates. Detailed information on these ownership groups is provided in the subsequent features.



DISTRIBUTION OF PRIVATE AND PUBLIC FOREST LAND. The notion of public land was introduced late in the Nation's history, during the period of western expansion. As a result, public lands tend to be concentrated in the Western United States.

Family/individual Other private Corporate Family/individual Other private Corporate

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.

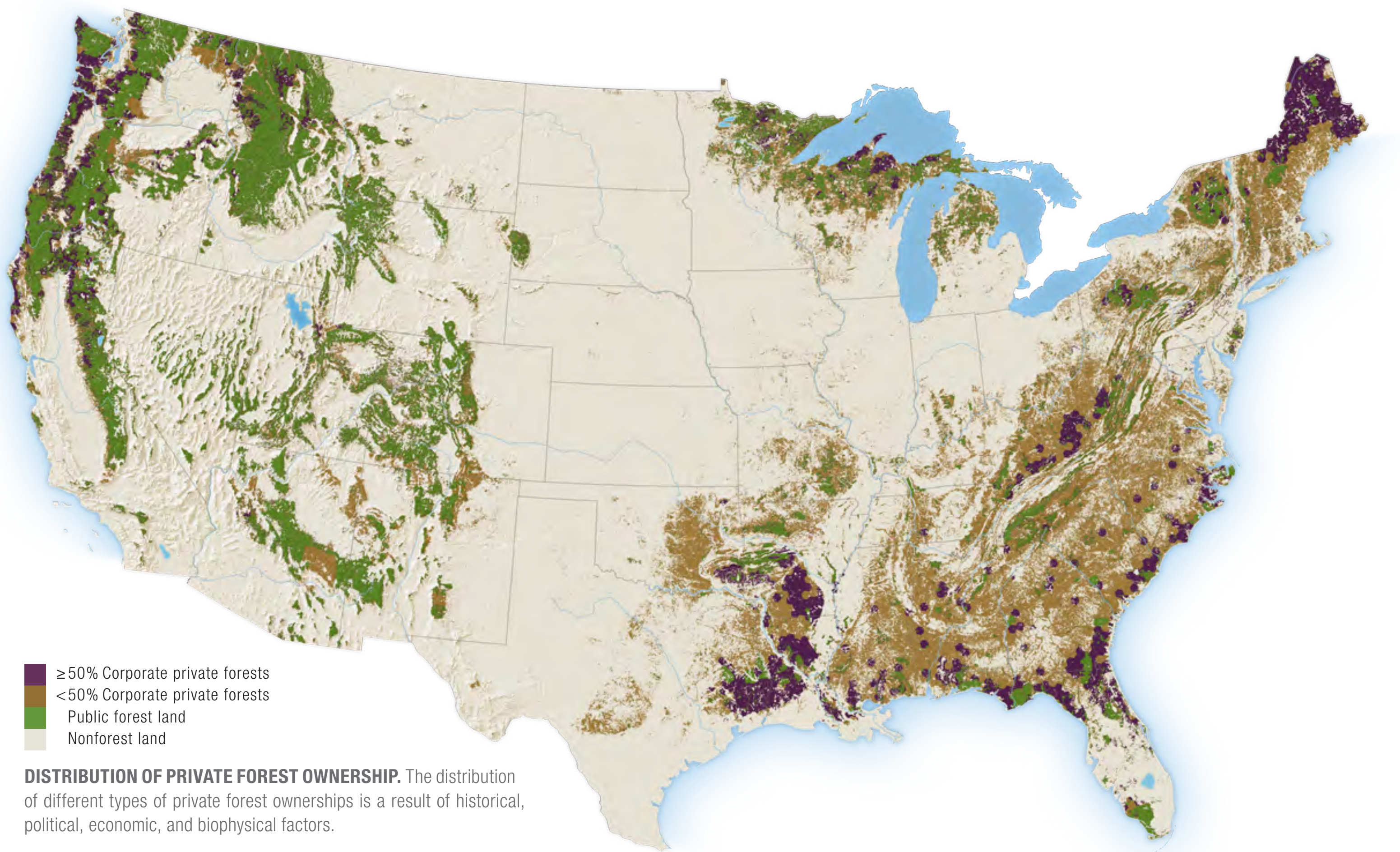
Most private forest land (62 percent) is owned by an estimated 10 million families, individuals, trusts, estates, and other groups who are collectively referred to as family forest owners. Although many share traits from more than one of these categories, there are four major "types" of family forest 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 (5 percent).
4. Those who do not express clear objectives for their property (18 percent).

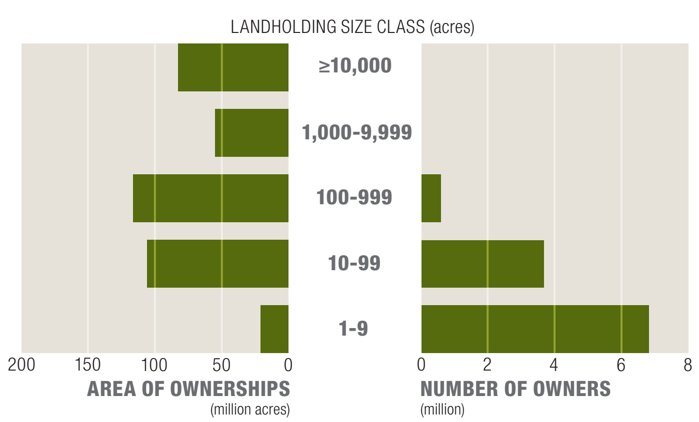
Corporations own 33 percent of private forest land. This group includes multinational, regional, and local companies. Forestry is the primary objective for some of these owners, but others are energy companies or own it for other reasons, such as buffers around manufacturing plants. Two newer types of 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.

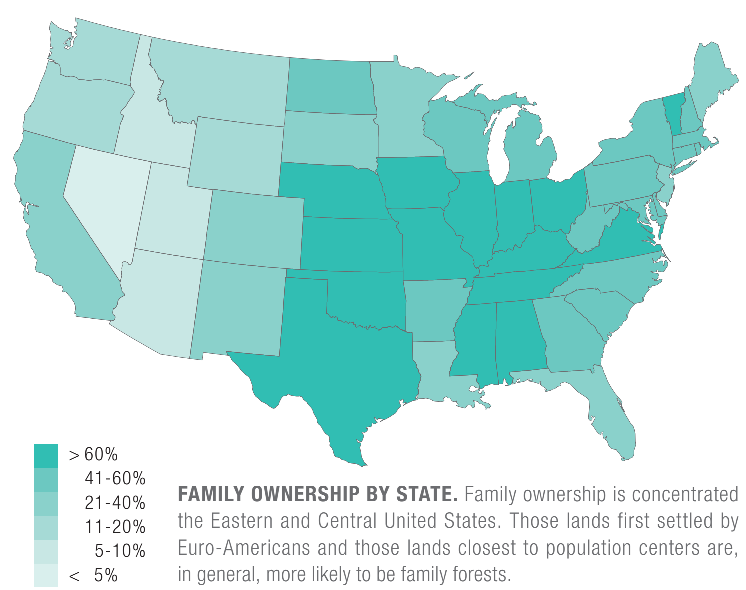
The cumulative decisions of private owners determine which private lands remain forested; what, if any, forest management occurs; and what goods and services are provided. Private forests can provide valuable public benefits.



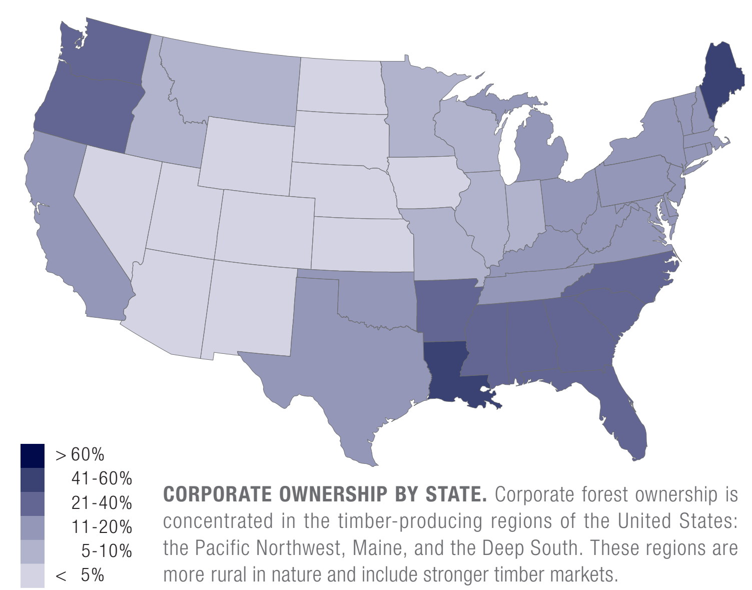
DISTRIBUTION OF PRIVATE FOREST OWNERSHIP. The distribution of different types of private forest ownerships is a result of historical, political, economic, and biophysical factors.



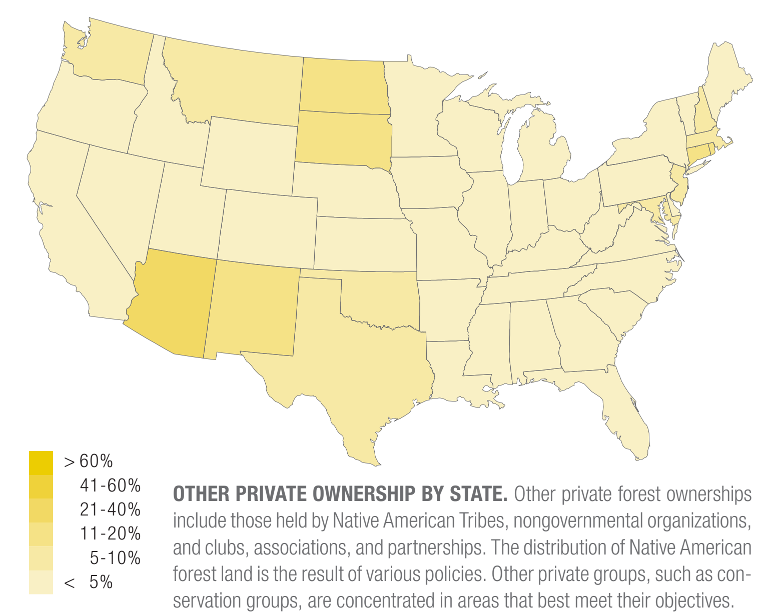
AREA AND NUMBER OF PRIVATE FOREST OWNERSHIPS BY SIZE. These two metrics are skewed in opposite directions. More than 6.8 million forest owners each hold parcels smaller than 10 acres; by contrast, approximately 9,000 owners hold parcels larger than 10,000 acres (15.6 sq. mi.).



FAMILY OWNERSHIP BY STATE. Family ownership is concentrated the Eastern and Central United States. Those lands first settled by Euro-Americans and those lands closest to population centers are, in general, more likely to be family forests.



CORPORATE OWNERSHIP BY STATE. Corporate forest ownership is concentrated in the timber-producing regions of the United States: the Pacific Northwest, Maine, and the Deep South. These regions are more rural in nature and include stronger timber markets.



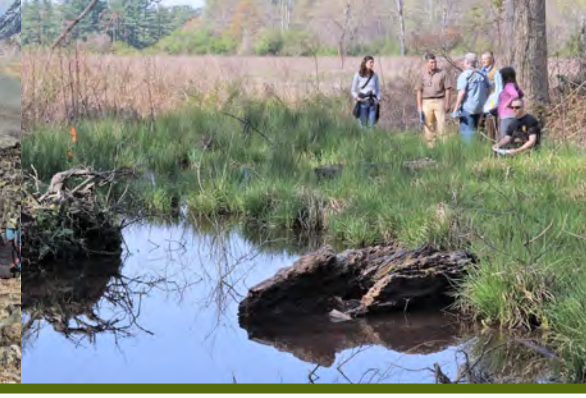
OTHER PRIVATE OWNERSHIP BY STATE. Other private forest ownerships include those held by Native American Tribes, nongovernmental organizations, and clubs, associations, and partnerships. The distribution of Native American forest land is the result of various policies. Other private groups, such as conservation groups, are concentrated in areas that best meet their objectives.

PHOTOS: Private forest owners are a diverse group with a wide variety of objectives. Timber sales are important parts of the management on some lands. Tree planting is an activity that gives everyone a stake in the future forest. Public and private foresters provide advice to private forest owners. Some private landowners participate in national organizations, such as the American Tree Farm System. Corporate forest owners are focused on generating a w ide variety of pulp and wood products and, increasingly, biomass energy.

■ USFS; Boundary Waters Canoe Area Wilderness, Minnesota

■ BLM; St Anthony Sand Dunes, Idaho

■ NPS; Lake Clark National Park, Alaska



■ FWS; Farm field back t restoration, North Carolina

■ State; Webster Forest Nursery Department of Natural Resources, Washington

■ Local; Morton Arboretum, DuPage County, Illinois

America's Public Forest Owners

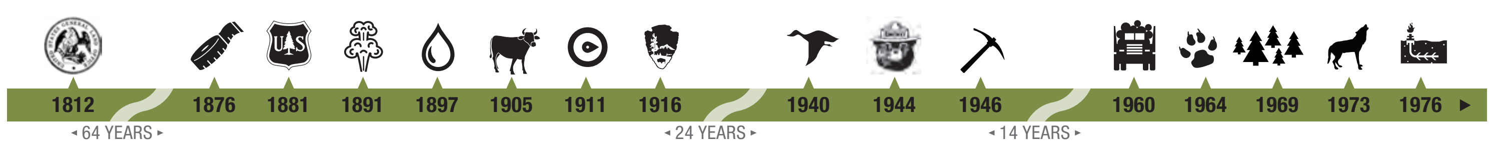
More than 300 million acres of forest land are managed by Federal, State, and local government agencies on behalf of the general public. Gifford Pinchot, the first Chief of the Forest Service, believed in "the greatest good, for the greatest number," and these lands are managed to provide the American 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 varied 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.



President Theodore Roosevelt (left) and nature preservationist John Muir, founder of the Sierra Club, on Glacier Point in Yosemite National Park.

1812 GENERAL LAND OFFICE. Created to oversee the surveying, planning and sale of public lands in the West.

1876 FIRST FOREST ASSESSMENT. Published in 1877.

1881 DIVISION OF FORESTRY. Documented forests and timber resources.

1891 FOREST RESERVE ACT. Authorized the President to establish forest reserves. Yellowstone Forest Reserve was the first.

1897 ORGANIC ACT. Established first legislation to protect Federal forest land, watersheds, and timber production.

1905 TRANSFER ACT. Established to protect against overgrazing, manage fish and game, combat and control fires, and provide public recreation.

1911 WEEKS ACT. Expanded national forests in the East leading to the protection and restoration of millions of acres.

1916 NATIONAL PARK SERVICE ORGANIC ACT. Provided for the management of all national parks, national monuments, and conservation and historical properties.

1940 FISH & WILDLIFE SERVICE (FWS). Established management of the Nation's first wildlife refuges and direction for controlling predators, enforcing wildlife laws, and managing migratory bird conservation.

1944 SMOKEY BEAR. Created symbol to educate the public about the dangers of forest fires. "Only You Can Prevent Forest Fires."

1946 BUREAU OF LAND MANAGEMENT (BLM). Regulated forest recreational activities, including allowing naturalist hobbies and visiting natural and cultural heritage sites. Provided for regulation of forest logging, mining, fracking, and other activities.

1960 MULTIPLE-USE SUSTAINED YIELD ACT. Provided for development and administration of renewable resources of timber, range, water, recreation, and wildlife.

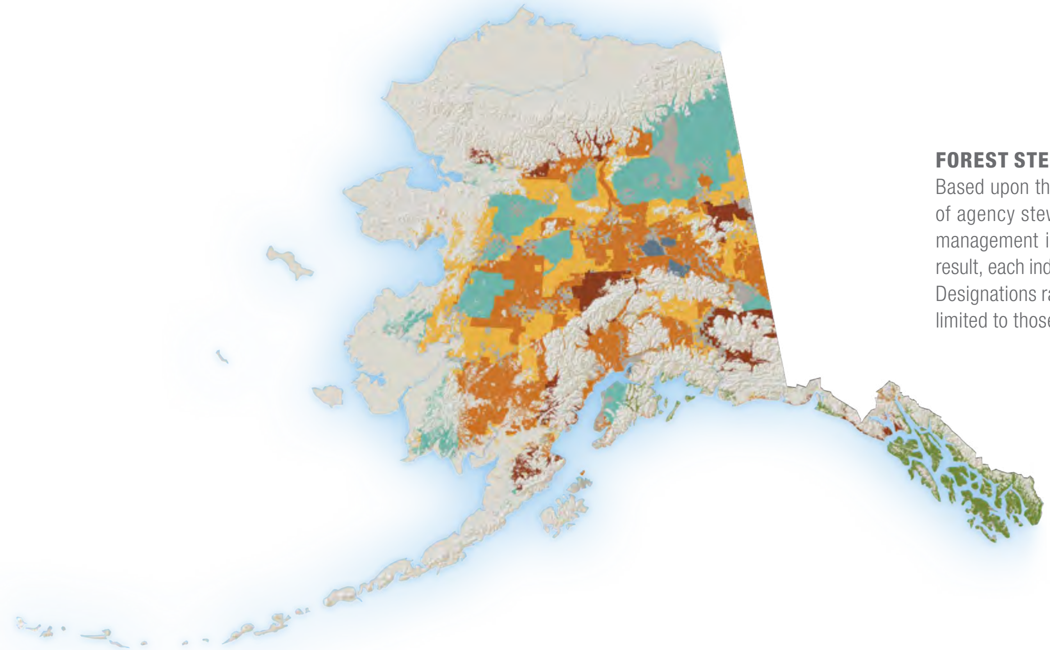
1964 WILDERNESS ACT. Designated lands for preservation and protection in their natural condition.

1969 NATIONAL FOREST MANAGEMENT ACT (NFMA). Expanded goals of multiple-use forestry and provided guidance on public input.

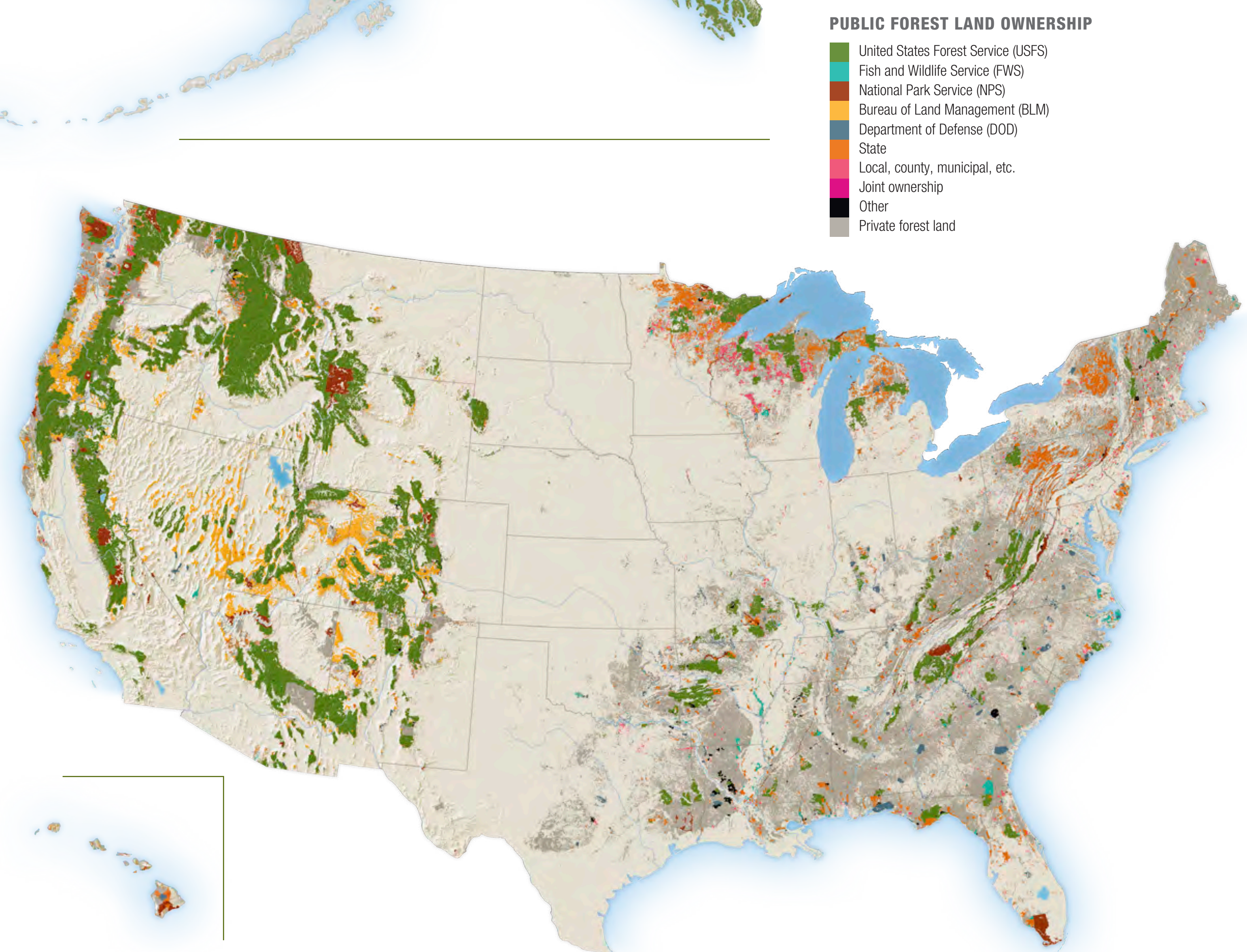
1973 ENDANGERED SPECIES ACT (ESA). Provides protection for rare, threatened, and endangered plants and animals.

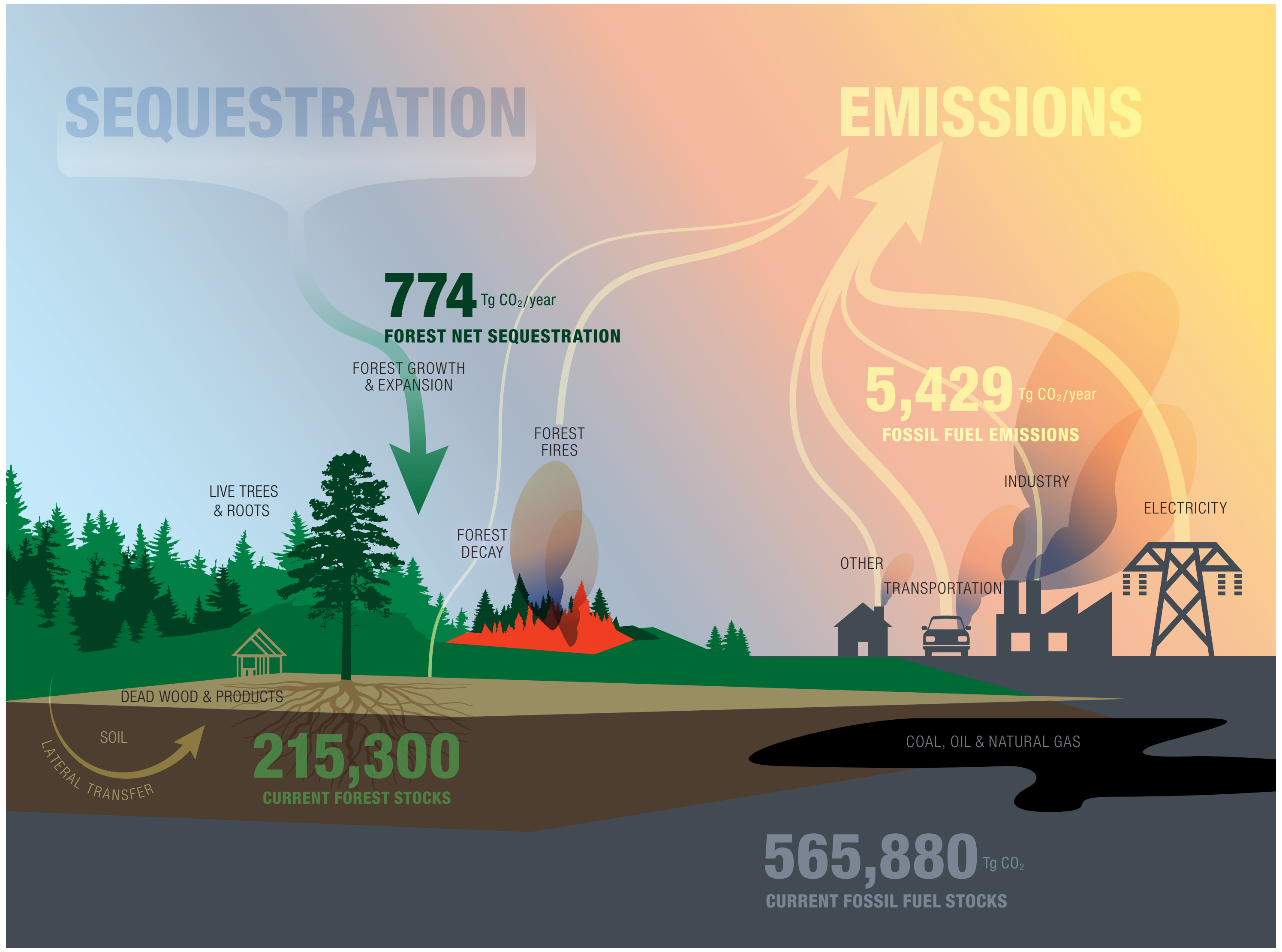
1976 NATIONAL ENVIRONMENTAL POLICY ACT (NEPA). Mandated the assessment of environmental impacts of proposed projects on Federal lands.

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



FOREST 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.





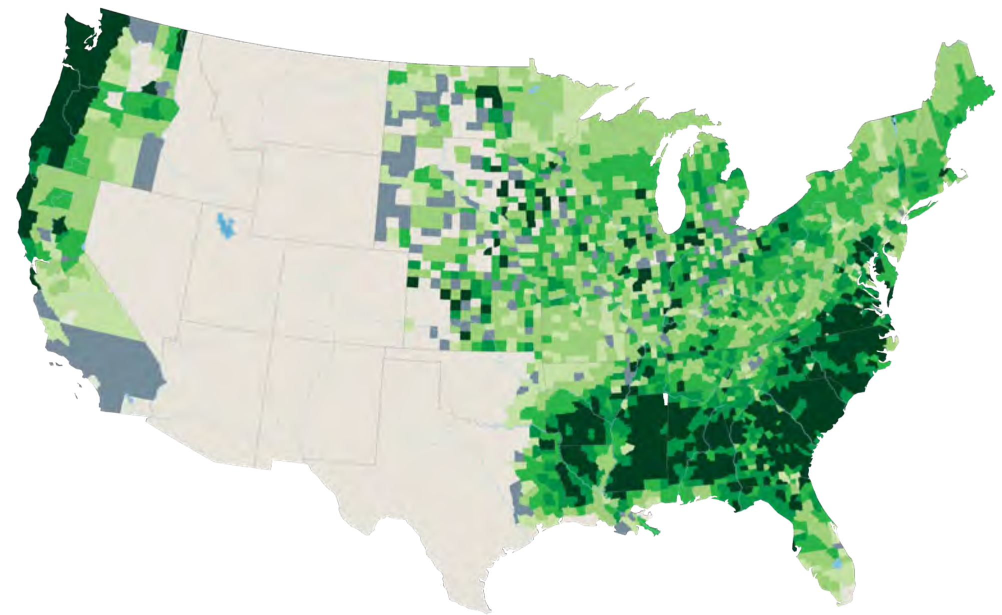
Forests and the Carbon Cycle

Forests—through photosynthesis—sequester carbon from the atmosphere and store it as plant mass or eventual wood products. When trees die, carbon continues to remain in the forest ecosystem and cycle through dead trees (or wood products), downed dead wood, forest floor, soil organic carbon, and, eventually, to the atmosphere through decay or combustion.

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 materials), so forests may play a critical role in climate change mitigation. The cycle of carbon atoms from the atmosphere through forest ecosystems and back to the atmosphere is highly complex and varies over both time and spatial scales.

Across highly productive forests (for example, the central hardwoods of the Eastern United States), large quantities of carbon are sequestered on an annual basis. Forest products, like furniture and building timbers, offer an alternative approach to storing carbon over longer time periods. By contrast, disturbance events like wildfires and hurricanes may be important for forest health, but they also release large quantities of carbon dioxide. Forest carbon currently stored in trees and soils is much greater than annual fossil fuel emissions, and there are concerns about the stability of these pools under a changing climate.

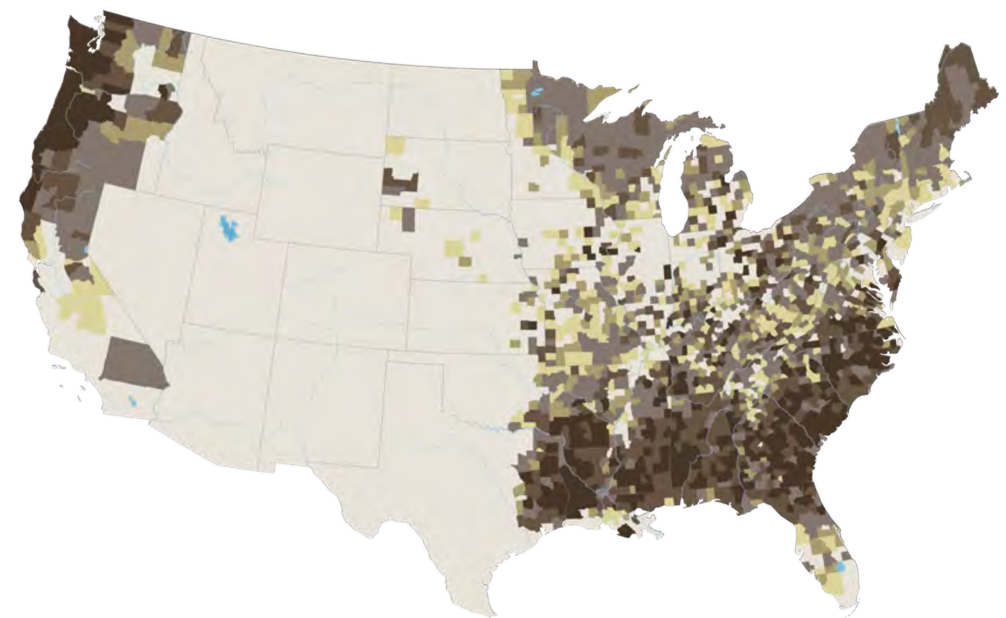
A STORY OF GIVE AND TAKE: FOREST CARBON STOCKS AND FLUXES WITH THE ATMOSPHERE SCALED IN THE CONTEXT OF FOREST ECOSYSTEM COMPONENTS/PRODUCTS AND FOSSIL FUEL EMISSIONS. Forests have always altered the amount of carbon dioxide in the atmosphere, removing (or sequestering) it as they grow and returning it 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.



CARBON IS SEQUESTERED. One of the first steps in the forest carbon cycle is the initial conversion of carbon dioxide through photosynthesis into living forest tissue. Many areas of the United States, such as the central hardwoods of the East, are densely forested regions with high levels of carbon sequestration into living biomass. Given the complexity of the forest carbon cycle, however, the question of what this initial storage eventually becomes still remains.

ANNUAL FOREST CARBON GROWTH (cubic ft/acres)

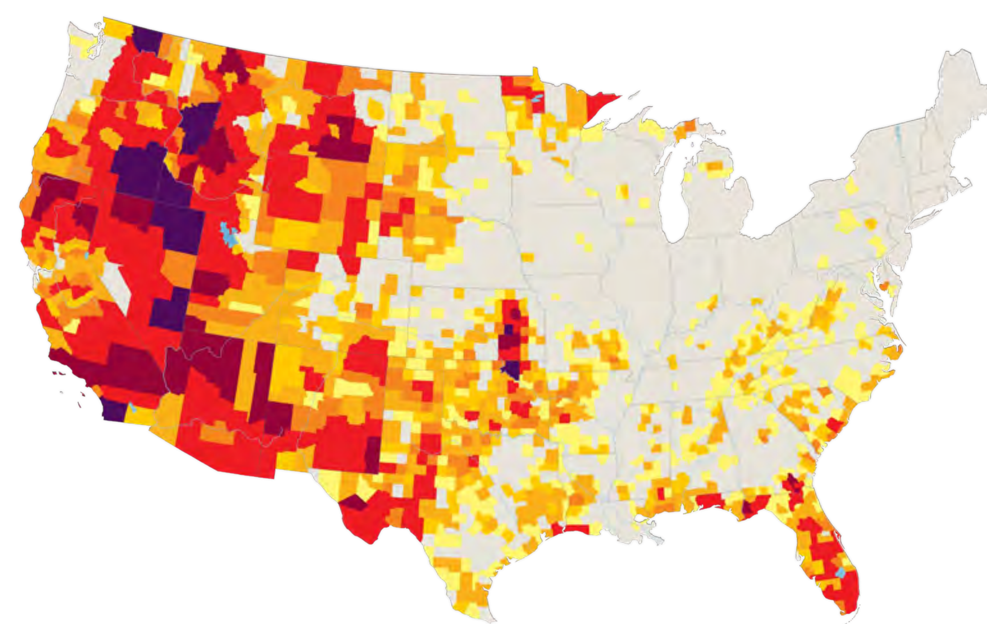
- > 80
- 61 - 80
- 41 - 60
- 21 - 40
- 0 - 20
- No data
- < 0



CARBON IS STORED. Although carbon may reside in many long-lived forest pools for centuries (e.g., soil), there are opportunities to combine society's need for forest products (e.g., housing materials) with the need to sequester atmospheric carbon. Pulpwood harvests are common across the Eastern United States and although not as long-lived as sawtimber products, they offer an opportunity to provide social benefits while maintaining a level of ecosystem services (e.g., carbon sequestration).

ANNUAL CARBON SEQUESTERED IN HARVESTED PRODUCTS (cubic ft/acres)

- 51 - 668
- 26 - 50
- 11 - 25
- 6 - 10
- 1 - 5
- 0 or no data



CARBON IS RELEASED. 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 in excess 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 forested settings.

CARBON BURNED 2003 - 2012 (acres)

- 100,001 - 320,033
- 50,001 - 100,000
- 10,001 - 50,000
- 5,001 - 10,000
- 1,001 - 5,000
- 501 - 1,000
- 1 - 500
- 0

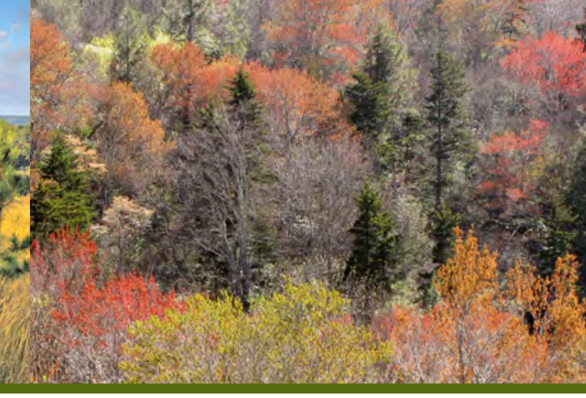

Engelmann spruce (*Picea engelmanii*)


Western hemlock (*Tsuga heterophylla*)


American beech (*Fagus grandifolia*)


Sugar maple (*Acer saccharum*)

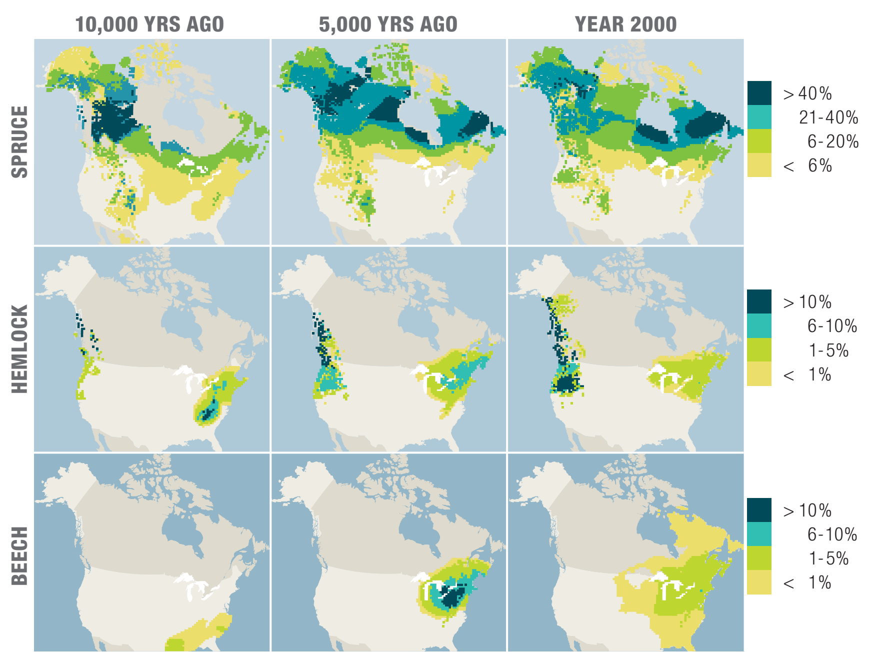

Shortleaf pine (*Pinus echinata*)


Mixed forest types

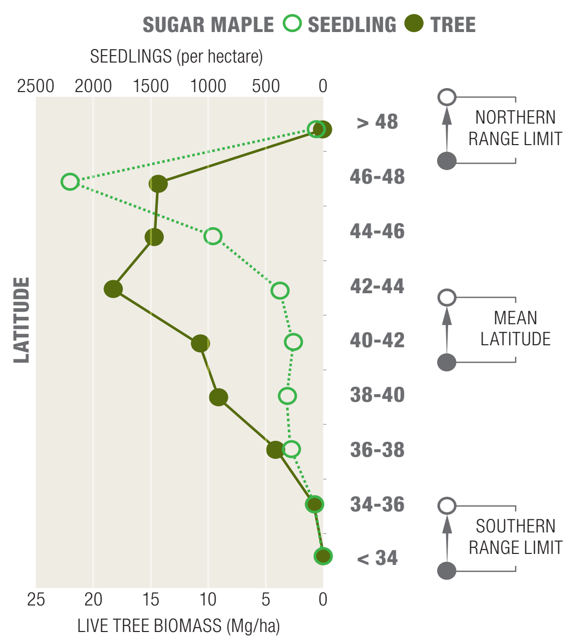
Forests on the Move

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 adaption will be species migration.

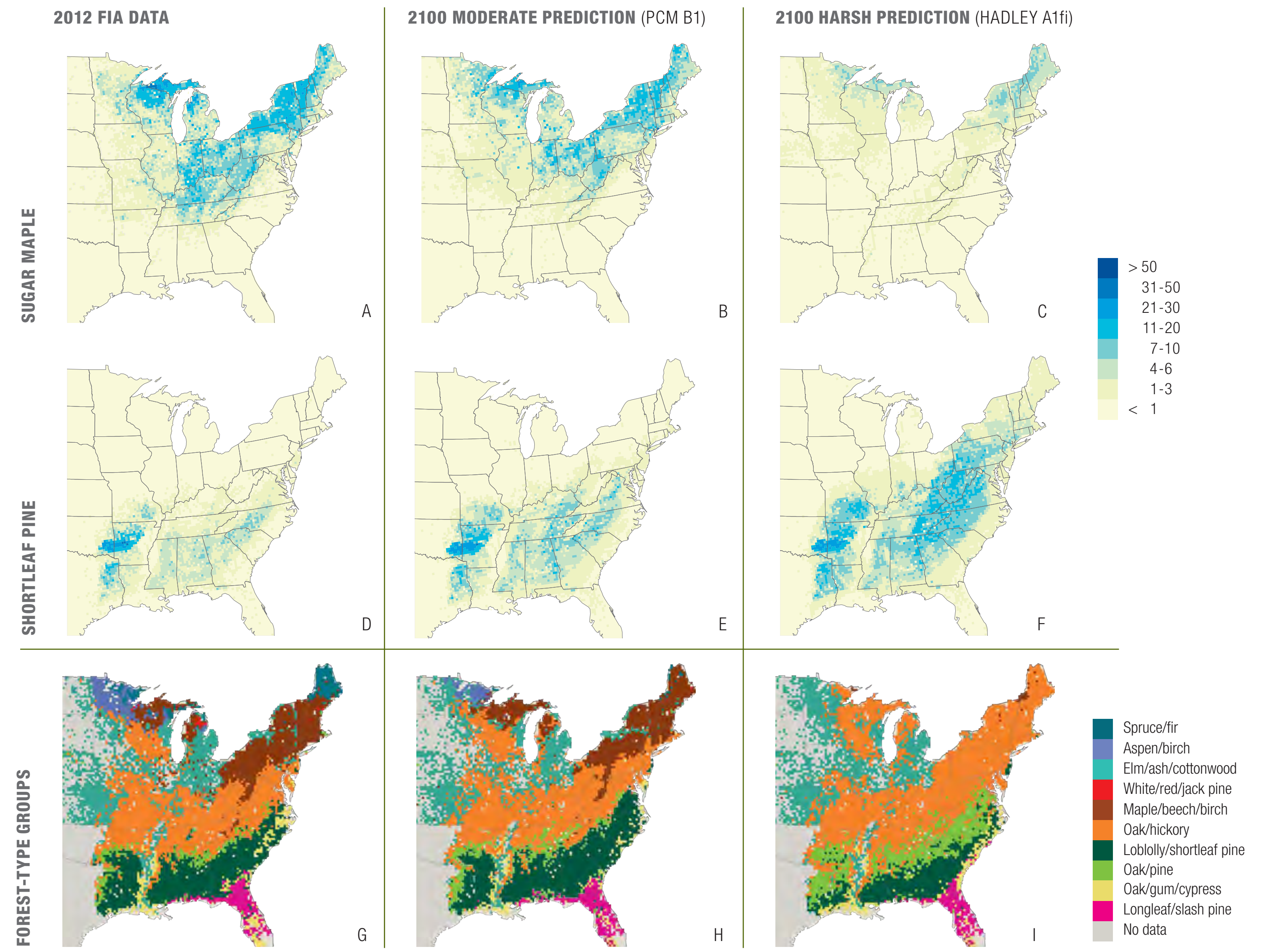
Tree species migration is closely related to why species occur where they do: how do climate, soil, and landscape characteristics create suitable habitats for different tree species? While generalist species respond to broad ecological conditions, species with narrow ranges of environmental conditions 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 ha bitat 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 multilayered approaches integrating climate predictions, disturbance patterns, and habitat needs allow us to evaluate forest vulnerabilities to climate change.



EVIDENCE OF PAST MOVEMENTS. Ancient pollen trapped in soil helps us understand historical tree species migrations. The occurrence of pollen in different layers indicates species presence on the landscape and allows us to see how trees recolonized North America after the last glaciation. These maps of pollen abundance (percent of total) include pollen in areas currently underwater because sea levels were lower in the past.



HOW DO TREE SPECIES MIGRATE? Mature trees can't migrate like animals, but tree seedlings may colonize locations beyond the range of established trees. For example, sugar maple seedlings (open circles) occur farther north than mature sugar maples (solid circles). The species' distributions may shift as a result.



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 just 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-C). It is likely to lose substantial habitat by 2100 under a harsh climate model and emission scenario (C), 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 (D-F). 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 harsher Hadley A1fi (F).

FOREST TYPES. Foresters 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 reassemble 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).

Acknowledgments

We thank the following individuals:

For the development of feature content that is the foundation of the Forest Atlas:
Gary Bentrup, Ken Brewer, Tom Brown, Brett Butler, Grant Domke, Andy Gray, Mark Finco, Louis Iverson, Todd Kellerman, Peter Landres, Kris Lee, Sandy Liebhold, Steve Matthews, Todd Morgan, Mark Nelson, Dave Nowak, Chris Oswalt, Sonja Oswalt, Hobie Perry, Matthew Peters, Anantha Prasad, Frank Sapio, Michele Schoeneberger, Rich Straight, Colin Sorenson, Brian Walters, Ty Wilson, and Chris Woodall.

For design work that converted a dry scientific document into something beautiful:
Linda R. Smith and Lou Ann Reineke.

For assistance with content management and development:
Gail Shaw and Vicky C. Johnson.

For insight and technical implementation on the digital companion to the Forest Atlas:
Erich Kuster, James Monty, Toly Zharkhik, and Erik Lindblom.

For cartographic assistance:
Andrew Keske and Randy Vreeke.

For project management at the Geospatial Technology and Applications Center:
Mark Finco and Kevin Megown.

For writing and editorial support:
Mary Carr, Jennifer Geraci, and Monique Nelson.

For technical reviews and feedback:
Dave Bell, Jesse Caputo, Dan Crane, Jim Garner, Eric Greenfield, Sean Healey, Emily Huff, Rachel Riemann, Karen Schleeweis, and Brian Tavernia.

For editing and publication guidance:
Sonja Beavers and Amanda Perry.

For guidance and support in the Washington Office:
Ken Brewer, Linda Heath, Greg Reams, Brad Smith, and Jim Ellenwood.

For the initial vision and inspiration:
Rich Guldin.

Credits

COVER

Photographs

Mount Timpanogos: Arbyreed, flickr.com.

WHERE DO TREES GROW, AND WHY?

Authors

Perry, Charles H.; Domke, Grant M. USDA Forest Service, St. Paul, MN.

General References

Hardin, J.W.; Leopold, D.J.; White, F.M. 2001. Harlow and Harrar's textbook of dendrology. 9th ed. San Bernardino, CA: McGraw-Hill: 117–119.

Perry, D.A.; Oren, R.; Hart, S.C. 2008. Forest ecosystems, 2nd ed. Baltimore, MD: Johns Hopkins University Press. 606 p.

Photographs

Bristlecone pine: National Park Service, wikimedia.org. *Sugar maple:* Joseph O'Brien, forestryimages.org. *Bald cypress*: Michael Hart Photography, flickr.com. *Front matter/Prairie forest border:* Ian Vorster, Thinkstock by gettyimages.com. *Limber pine:* National Park Service, flickr.com. *Hoh rainforest:* R. Litewriter, Thinkstock by gettyimages.com.

ECOLOGICAL DIVISIONS OF NORTH AMERICA

Authors

Perry, Charles H.; Wilson, Barry T. USDA Forest Service, St. Paul, MN.; Finco, Mark V., RedCastle Resources, Inc., Salt Lake City, UT.

General Reference

Bailey, R.G. 1998. Ecoregions map of North America: explanatory note. Misc. Pub. 1548. Washington, DC: U.S. Department of Agriculture, Forest Service. 10 p. http://www.fs.fed.us/rm/ecoregions/products/map-ecoregions-north-america. [Date accessed: 29 May 2018].

Map Source

Ecological Divisions of Canada, the United States, and Mexico: Bailey, R.G. 1998. Ecoregions map of North America: explanatory note. Misc. Pub. 1548. Washington, DC: U.S. Department of Agriculture, Forest Service. 10 p. http://www.fs.fed.us/rm/ecoregions/products/map-ecoregions-north-america. [Date accessed: 29 May 2018].

Graph Source

Area of forest land in the conterminous United States by ecological division: U.S. Department of Agriculture, Forest Service. 2016. Forest Inventory and Analysis program data and tools. http://www.fia.fs.fed.us/tools-data/index.php. [Date accessed: 29 May 2018].

Illustration Source

Ecological division classification system: Bailey, R.G. 1998. Ecoregions map of North America: explanatory note. Misc. Pub. 1548. Washington, DC: U.S. Department of Agriculture, Forest Service. 10 p. http://www.fs.fed.us/rm/ecoregions/products/map-ecoregions-north-america. [Date accessed: 29 May 2018].

Photographs

Rainforest (Kauai, HI): Joe Giordano, flickr.com. *Marine (So-Etolin Wilderness, AK):* Maria Burke, wilderness.net. *Temperate-steppe (Grand Canyon, AZ):* Michael Quinn, flickr.com. *Prairie: Wildlife refuge (MN):* Eric C. Koronka, U.S. Fish and Wildlife Service, flickr.com. *Hot continental (Smoky Mountains, TN):* Dave Allen, Thinkstock by gettyimages.com. *Warm continental (Mount Washington, NH):* John Anderson, Thinkstock by gettyimages.com.

FOREST EXTENT

Authors

Finco, Mark V. RedCastle Resources Inc., Salt Lake City, UT.; Perry, Charles H. USDA Forest Service, St. Paul, MN.

General References

Homer, C.; Dewitz, J.; Yang, L.; Jin, S.; Danielson, P.; Xian, G.; Coulston, J.; Herold, N.; Wickham, J.; Megown, K. 2015. Completion of the 2011 National Land Cover Database for the conterminous United States—representing a decade of land cover change information. Photogrammetric Engineering and Remote Sensing. 81(5):345–354.

Wilson, B.T.; Lister, A.J.; Riemann, R.I. 2012. A nearest-neighbor imputation approach to mapping tree species over large areas using forest inventory plots and moderate resolution raster data. Forest Ecology and Management. 271: 182–198. https://www.fs.usda.gov/treesearch/pubs/40312. [Date accessed: 04 June 2018].

Wilson, B.T.; Woodall, C.W.; Griffith, D.M. 2013. Imputing forest carbon stock estimates from inventory plots to a nationally continuous coverage. Carbon Balance and Management. 8:1. https://www.fs.usda.gov/treesearch/pubs/42806. [Date accessed: 04 June 2018].

Map Sources

Tree canopy cover: Multi-Resolution Land Characteristics Consortium (MRLC). 2015. National Land Cover Database, 2011. http://www.mrlc.gov/data. [Date accessed: 14 November 2018].

Forest land use: Wilson, B.T.; Lister, A.J.; Riemann, R.I. 2012. A nearest-neighbor imputation approach to mapping tree species over large areas using forest inventory plots and moderate resolution raster data. Forest Ecology and Management. 271: 182–198. https://www.fs.usda.gov/treesearch/pubs/40312. [Date accessed: 04 June 2018].

Photographs

Dense forest (PA): Nicholas A. Tonelli, flickr.com. *Post-fire (Coconino National Forest, AZ):* Brady Smith, USDA Forest Service. *Industrial Forest Management (OR):* Francis Eatherington, flickr.com. *Golf Course (CA):* D. Ramey Logan, wikipedia.org. *Central Park (NY):* Ed Yourdon, wikipedia.org. *Farmland (WI):* Darin, flickr.com.

TREE SPECIES RANGES

Authors

Wilson, Barry T.; Perry, Charles H. USDA Forest Service, St. Paul, MN.

General References

Burns, R.M.; Honkala, B.H., tech. coords. 1990. Silvics of North America: 1. Conifers; 2. Hardwoods. Agriculture Handbook 654. Washington, DC: U.S. Department of Agriculture, Forest Service. 877 p.

Little, Jr., E.L. 1971. Atlas of United States trees. Volume 1. Conifers and important hardwoods. Misc. Pub. 1146. Washington, DC: U.S. Department of Agriculture, Forest Service. 9 p., 200 maps.

Little, Jr., E.L. 1977. Atlas of United States trees. Volume 4. Minor eastern hardwoods. Misc. Pub. 1342. Washington, DC: U.S. Department of Agriculture, Forest Service. 17 p., 230 maps.

U.S. Department of Agriculture, Forest Service. 2013. Fire effects information system. http://www.feis-crs.org/beta. [Date accessed: 29 May 2018].

U.S. Department of Agriculture, Natural Resources Conservation Service. 2013. The PLANTS database. http://plants.usda.gov. [Date accessed: 29 May 2018].

Wilson, B.T.; Lister, A.J.; Riemann, R.I. 2012. A nearest-neighbor imputation approach to mapping tree species over large areas using forest inventory plots and moderate resolution raster data. Forest Ecology and Management. 271: 182–198. https://www.fs.usda.gov/treesearch/pubs/40312. [Date accessed: 04 June 2018].

Wilson, B.T.; Lister, A.J.; Riemann, R.I.; Griffith, D.M. 2013. Live tree species basal area of the contiguous United States (2000–2009). Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 323 maps. http://dx.doi.org/10.2737/RDS-2013-0013. [Date accessed: 22 November 2019].

Map Sources

Ecological divisions: Bailey, R.G. 1998. Ecoregions map of North America: explanatory note. Misc. Pub. 1548. Washington, DC: U.S. Department of Agriculture, Forest Service. 10 p. http://www.fs.fed.us/rm/ecoregions/products/map-ecoregions-north-america. [Date accessed: 29 May 2018].

Tree species ranges of the contiguous United States: Wilson, B.T.; Lister, A.J.; Riemann, R.I. 2012. A nearest-neighbor imputation approach to mapping tree species over large areas using forest inventory plots and moderate resolution raster data. Forest Ecology and Management. 271: 182–198. https://www.fs.usda.gov/treesearch/pubs/40312. [Date accessed: 04 June 2018].

Tree species ranges of Canada, the United States, and Mexico: Little, Jr., E.L. 1971. Atlas of United States trees. Volume 1. Conifers and important hardwoods. Misc. Pub. 1146. Washington, DC: U.S. Department of Agriculture, Forest Service. 9 p. 200 maps.

Little, Jr., E.L. 1977. Atlas of United States trees. Volume 4. Minor Eastern hardwoods. Misc. Pub. 1342. Washington, DC: U.S. Department of Agriculture, Forest Service. 17 p., 230 maps.

Prasad, A.M.; Iverson, L.R. 2003. Little's range and FIA importance value database for 135 eastern U.S. tree species. Delaware, OH: U.S. Department of Agriculture, Forest Service, Northeastern Research Station. 135 maps. http://www.fs.fed.us/ne/delaware/4153/global/littlefia/index.html. [Date accessed: 29 May 2018].

Graph Source

Number and volume of trees: USDA Forest Service. 2016. Forest Inventory and Analysis Program data and tools. http://www.fia.fs.fed.us/tools-data/index.php. [Date accessed: 29 May 2018].

Photographs

Balsam fir: Eli Sagor, flickr.com. *Red maple:* Geneva Wirth, flickr.com. *Sugar maple:* Leslie Geissinger, counterpointfarm.blogspot.com. *Red alder:* Camille Stroch, waywardspark.com. *Ashe juniper/Golden Cheeked Warbler:* Gil Eckrich, geckrich.com. *Utah juniper*: Mark W. Skinner, plants.usda.gov. *Sweetgum:* Ashley Whitworth, Thinkstock by gettyimages.com. *Tanoak:* Elliot Lowe, flickr.com. *Lodgepole pine:* Kevin Cass, Thinkstock by gettyimages.com. *Shortleaf pine:* Ken Lund, flickr.com. *Front matter/Common pinyon:* imagixian, Thinkstock by gettyimages.com. *Ponderosa pine:* Ray Roper, Thinkstock by gettyimages.com. *Loblolly pine:* Karl Kehm, iStock by gettyimages.com. *Front matter/Quaking aspen:* Wendy Selvig, Thinkstock by gettyimages.com. *Honey mesquite*: Belinda Lo, flickr.com. *Douglas-fir:* Roland Tanglao, flickr.com. *White oak:* Bob Gutowski, flickr.com. *Gambel oak:* Michael Quinn, flickr.com. *Chestnut oak:* Mwanner, Wikimedia.org. *Post oak:* Paul Nelson, USDA Forest Service. *Front matter/Redwood:* Choudhury Nanda, Thinkstock by gettyimages.com. *Pondcypress:* Patrick Eilers, Thinkstock by gettyimages.com. *Western hemlock:* Rachel Wente-Chaney, flickr.com. *American elm:* Chris Ford, flickr.com.

Icons

Balsam fir—Moose: Thinkstock by gettyimages.com. *Red maple—Deer:* Chalet Silhouettes, House Industries. *Sugar maple—Syrup pitcher:* Linda R. Smith, RedCastle Resources, Inc. *Red alder—Dresser:* Sergey Krivoy, Noun Project, Inc. *Ashe juniper—Golden Cheeked Warbler:* Linda R. Smith, RedCastle Resources, Inc. *Utah juniper—Gin/martini glass:* Stanislav Levin, Noun Project, Inc. *Sweetgum—Pallet:* Dmitriy Lanunov, RU, Noun Project, Inc. *Tanoak—Acorn:* Louis Marttins, Noun Project, Inc. *Lodgepole pine—Power poles:* Christine Chen, Noun Project, Inc. *Shortleaf pine—Squirrel:* Andy Beksa, Noun Project, Inc. *Common pinyon—Pine cone:* Lou Ann Reineke, RedCastle Resources, Inc. *Ponderosa pine—Hiker:* Open source, National Park Service. *Loblolly pine—Turkey*: Nebojsa Ilic, Thinkstock by gettyimages.com. *Quaking aspen—Binoculars:* Open source, National Park Service. *Honey mesquite—Honey bee:* James Keuning, Noun Project, Inc. *Douglas-fir—Christmas tree:* Dan Christopher, Noun Project, Inc.—Edited by Linda R. Smith, RedCastle Resources, Inc. *White oak—Wine glass:* Edward Boatman, Noun Project, Inc. *Gambel oak—Camp fire:* Evan McDonald, Noun Project, Inc. *Chestnut oak—Rat:* Gilad Fried, Noun Project, Inc. *Post oak—Park bench:* Luiza Moraes, Noun Project, Inc. *Redwood—Picnic table:* Open source, National Park Service Collection, Noun Project, Inc. *Pondcypress—Catfish:* Mallory Hawes, Noun Project, Inc. *Western hemlock—Ranger station:* Open source, National Park Service. *American elm—Hockey stick:* House Industries.

TYPES OF FOREST COMMUNITIES

Author
Wilson, Barry T. USDA Forest Service, St. Paul, MN.

General Reference
Eyre, F.H. ed. 1980. Forest cover types of the United States and Canada. Washington DC: Society of American Foresters. 148 p.

Map Source
Distribution of Forest-type groups: Ruefenacht, B.; Finco, M.V.; Nelson, M.D.; Czaplewski, R.; Helmer, E.H.; Blackard, J.A.; Holden, G.R.; Lister, A.J.; Salajanu, D.; Weyermann, D.; Winterberger, K. 2008. Conterminous U.S. and Alaska forest type mapping using Forest Inventory and Analysis data. Photogrammetric Engineering & Remote Sensing. 74(11):1379–1388. https://www.fs.usda.gov/treesearch/pubs/19002. [Date accessed: 04 June 2018].

Graph Source
Circular dendrogram of forest-type groups: U.S. Department of Agriculture, Forest Service. 2016. Forest Inventory and Analysis program data and tools. http://www.fia.fs.fed.us/tools-data/index.php. [Date accessed: 04 April 2016].

WHAT ELSE LIVES IN THE FOREST?

Authors
Oswalt, Sonja N. USDA Forest Service, Knoxville, TN.; Nelson, Mark D. USDA Forest Service, St. Paul, MN.

General References
Beaudry, F.; Pidgeon, A.M.; Radeloff, V.C.; Howe, R.W.; Mladenoff, D.J.; Bartelt, G.A. 2010. Modeling regional-scale habitat of forest birds when land management guidelines are needed but information is limited. Biological Conservation. 143(7): 1759–1769. https://doi.org/10.1016/j.biocon.2010.04.025. [Date accessed: 04 June 2018].

Hall, L.S.; Krausman, P.R.; Morrison, M.L. 1997. The habitat concept and a plea for standard terminology. Wildlife Society Bulletin. 25(1): 173–182.

Photographs
Brown bear family: Judy Alderson, National Park Service. *Gray tree frog:* irin717, Thinkstock by gettyimages.com. *Clark's nutcracker:* Ken Hoehn, Thinkstock by gettyimages.com. *Eastern indigo snake:* S. Staton, Thinkstock by gettyimages.com. *Sockeye salmon:* Olga N. Vasik, Thinkstock by gettyimages.com. *Cougar with cub:* Jupiter Images, Thinkstock by gettyimages.com.

WILDLIFE HABITAT

Authors
Nelson, Mark D. USDA Forest Service, St. Paul, MN; Oswalt, Sonja N. USDA Forest Service, Knoxville, TN.; Riitters, Kurt H. USDA Forest Service, Research Triangle Park, NC.

General References
Hall, L.S.; Krausman, P.R.; Morrison, M.L. 1997. The habitat concept and a plea for standard terminology. Wildlife Society Bulletin. 25(1): 173–182.

Hunter, Jr., M.L. 1990. Wildlife, forests, and forestry: principles of managing forests for biological diversity. Englewood Cliffs, NJ: Regents/Prentice Hall. 370 p.

Morrison, M.L.; Marcot, B.G.; Mannan, R.W. 1992. Wildlife-habitat relationships: concepts and applications. Madison, WI: The University of Wisconsin Press. 343 p.

Map Sources
Blackard, J.A.; Finco, M.V.; Helmer, E.H.; Holden, G.R.; Hoppus, M.L.; Jacobs, D.M.; Lister, A.J.; Moisen, G.G.; Nelson, M.D.; Riemann, R.; Ruefenacht, B.; Salajanu, D.; Weyermann, D.L.; Winterberger, K.C.; Brandeis, T.J.; Czaplewski, R.L.; McRoberts, R.E.; Paterson, P.L.; Tymcio, R.P. 2008. Mapping U.S. forest biomass using nationwide forest inventory data and moderate resolution information. Remote Sensing of Environment. 112(4): 1658–1677. https://www.fs.usda.gov/treesearch/pubs/29860. [Date accessed: 04 June 2018].

Homer, C.G.; Dewitz, J.A.; Yang, L.; Jin, S.; Danielson, P.; Xian, G.; Coulston, J.W.; Herold, N.D.; Wickham, J.D.; Megown, K.A. 2015. Completion of the 2011 National Land Cover Database for the conterminous United States: representing a decade of land cover change information. Photogrammetric Engineering & Remote Sensing. 81(5): 345–354.

Riitters, K.H.; Wickham, J.D.; O'Neill, R.V.; Jones, K.B.; Smith, E.R.; Coulston, J.W.; Wade, T.G.; Smith, J.H. 2002. Fragmentation of continental United States forests. Ecosystems. 5: 815–822. https://www.fs.usda.gov/treesearch/pubs/5196. [Date accessed: 04 June 2018].

Ruefenacht, B.; Finco, M.V.; Nelson, M.D.; Czaplewski, R.L.; Helmer, E.H.; Blackard, J.A.; Holden, G.R.; Lister, A.J.; Salajanu, D.; Weyermann, D.L.; Winterberger, K.C. 2008. Conterminous U.S. and Alaska forest type mapping using Forest Inventory and Analysis data. Photogrammetric Engineering & Remote Sensing. 74(11): 1379–1388. https://www.fs.usda.gov/treesearch/pubs/19002. [Date accessed: 04 June 2018].

U.S. Department of Agriculture, Forest Service [Unknown date]. FS Geodata Clearinghouse. https://data.fs.usda.gov/geodata/rastergateway/biomass/index.php. [Date accessed: 29 May 2018].

U.S. Department of Agriculture, Forest Service. 2016. Forest Inventory and Analysis Program data and tools. http://www.fia.fs.fed.us/tools-data/index.php. [Date accessed: 29 May 2018].

Photographs
American-woodcock: Yvonne Sufronk, flickr.com. *Early succession young forest:* Charles Fergus, Wildlife Management Institute. *North American beaver:* Pat Gaines, flickr.com. *Mid succession pole-timber forest:* Tina Shaw, flickr.com. *Pacific banana slug:* Jim Bahn, flickr.com. *Late succession old growth forest:* Nickpdx, wikipedia.org

FOREST BIRDS

Authors
Nelson, Mark D. USDA Forest Service, St. Paul, MN.; Oswalt, Sonja N. USDA Forest Service, Knoxville, TN.

General References
DeGraaf, R.M.; Scott, V.E.; Hamre, R.H.; Ernst, L.; Anderson, S.H. 1991. Forest and rangeland birds of the United States natural history and habitat use. U.S. Department of Agriculture, Forest Service, Agriculture Handbook 688. 625 p.

Nelson, M.D.; Johnson, D.H.; Linkhart, B.D.; Miles, P.D. 2009. Flammulated owl *(Otus flammeolus)* breeding habitat abundance in ponderosa pine forests of the United States. In: Rich, T.D.; Arizmendi, C.; Demarest, D.; Thompson, C. (eds.). Proceedings: Tundra to tropics: connecting birds, habitats and people. McAllen, TX: Partners in Flight. 71–81. https://www.fs.usda.gov/treesearch/pubs/34271. [Date accessed: 04 June 2018].

Peterson, S.R. 1975. Ecological distribution of breeding birds In: Smith, D.R., tech. coord. Proceedings of the symposium on management of forest and range habitats for non-game birds. Gen. Tech. Rep. WO-1. Washington, DC: U.S. Department of Agriculture, Forest Service: 22–38.

Shugart, H.H.; Anderson, S.H.; Strand, R.H. 1975. Dominant patterns in bird populations of the eastern deciduous forest biome. In: Smith, D.R., tech. coord. Proceedings of the symposium on management of forest and range habitats for non-game birds. Gen. Tech. Rep. WO-1. Washington, DC: U.S. Department of Agriculture, Forest Service: 90–95.

Map Sources
Number of breeding bird species: NatureServe. 2011. Lists of vertebrate species in the contiguous U.S. [database]. Arlington, VA. [Date accessed: 17 February 2011].

U.S. Geological Survey. 2016. National Gap Analysis Program (GAP) species data portal. http://gapanalysis.usgs.gov/species/. [Date accessed: 4 April 2016].

U.S. Geological Survey. 2016. Watershed boundary dataset (WBD). http://nhd.usgs.gov/wbd.html. [Date accessed: 04 April 2016].

Flammulated owl breeding range, Western United States: Range data provided by NatureServe in collaboration with Robert Ridgely, James Zook, The Nature Conservancy—Migratory Bird Program, Conservation International—CABS, World Wildlife Fund—U.S., and Environment Canada—WILDSPACE. http://explorer.natureserve.org/servlet/NatureServe. [Date accessed: 03 February 2020].

Wilson, B.T.; Lister, A.J.; Riemann, R.I.; Griffith, D.M. 2013. Live tree species basal area of the contiguous United States (2000-2009). RDS-2013-0013. Newtown Square, PA: USDA Forest Service, Northern Research Station. http://dx.doi.org/10.2737/RDS-2013-0013. [Date accessed: 22 November 2019].

Illustration Source
Forest bird habitat: Sonja N. Oswalt, USDA Forest Service, Knoxville, TN.

Illustration
Forest bird habitat: Linda R. Smith and Lou Ann Reineke; RedCastle Resources, Inc.

Photographs
Wood duck: Arjan Haverkamp, flickr.com. *Northern cardinal:* Curt Hart, flickr.com. *Cooper's hawk:* Steve Herseyva, Wikimedia.org. *Baltimore oriole:* Julian Colton, Wikimedia.org. *Acorn woodpecker:* James N. Perdue. *Ruffed grouse:* Thinkstock by gettyimages.com. *Flammulated owl:* Coconino National Forest, AZ, flickr.com. *Ponderosa pine forest:* Dianne Fristrom, flickr.com.

FOREST FISH AND AQUATIC SPECIES

Authors
Nelson, Mark D. USDA Forest Service, St. Paul, MN.; Oswalt, Sonja N. USDA Forest Service, Knoxville, TN.

General References
Eastern Brook Trout Joint Venture. 2015. Eastern brook trout. http://easternbrooktrout.org. [Date accessed: 29 May 2014].

Gende, S.M.; Quinn, T.P. 2006. The fish and the forest. Scientific American. 295(2): 84–89. https://doi.org/10.1038/scientificamerican0806-84. [Date accessed: 4 June 2018].

Hudy, M.; Thieling, T.M.; Gillespie, N.; Smith, E.P. 2008. Distribution, status, and land use characteristics of subwatersheds within the native range of brook trout in the Eastern United States. North American Journal of Fisheries Management. 28(4): 1069–1085. https://doi.org/10.1577/M07-017.1. [Date accessed: 04 June 2018].

Master, L.L.; Flack, S.R.; Stein, B.A. eds., 1998. Rivers of life: critical watersheds for protecting freshwater biodiversity. Arlington, VA: The Nature Conservancy. 71 p.

U.S. Department of Agriculture, Forest Service. 2016. Watershed, fish, wildlife, air, and rare plants. http://www.fs.fed.us/fishing. [Date accessed: 29 May 2018].

Map Sources
Salamander species count: International Union for Conservation of Nature and Natural Resources (IUCN). 2013. IUCN Red List of threatened species: spatial data download. http://www.iucnredlist.org/technical-documents/spatial-data. [Date accessed: 29 May 2018]. U.S. Geological Survey. 2016. Watershed boundary dataset (WBD). http://nhd.usgs.gov/wbd.html. [Date accessed: 29 May 2018].

Eastern brook trout distribution: Eastern Brook Trout Joint Venture. 2015. Eastern brook trout. http://easternbrooktrout.org. [Date accessed: 29 May 2018].

Wilson, B.T.; Lister, A.J.; Riemann, R.I.; Griffith, D.M. 2013. Live tree species basal area of the contiguous United States (2000-2009). RDS-2013-0013. Newtown Square, PA: USDA Forest Service, St. Paul, MN. http://dx.doi.org/10.2737/RDS-2013-0013. [Date accessed: 22 November 2019].

Illustration Sources

Riparian zone: Naiman, R.J.; Décamps, H. 1997. The ecology of interfaces: riparian zones. Annual Review of Ecology and Systematics. 28: 621–658. https://doi.org/10.1146/annurev.ecolsys.28.1.621. [Date accessed: 04 June 2018].

Ward, J.V. 1998. Riverine landscapes: biodiversity patterns, disturbance regimes, and aquatic conservation. Biological Conservation. 83(3): 269–278. https://doi.org/10.1016/S0006-3207(97)00083-9. [Date accessed: 04 June 2018].

Illustration

Riparian zone: Lou Ann Reineke, RedCastle Resources, Inc.

Photographs

Spotted gar: Sergey Lavrentev, iStock by gettyimages.com. *Mayfly:* Iliuta Goean, iStock by gettyimages.com. *Texas pigtoe:* Michael Gras, M.Ed., flickr.com. *Marbled salamander:* Patrick Coin, flickr.com. *Pacific giant salamander:* John P. Clare, flickr.com. *Eastern brook trout:* U.S. Fish and Wildlife Service, flickr.com.

Icon

Eastern brook trout: Teresa S. Garner, Noun Project, Inc.

FOREST MAMMALS

Authors

Oswalt, Sonja N. USDA Forest Service, Knoxville, TN.; Nelson, Mark D. USDA Forest Service, St. Paul, MN.

General References

Garshelis, D.L.; Crider, D.; van Manen, F. (IUCN SSC Bear Specialist Group). 2008. Ursus americanus. The IUCN Red List of Threatened Species 2008: e.T41687A10513074. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T41687A10513074.en. [Date accessed: 29 May 2018].

Hunter Jr., M.L. 1990. Wildlife, forests, and forestry: principles of managing forests for biological diversity. Englewood Cliffs, NJ: Regents/Prentice Hall. 370 p.

Morrison, M.L.; Marcot, B.G.; Mannan, R.W. 1992. Wildlife-habitat relationships: concepts and applications. Madison, WI: The University of Wisconsin Press. 343 p.

U.S. Department of Agriculture, Forest Service. 2011. National Report on Sustainable Forests—2010. FS-979. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office. 214 p. https://www.fs.usda.gov/treesearch/pubs/54685. [Date accessed: 04 June 2018].

Vaughn, M.R.; Pelton, M.R. 1995. Black bears in North America. In: LaRoe, E.T.; Farris, G.S.; Puckett, C.E.; Doran, P.D.; Mac, M.J., eds. Our living resources: a report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. Washington, DC: U.S. Department of the Interior, National Biological Survey: 100–105. https://pubs.er.usgs.gov/publication/70148108. [Date accessed: 04 June 2018].

Map Sources

Mountains offer rich habitat: NatureServe. 2011. Lists of vertebrate species in the contiguous U.S. [database]. Arlington, VA. [Date accessed: 17 February 2011].

U.S. Geological Survey. 2016. National Gap Analysis Program (GAP) species data portal. http://gapanalysis.usgs.gov/species/. [Date accessed: 04 April 2016].

U.S. Geological Survey. 2016. Watershed boundary dataset (WBD). http://nhd.usgs.gov/wbd.html. [Date accessed: 04 April 2016].

Geographic breeding range of American black bear and associated forest habitat: NatureServe. 2014. NatureServe Explorer. http://explorer.natureserve.org/servlet/NatureServe. [Date accessed: 17 November 2014].

Commission for Environmental Cooperation. 2016. Land cover, 2005. http://www.cec.org/tools-and-resources/map-files/land-cover-2005 [Date accessed: 28 March 2016].

Photographs

Red fox: Betty 4240, iStock by gettyimages.com. *White-tailed deer:* Wendell, flickr.com. *American pine marten (Frontispiece):* Thinkstock by gettyimages.com. *Snowshoe hare:* Traveler 7001, flickr.com. *Indiana bat:* Andrew King, flickr.com. *Bobcat:* S.M. Carter, iStock by gettyimages.com.

Icon

Bear: Noun Project, Inc.

WHAT SHAPES THE FOREST?

Authors

Gray, Andrew N. USDA Forest Service, Corvallis, OR.; Perry, Charles H. USDA Forest Service, St. Paul, MN.

General Reference

Canham, C.D.; Marks, P.L. 1985. The response of woody plants to disturbance: patterns of establishment and growth. In: Pickett, S.T.A.; White, P.S., eds. The ecology of natural disturbance and patch dynamics. New York: Academic Press: 197–216. https://doi.org/10.1016/B978-0-12-554520-4.50016-2. [Date accessed: 04 June 2018].

Photographs

Burn severity study, Yosemite National Park 2011: Andrew Gray, USDA Forest Service. *Mount St. Helens eruption 1980:* United States Geological Survey, Wikipedia.org. *Mount St. Helens Clearwater Ridge 1980:* Charlie Crisafulli, USDA Forest Service, Pacific Northwest. *Mount St. Helens recovery 1984:* Lyn Topinka, usgs.gov. *Mount St. Helens rehabilitation 2005:* Tobias Haase, flickr.com. *Sifford Lake Rehabilitation:* W. Hall, flickr.com.

NATIVE AND NONNATIVE INSECTS AND DISEASES

Authors

Finco, Mark V. RedCastle Resources, Inc., Salt Lake City, UT.; Sapio, Frank J. USDA Forest Service, Fort Collins, CO.; Liebhold, Andrew M. USDA Forest Service, Morgantown, WV.

General Reference

Liebhold, A.M.; McCullough, D.G.; Blackburn, L.M.; Frankel, S.J.; Von Holle, B.; Aukema, J. 2013. A highly aggregated geographical distribution of forest pest invasions in the USA. Diversity and Distributions. 19:1208–1216. https://www.fs.usda.gov/treesearch/pubs/43853. [Date accessed: 04 June 2018].

Map Source

USDA Forest Service. 2016. Forest health protection mapping and reporting. http://foresthealth.fs.usda.gov/portal. [Date accessed: 04 June 2018].

Photographs

Front matter/Mountain pine beetle: Marjorie Nockels, flickr.com. *Western tent caterpillar:* Brytten Steed, USDA Forest Service, Bugwood.org. *Fruiting body of annosum root disease:* Isael Kate, Wikipedia.org. *Gypsy moth:* Susan Ellis, Bugwood.org. *Adult emerald ash borer:* Debbie Miller, USDA Forest Service, Bugwood.org. *White pine blister rust:* Christopher Steenbock, flickr.com.

WILDLAND FIRE AS A NATURAL DISTURBANCE

Authors

Brewer, Charles K. USDA Forest Service, Washington, DC [retired].; Lee, Kristine M. USDA Forest Service, Ogden, UT.

General References

Agee, J.K. 1993. Fire ecology of Pacific Northwest forests. Washington, DC: Island Press. 493 p.

Arno, S.F.; Allison-Bunnell, S. 2002. Flames in our forest: Disaster or renewal? Washington, DC: Island Press. 227 p.

Brewer, C.K.; Winne, J.C.; Redmond, R.L.; Opitz, D.W.; Mangrich, M.V. 2005. Classifying and mapping wildfire severity: a comparison of methods. Photogrammetric Engineering and Remote Sensing. 71(11): 1311–1320. https://doi.org/10.14358/PERS.71.11.1311. [Date accessed: 04 June 2018].

Eidenshink, J.; Schwind, B.; Brewer, K.; Zhu, Z.; Quayle, B.; Howard, S. 2007. A project for monitoring trends in burn severity. Fire Ecology. 3(1): 3–21. https://doi.org/10.4996/fireecology.0301003. [Date accessed: 04 June 2018].

National Wildfire Coordinating Group. 2015. Glossary of wildland fire terminology. https://www.nwcg.gov/glossary/a-z. [Date accessed: 04 June 2018].

Pyne, S.J. 1982. Fire in America: A cultural history of wildland and rural fire. Princeton: Princeton University Press. 654 p.

Map Source:

Natural wildland fires 2014-2018: USDA Forest Service and US Geological Survey. 2020. Monitoring trends in burn severity (MTBS). http://www.mtbs.gov. [Date accessed: 02 June 2020].

Graph Source:

Natural wildland fires 2014-2018: USDA Forest Service and US Geological Survey. 2020. Monitoring trends in burn severity (MTBS). http://www.mtbs.gov. [Date accessed: 02 June 2020].

Photographs

Surface fire: permission granted by Bobby J. Shindelar, Forest Fire Chief, flickr.com. Kari Greer, Contract Photographer, USDA Forest Service, flickr.com. *Understory:* U.S. Fish and Wildlife Service Southeast Region, flickr.com. Josh O'Connor, U.S. Fish and Wildlife Service Southeast Region; flickr.com. *Crown:* Kari Greer, Contract Photographer, USDA Forest Service, flickr.com. Mike Lewelling; National Park Service, Yellowstone, flickr.com.

Icon

Satellite: ESRI Telecom Typeface, esri.com.

WILDLAND FIRE MANAGEMENT

Authors

Brewer, Charles K. USDA Forest Service, Washington, DC [retired].; Lee, Kristine M. USDA Forest Service, Ogden, UT.

General References

Agee, J.K. 1993. Fire ecology of Pacific Northwest forests. Washington, DC: Island Press. 493 p.

Arno, S.F.; Allison-Bunnell, S. 2002. Flames in our forest: Disaster or renewal? Washington, DC: Island Press. 227 p.

Hardy, C.C. 2005. Wildland fire hazard and risk: problems, definitions, and context. Forest Ecology and Management. 211(1/2): 73–82. https://doi.org/10.1016/j.foreco.2005.01.029. [Date accessed: 04 June 2018].

Keane, R.E.; Ryan, K.C.; Veblen, T.T.; Allen, C.D.; Logan, J.A.; Hawkes, B.C. 2002. Cascading effects of fire exclusion in Rocky Mountain ecosystems: a literature review. Gen. Tech. Rep. RMRS-GTR-91. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 24 p. https://www.fs.usda.gov/treesearch/pubs/5132. [Date accessed: 04 June 2018].

National Interagency Fuels, Fire, and Vegetation Technology Transfer. 2010. Interagency Fire Regime Condition Class (FRCC) guidebook. Version 3.0. http://www.fire.org/niftt/released/FRCC_Guidebook_2010_final.pdf. [Date accessed: 22 March 2016].

National Wildfire Coordinating Group. 2015. Glossary of wildland fire terminology. https://www.nwcg.gov/glossary/a-z. [Date accessed: 04 June 2018]..

Pyne, S.J. 1982. Fire in America: A cultural history of wildland and rural fire. Princeton: Princeton University Press. 654 p.

Rollins, M.G.; Frame, C.K., tech. eds. 2006. The LANDFIRE Prototype Project: nationally consistent and locally relevant geospatial data for wildland fire management. Gen. Tech. Rep. RMRS-GTR-175. Fort Collins: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 416 p. https://www.fs.usda.gov/treesearch/pubs/24484. [Date accessed: 04 June 2018].

Stephens, S.L.; Lawrence, W.R. 2005. Federal forest-fire policy in the United States. Ecological Applications. 15: 532–542. https://doi.org/10.1890/04-0545. [Date accessed: 04 June 2018].

Map Source

LandFire. 2013. Vegetation conditional class. https://www.landfire.gov/NationalProductDescriptions10.php. [Date accessed: 04 June 2018].

Photographs

Firefighting team, Hotshot crew: Kari Greer, Contract Photographer, USDA Forest Service, flickr.com. *Fire management strategy, Gladiator Fire:* Kari Greer, Contract Photographer, USDA Forest Service, flickr.com. *Fire management strategy, helicopter drop:* Master Sgt. Jeremy Lock, U.S. Air Force, flickr.com. *Ground resources:* Buck Kline; Incident Commander Georgia Forestry Commission, Fire Management Today. *Looking and feeling for hotspots:* Lance Cheung, Photographer, USDA Forest Service, flickr.com. *Prescribed fire:* Eli Lehmann, USDA Forest Service, Fire Management Today.

Icon

Fire: Nick Abrams, Noun Project, Inc.—Edited by Linda R. Smith, RedCastle Resources, Inc.

PROVIDING QUALITY WOOD PRODUCTS WHILE SUSTAINING OUR FORESTS

Authors

Morgan, Todd A. University of Montana, Missoula, MT.; Sorenson, Colin B. USDA Forest Service, Missoula, MT.

General References

Gale, C.B.; Keegan, C.E., III; Berg, E.C.; Daniels, J.; Christensen, G.A.; Sorenson, C.B.; Morgan, T.A.; Polzin, P. 2012. Oregon's forest products industry and timber harvest, 2008: Industry trends and impacts of the Great Recession through 2010. Gen. Tech. Rep. PNW-GTR-868. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 55 p. https://www.fs.usda.gov/treesearch/pubs/41541. [Date accessed: 04 June 2018].

Hayes, S.W.; Morgan, T.A.; Berg, E.C.; Daniels, J.M.; Thompson, M.T. 2012. The Four Corners timber harvest and forest products industry, 2007. Res. Bull. RMRS-RB-13. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 61 p. https://www.fs.usda.gov/treesearch/pubs/40885. [Date accessed: 04 June 2018].

Smith, W.B.; Miles, P.D.; Perry, C.H.; Pugh, S.A. 2009. Forest Resources of the United States, 2007: a technical document supporting the forest service 2010 RPA Assessment. Gen. Tech. Rep. WO-78. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office. 336 p. https://www.fs.usda.gov/treesearch/pubs/17334. [Date accessed: 04 June 2018].

Map Sources

Timber harvest: U.S. Department of Agriculture, Forest Service. 2016. Forest Inventory and Analysis program data and tools. http://www.fia.fs.fed.us/tools-data/index.php. ([Date accessed: 04 June 2018].

U.S. Department of Agriculture, Forest Service. 2007. Timber product output (TPO) reports. http://srsfia2.fs.fed.us/php/tpo_2009/tpo_rpa_int1.php. [Date accessed: 22 March 2016].

Graph Sources

Warren, D.D. 2000. Production, prices, employment, and trade in Northwest forest industries, all quarters 1998. Res. Bull. PNW-RB-231. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 171 p. https://www.fs.usda.gov/treesearch/pubs/3025. [Date accessed: 4 June 2018].

Warren, D.D. 2011. Production, prices, employment, and trade in Northwest forest industries, all quarters 2010. Res. Bull. PNW-RB-260. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 161 p. https://www.fs.usda.gov/treesearch/pubs/38431. [Date accessed: 04 June 2018].

Graphic Source

Perry, C.H.; Nelson, M.D.; Piva, R.J. 2010. Imports and exports of roundwood in the upper Midwestern United States: the movement of raw logs from harvest sites to out-of-state processing mills. In: Eredics, P., ed. Mapping forestry. Redlands, CA: ESRI Press. 5–8.

Photographs

Delimber: Eric Simmons, University of Montana. *Log tractor:* Abadonian, iStock by gettyimages.com. *Log hauling truck:* Darin Burt, iStock by gettyimages.com. *Sawmill plant:* Paul Grecaud, iStock by gettyimages.com. *Wood production:* Bogdanhoda, iStock by gettyimages.com. *Lumber mill plant:* Charles B. Gale.

PLANTED FORESTS

Author

Oswalt, Christopher M. USDA Forest Service, Knoxville, TN.

General References

Brown, C. 2000. The global outlook for future wood supply from forest plantations. Working Paper No. GFPOS/WP/03. Rome: United Nations Food and Agriculture Organization, Forest Policy and Planning Division. 141 p. http://www.fao.org/docrep/003/x8423e/x8423e00.htm. [Date accessed: 04 June 2018].

Zhang, D.; Stanturf, J. 2008. Forest plantations. In: Jørgensen, S.E.; Fath, B.D., eds. Encyclopedia of ecology, Vol. 2. Oxford, England: Elsevier: 1673–1680.

Map Source

U.S. Department of Agriculture, Forest Service. 2016. Forest Inventory and Analysis program data and tools. http://www.fia.fs.fed.us/tools-data/index.php. [Date accessed: 04 June 2018].

Illustration

Lou Ann Reineke, RedCastle Resources, Inc.

Photographs

Douglas fir: Francis Eatherington, flickr.com. *Ponderosa pine:* Patrick Alexander, flickr.com. *Red pine:* Joshua Mayer, flickr.com. *American chestnut:* AM Daugherty, flickr.com. *Loblolly pine:* Larry D. Moore, Wikimedia.org. *Slash pine:* Jennifer Hinckley, U.S. Fish and Wildlife Service Southeast Region, flickr.com.

OUR CHANGING FORESTS

Authors

Finco, Mark V. RedCastle Resources, Inc., Salt Lake City, UT.; Gray, Andrew N. USDA Forest Service, Corvallis, OR.

General References

Greenberg, C.H.; Weeks, K.; Warburton, G.S. 2015. The historic role of humans and other keystone species in shaping central hardwood forests for disturbance-dependent wildlife. In: Greenberg, C.H.; Collins, B.S., eds. Natural disturbances and historic range of variation: type, frequency, severity, and post-disturbance structure in central hardwood forests USA. Managing Forest Ecosystems. 32: 319–354.

Oswalt, S.N.; Smith, W.B.; Miles, P.D.; Pugh, S.A. 2014. Forest resources of the United States, 2012: a technical document supporting the Forest Service 2015 update of the RPA Assessment. Gen. Tech. Rep. WO-91. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office. 218 p. https://www.fs.usda.gov/treesearch/pubs/47322. [Date accessed: 04 June 2018].

Sisk, T.D., ed. 1998. Perspectives on the land-use history of North America: a context for understanding our changing environment. Biol. Sci. Rep. 1998-0003. Reston, VA: U.S. Geological Survey, Biological Resources Division. 104 p.

Map sources

Forest area projections: Oswalt, Sonja S.N.; Smith, W.B.; Miles, P.D.; Pugh, S.A. 2014. Forest resources of the United States, 2012: a technical document supporting the Forest Service 2015 update of the RPA Assessment. Gen. Tech. Rep. WO-91. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office. 218 p. https://www.fs.usda.gov/treesearch/pubs/47322. [Date accessed: 04 June 2018].

Current land cover: Homer, C.; Dewitz, J.; Fry, J.; Coan, M.; Hossain, N.; Larson, C.; Herold, N.; McKerrow, A.; VanDriel, J.N.; Wickham, J. 2007. Completion of the 2001 National Land Cover Database for the conterminous United States. Photogrammetric Engineering and Remote Sensing. 73(4): 337–341.

Homer, C.G.; Dewitz, J.A.; Yang, L.; Jin, S.; Danielson, P.; Xian, G.; Coulston, J.; Herold, N.D.; Wickham, J.D.; Megown, K. 2015. Completion of the 2011 National Land Cover Database for the conterminous United States: representing a decade of land cover change information. Photogrammetric Engineering and Remote Sensing. 81(5): 345–354.

Multi-Resolution Land Characteristics Consortium (MRLC). 2015. National Land Cover Database, 2011. http://www.mrlc.gov/data. [Date accessed: 14 November 2018].

Graphic source

Forest land trends: Oswalt, Sonja S.N.; Smith, W.B.; Miles, P.D.; Pugh, S.A. 2014. Forest resources of the United States, 2012: a technical document supporting the Forest Service 2015 update of the RPA Assessment. Gen. Tech. Rep. WO-91. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office. 218 p. https://www.fs.usda.gov/treesearch/pubs/47322. [Date accessed: 04 June 2018].

Photographs
Acoma Pueblo, NM, 1899: W.H. Jackson. https://archive.usgs.gov/archive/sites/landcover.usgs.gov/luhna/chap9.html. [Date accessed: 22 November 2019]. *Acoma Pueblo, NM, 1977:* H.E. Malde Allen. *Ross Hole, MT, 1895:* Unknown Author. *Ross Hole, MT, 1980:* George Gruell, Mansfield Library, University of Montana. *Mountaintop coal mining, Magoffin County, KY, 2008*: Google Earth, Google Maps, Appalachian Voices. *Mountaintop coal mining, Magoffin County, KY, 2013:* Google Earth, Google Maps, Appalachian Voices.

WHAT BENEFITS DO FORESTS PROVIDE?

Authors
Finco, Mark V. RedCastle Resources, Inc., Salt Lake City, UT; Perry, Charles H. USDA Forest Service, St. Paul, MN.

General Reference
Millennium Ecosystem Assessment. 2005. Ecosystems and human well-being: a framework for assessment. Washington, DC: Island Press. 5 volumes. https://www.millenniumassessment.org/en/index.html. [Date accessed: 29 May 2018].

Photographs
Forests provide clean water: Dave Kuebler, iStock by gettyimages.com. *Urban forests provide benefits where we live:* Tri Met, flickr.com. *Regenerated longleaf pine (Frontispiece):* © 2007 Andrew Kornylak. *Riparian forest buffers agricultural landscapes:* Nicholas A. Tonelli, flickr.com. *Wood products are ever present in our daily lives:* Maudib, iStock by gettyimages.com. *Forests and Grasslands provide the greatest diversity of outdoor recreation opportunities:* Christopher Futcher, iStock by gettyimages.com.

CLEAN WATER

Author
Brown, Thomas C. USDA Forest Service, Fort Collins, CO.

General References
Brooks, K.N.; Ffolliott, P.F.; Magner, J.A. 2013. Hydrology and the management of watersheds, 4th ed. Ames, IA: Wiley-Blackwell. 533 p.

Brown, T.C.; Foti, R.; Ramirez, J.A. 2012. Water resources (Chapter 12). In: Future of America's forest and rangelands: Forest Service 2010 Resources Planning Act Assessment. Gen. Tech. Rep. WO-87. Washington, DC: U.S. Department of Agriculture, Forest Service: 109–121. https://www.fs.usda.gov/treesearch/pubs/41976. [Date accessed: 29 May 2018].

Foti, R.; Ramirez, J.A.; Brown, T.C. 2012. Vulnerability of U.S. water supply to shortage: a technical document supporting the Forest Service 2010 RPA Assessment. Gen. Tech. Rep. RMRS-GTR-295. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 147 p. https://www.fs.usda.gov/treesearch/pubs/42363. [Date accessed: 29 May 2018].

Map Source
Foti, R.; Ramirez, J.A.; Brown, T.C. 2012. Vulnerability of U.S. water supply to shortage: a technical document supporting the Forest Service 2010 RPA Assessment. Gen. Tech. Rep. RMRS-GTR-295. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 147 p. https://www.fs.usda.gov/treesearch/pubs/42363. [Date accessed: 29 May 2018].

Graph Source
Brown, T.C.; Foti, R.; Ramirez, J.A. 2012. Water resources (Chapter 12). In: Future of America's forest and rangelands: Forest Service 2010 Resources Planning Act Assessment. Gen. Tech. Rep. WO-87. Washington, DC: U.S. Department of Agriculture, Forest Service. p. 109-121. https://www.fs.usda.gov/treesearch/pubs/41976. [Date accessed: 29 May 2018].

Foti, R.; Ramirez, J.A.; Brown, T.C. 2012. Vulnerability of U.S. water supply to shortage: a technical document supporting the Forest Service 2010 RPA Assessment. Gen. Tech. Rep. RMRS-GTR-295. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 147 p. https://www.fs.usda.gov/treesearch/pubs/42363. [Date accessed: 29 May 2018].

Illustration
Lou Ann Reineke, RedCastle Resources, Inc.

Photographs
Rainfall on forest: Welcomia, iStock by gettyimages.com. *Leaf interception:* Drew Brayshaw, flickr.com. *Streamflow:* Jesse Varner, flickr.com. *Stemflow:* Patrik Stedrak, iStock by gettyimages.com. *Throughfall:* Andy Pantz, iStock by gettyimages.com. *Infiltration/forest floor (Frontispiece):* Kanonsky, iStock by gettyimages.com.

WILDERNESS

Author
Landres, Peter B. USDA Forest Service, Missoula, MT.

General References
Fox, S.; Phillippe, C.; Hoover, V.; Lambert, L., eds. 2015. Celebrating the 50th Anniversary of the Wilderness Act, Proceedings of the National Wilderness Conference. 364 p. http://www.wilderness.net/toolboxes/documents/50th/National_Wilderness_Conference_Proceedings_2014.pdf. [Date accessed: 29 May 2018].

Landres, P.; Barns, C.; Boutcher, S.; Devine, T.; Dratch, P.; Lindholm, A.; Merigliano, L.; Roeper, N.; Simpson, E. 2015. Keeping it wild 2: an updated interagency strategy to monitor trends in wilderness character across the National Wilderness Preservation System. Gen. Tech. Rep. RMRS-GTR-340. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 114 p. https://www.fs.usda.gov/treesearch/pubs/49721. [Date accessed: 29 May 2018].

Wilderness Act of 1964, 16 U.S.C. 1121 (note), 1131–1136.

Map Source
Wilderness.net. 2016. Wilderness boundary data. http://www.wilderness.net/NWPS/geography. [Date accessed: 22 November 2019].

Graph Source
Wilderness.net. 2016. Wilderness boundary data. http://www.wilderness.net/NWPS/geography. [Date accessed: 22 November 2019].

Photographs
Caribou-Speckled Mountain Wilderness, NH: Sean Munson, flickr.com. *Kings Range Wilderness, CA:* Bob Wick, Bureau of Land Management, flickr.com. *Charon's Garden Wilderness Area,OK:* Justin Meissen, flickr.com. *Wrangell-Saint Elias Wilderness, AK:* Jacob W. Frank, National Park Service, flickr.com. *Pelican Island National Wildlife Refuge, FL:* George Gentry, U.S. Fish and Wildlife Service. *Gila Wilderness, NM:* Unknown Author, wikimedia.org.

AGROFORESTRY

Authors
Bentrup, Gary; Kellerman, Todd A.; Schoeneberger, Michele M.; Straight, Richard T. USDA Forest Service, Lincoln, NE.

General References
Garrett, H.E. (ed). 2009. North American agroforestry: an integrated science and practice. 2nd ed. Madison, WI: American Society of Agronomy. 379 p.

Jose, S.; Gordon, A.M. 2008. Ecological knowledge and agroforestry design: an introduction. In: Jose, S.; Gordon, A.M., eds. Toward agroforestry design: an ecological approach. Advances in Agroforestry. Dordrecht, Netherlands: Springer: 3-9. Vol. 4.

U.S. Department of Agriculture, Forest Service/Natural Resources Conservation Service, National Agroforestry Center. Working trees series. http://nac.unl.edu/workingtrees.htm. [Date accessed: 24 October 2012].

Map Sources
Fry, J.; Xian, G.; Jin, S.; Dewitz, J.; Homer, C.; Yang, L.; Barnes, C.; Herold, N.; Wickham, J. 2011. Completion of the 2006 National Land Cover Database for the conterminous United States. Photogrammetric Engineering and Remote Sensing. 77(9): 858–864. http://www.mrlc.gov/nlcd2006.php. [Date accessed: 24 October 2012].

U.S. Department of Agriculture. 2010. 2007 Natural resources inventory: soil erosion on cropland. Natural Resources Conservation Service. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_012269.pdf. [Date accessed: 29 May 2018].

Illustration Source
Schoeneberger, Michele M.; Bentrup, Gary; Patel-Weynand, Toral, eds. 2017. Agroforestry: Enhancing resiliency in U.S. agricultural landscapes under changing conditions. Gen. Tech. Rep. WO-96. Washington, DC: U.S. Department of Agriculture, Forest Service. 228 p. https://doi.org/10.2737/WO-GTR-96. [Date accessed unknown].

Illustration
Lou Ann Reineke, RedCastle Resources, Inc.

Photographs
Silvopasture: Mack Evans, Private forest landowner. *Riparian forest buffers:* Nicholas A. Tonelli, flickr.com. *Forest farming:* USDA Forest Service, National Agroforestry Center. *Special applications:* USDA Forest Service, National Agroforestry Center. *Alley cropping:* Tracey Coulter, Agroforestry Coordinator, PA DCNR, Bureau of Forestry. *Windbreaks:* Erwin Cole, USDA Natural Resources Conservation Service.

URBAN FORESTS PROVIDE BENEFITS WHERE WE LIVE

Author
Nowak, David J. USDA Forest Service, Syracuse, NY.

General References
Nowak, D.J.; Dwyer, J.F. 2007. Understanding the benefits and costs of urban forest ecosystems. In: Kuser, J.E., ed. Urban and community forestry in the northeast. Springer Netherlands. 25–46.

Wear, D.N. 2011. Forecasts of county-level land uses under three future scenarios: a technical document supporting the Forest Service 2010 RPA Assessment. Gen. Tech. Rep. SRS-141. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 41 p. http://www.treesearch.fs.fed.us/pubs/39404. [Date accessed: 29 May 2018].

Map Sources
Nowak, D.J.; Greenfield, E.J. 2012. Tree and impervious cover change in U.S. cities. Urban Forestry and Urban Greening. 11: 21–30. https://www.fs.usda.gov/treesearch/pubs/40114. [Date accessed: 29 May 2018].

Nowak, D.J.; Greenfield, E.J. 2012. Tree and impervious cover in the United States. Landscape and Urban Planning. 107: 21–30. https://www.fs.usda.gov/treesearch/pubs/40876. [Date accessed: 29 May 2018].

Nowak, D.J.; Greenfield, E.J.; Hoehn, R.; LaPoint. E. 2013. Carbon storage and sequestration by trees in urban and community areas of the United States. Environmental Pollution. 178: 229–236. https://www.fs.usda.gov/treesearch/pubs/46254. [Date accessed: 29 May 2018].

Nowak, D.J.; Hirabayashi, S.; Bodine, A.; Greenfield, E. 2014. Tree and forest effects on air quality and human health in the United States. Environmental Pollution. 193: 119–129. https://www.fs.usda.gov/treesearch/pubs/46102. [Date accessed: 29 May 2018].

Urban forest projections: USDA Forest Service. 2012. Future scenarios: a technical document supporting the Forest Service 2010 RPA Assessment. Gen. Tech. Rep. RMRS-GTR-272. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 34 p. http://www.fs.fed.us/research/rpa/assessment/. [Date accessed: 29 May 2018].

County land area: U.S. Census Bureau. 2016. 2010 Census, Community facts. http://factfinder2.census.gov. [Date accessed: 23 March 2016].

Photographs

Residential district, Fort Collins, CO: Marek Uliasz, iStock by gettyimages.com. *Cedar Lake Trail to Minneapolis, MN:* Michael Hicks, flickr.com. *Henry Hudson Parkway to Manhattan, NY:* B.K., flickr.com. *Audubon Riverview Park, New Orleans, LA:* Infrogmation of New Orleans, flickr.com. *Community tree planting, New York City, NY:* Tishman Environment and Design Center, flickr.com. *Transit Mall, Portland, OR:* Tri Met, flickr.com.

TAKING STOCK OF CARBON

Authors

Woodall, Christopher W. USDA Forest Service, Durham, NH.; Domke, Grant M. USDA Forest Service, St. Paul, MN.

General References

Birdsey, R.; Pregitzer, K.; Lucier, A. 2006. Forest carbon management in the United States: 1600–2100. Journal of Environmental Quality. 35: 1461–1469. https://www.fs.usda.gov/treesearch/pubs/15856. [Date accessed: 29 May 2018].

Pan, Y.; Birdsey, R.A.; Fang, J.; Houghton, R.; Kauppi, P.E.; Kurz, W.A.; Phillips, O.L.; Shvidenko, A.; Lewis, S.L.; Canadell, J.G.; Ciais, P.; Jackson, R.B.; Pacala, S.W.; McGuire, A.D.; Piao, S.; Rautiainen, A.; Sitch, S.; Hayes, D. 2011. A large and persistent carbon sink in the world's forests. Science. 333: 988–993. https://www.fs.usda.gov/treesearch/pubs/38624. [Date accessed: 29 May 2018].

U.S. Environmental Protection Agency. 2020. Inventory of U.S. greenhouse gas emissions and sinks: 1990–2018. Washington, DC: U.S. Environmental Protection Agency.EPA 430-R-20-002.

Woodall, C.W.; Skog, K.; Smith, J.E.; Perry, C.H. 2011. Criterion 5: Maintenance of forest contribution to global carbon cycles. In: Robertson, G.; Gaulke, P.; McWilliams, R.; LaPLante, S.; Guldin, R., eds. National report on sustainable forests–2010. FS-979. Washington, DC: U.S. Department of Agriculture, Forest Service: II-59–II-65. https://www.fs.usda.gov/treesearch/pubs/54685. [Date accessed: 29 May 2018].

Map Source

Wilson, B.T.; Woodall, C.W.; Griffith, D.M. 2013. Imputing forest carbon stock estimates from inventory plots to a nationally continuous coverage. Carbon Balance and Management. 8:1. doi:10.1186/1750-0680-8-1. https://www.fs.usda.gov/treesearch/pubs/42806. [Date accessed: 29 May 2018].

Photographs

Vehicle emissions: Fuse, Thinkstock by gettyimages.com. *Electrical power generation:* Daniel Oertelt, Thinkstock by gettyimages.com. *Air conditioning:* Kathryn Neville, Thinkstock by gettyimages.com. *Aboveground live carbon:* Miguel Vieria, Wikimedia.org. *Deadwood and litter carbon:* VibeImages, Thinkstock by gettyimages.com. *Belowground live and soil organic carbon:* C.H. Perry, USDA Forest Service.

WOOD PRODUCTS IN EVERYDAY LIFE

Authors

Morgan, Todd A. University of Montana, Missoula, MT.; Sorenson, Colin B. USDA Forest Service, Missoula, MT.

General References

APA—The Engineered Wood Association. 2016. Resource library. https://www.apawood.org/resource-library. [Date accessed: 29 May 2018].

U.S. Census Bureau. [N.d.]. New Residential Construction. http://www.census.gov/construction/nrc/. [Date accessed: 29 May 2018].

U.S. Department of Agriculture, Forest Service. [N.d.]. Forest Products Laboratory. http://www.fpl.fs.fed.us/. [Date accessed: 29 May 2018].

Map Sources

Howard, J.L.; Jones, K.C. 2016. U.S. timber production, trade, consumption, and price statistics, 1965–2013. Res. Pap. FPL-RP-679. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 100 p. https://www.fs.usda.gov/treesearch/pubs/50895. [Date accessed: 29 May 2018].

Howard, J.L.; Westby, R.M. 2013. U.S. timber production, trade, consumption and price statistics 1965–2011. Res. Pap. FPL-RP-676. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 91 p. https://www.fs.usda.gov/treesearch/pubs/43952. [Date accessed: 29 May 2018].

U.S. Census Bureau. 2018. About the population. http://www.census.gov/topics/population/about.html. [Date accessed: 29 May 2018].

U.S. Department of Agriculture, Forest Service. 2012. Timber product output (TPO) Reports. Knoxville, TN: U.S. Department of Agriculture Forest Service, Southern Research Station. http://srsfia2.fs.fed.us/php/tpo_2009/tpo_rpa_int1.php. [Date accessed: 29 May 2018].

Howard, J. L.; Liang, Shaobo. 2019. U.S. timber production, trade, consumption, and price statistics, 1965–2017. Research Paper FPL-RP-701. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 96 p.

Graph Source

Howard, J. L.; Liang, S. 2019. U.S. timber production, trade, consumption, and price statistics, 1965–2017. Research Paper FPL-RP-701. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 96 p. https://www.fs.usda.gov/treesearch/pubs/58506. [Date accessed unknown].

Illustration Sources

Types of wood products and where we encounter them: Morgan, Todd A. University of Montana, Missoula, MT. Sorenson, Colin B. USDA Forest Service, Missoula, MT.

Illustration

Blake Luther, Luther Studio Architects. Lou Ann Reineke, RedCastle Resources, Inc.

Photographs

Interior décor: Dr-Interior, iStock by gettyimages.com. *Construction:* Maudib, Thinkstock by gettyimages.com. *Charcoal:* Takahashi Kei, Thinkstock by gettyimages.com. *Shampoo:* Fotoedu, Thinkstock by gettyimages.com. *Diapers:* 3sbworld, Thinkstock by gettyimages.com. *Television screen:* Fuse, Thinkstock by gettyimages.com.

FOREST INDUSTRIES KEEP AMERICA WORKING

Authors

Morgan, Todd A. University of Montana, Missoula, MT.; Sorenson, Colin B. USDA Forest Service, Missoula, MT.

General References

Hodges, D.G.; Hartsell, A.J.; Brandeis, C.; Brandeis, T.J.; Bentley, J.W. 2011. Recession effects on the forests and forest products industries of the south. Forest Products Journal. 61(8): 614–624. https://www.fs.usda.gov/treesearch/pubs/42268. [Date accessed: 29 May 2018].

Keegan, C.E.; Sorenson, C.B.; Morgan, T.A.; Hayes, S.W.; Daniels, J.M. 2011. Impact of great recession and housing collapse on the forest products industry in the western United States. Forest Products Journal. 61(8): 625–634. https://www.fs.usda.gov/treesearch/pubs/42663. [Date accessed: 29 May 2018].

U.S. Department of Commerce, Bureau of Economic Analysis. [N.d.]. Regional Economic Accounts. http://www.bea.gov/regional/. [Date accessed unknown].

Woodall, C.W.; Ince, P.J.; Skog, K.E.; Aguilar, F.X.; Keegan, C.E.; Sorenson, C.B.; Hodges, D.G.; Smith, W.B. 2011. An overview of the forest products sector downturn in the United States. Forest Products Journal. 61(8): 595–604. https://www.fs.usda.gov/treesearch/pubs/40917. [Date accessed: 29 May 2018].

Woodall, C.W.; Luppold, W.G.; Ince, P.J.; Piva, R.J.; Skog, K.E. 2011. An assessment of the downturn in the forest products sector in the northern region of the United States. Forest Products Journal. 61(8): 604–613. https://www.fs.usda.gov/treesearch/pubs/40916. [Date accessed: 29 May 2018].

Map Sources

Bentley, J. USDA Forest Service, Knoxville, TN.

Johnson, T.G.; Bentley, J.W.; Howell, M. 2008. The South's timber industry—an assessment of timber product output and use, 2005. Resour. Bull. SRS–135. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 52 p.

U.S. Department of Commerce, Bureau of Economic Analysis. [N.d.]. Regional Economic Accounts. http://www.bea.gov/regional/. [Date accessed unknown].

Graph Source

Perry, C.H. USDA Forest Service, St. Paul, MN. Smith, L.R. RedCastle Resources, Inc.

Photographs

Logger thinning forest: Stock studio X, iStock by gettyimages.com. *Helicopter logging:* Boots McGhee Photography. *Lumber counting:* Think out loud, flickr.com. *Lumber mill:* Emerald Forest Products Lab, Boise National Forest, ID, flickr.com. *Wood manufacturing:* Guru XOOX, iStock by gettyimages.com. *Paper mill:* Brandan Ozdemir, iStock by gettyimages.com.

WHAT IS THE FUTURE OF OUR FORESTS?

Authors

Perry, Charles H. USDA Forest Service, St. Paul, MN.; Finco, Mark V. RedCastle Resources, Inc., Salt Lake City, UT.

General References

Alexander, K.; Gorte, R.W. 2007. Federal land ownership: constitutional authority and the history of acquisition, disposal, and retention. RL34267. Washington, DC:

Congressional Research Service. 14 p. https://fas.org/sgp/crs/misc/RL34267.pdf. [Date accessed: 29 May 2018].

Millennium Ecosystem Assessment. 2005. Ecosystems and human well-being: a framework for assessment. Washington, DC: Island Press. 5 volumes. https://www.millenniumassessment.org/en/index.html. [Date accessed: 29 May 2018].

Photographs
Hardwood forest, NH: Daniel Sperduto, New Hampshire Department of Natural and Cultural Resources. *Tioga state forest, PA:* Nicholas A. Tonelli, flickr.com. *Prescribed burn, wildland-urban interface:* U.S. Fish and Wildlife Service, Fire Management Program. *Alaska Salmon watershed conservation project:* © Bridget Besaw for The Nature Conservancy. *Alaska glacier calving:* Andrewman327, wikipedia.org. *Mudslide, flood, Cascade Fire Complex:* Boise National Forest, ID, flickr.com.

WHO OWNS THE FORESTS?

Author
Butler, Brett J. USDA Forest Service, Amherst, MA.

General References
Oswalt, S.N.; Smith, W.B.; Miles, P.D.; Pugh, S.A. 2014. Forest resources of the United States, 2012: a technical document supporting the Forest Service 2015 update of the RPA Assessment. Gen. Tech. Rep. WO-91. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office. 218 p. https://www.fs.usda.gov/treesearch/pubs/47322. [Date accessed: 04 June 2018].

van Kooten, G.C. 1993. Land resource economics and sustainable development. Vancouver: UBC Press. 450 p.

Map Sources
Blackard, J.A.; Finco, M.V.; Helmer, E.H.; Holden, G.R.; Hoppus, M.L.; Jacobs, D.M.; Lister, A.J.; Moisen, G.G.; Nelson, M.D.; Riemann, R.; Ruefenacht, B.; Salajanu, D.; Weyermann, D.L.; Winterberger, K.C.; Brandeis, T.J.; Czaplewski, R.L.; McRoberts, R.E.; Paterson, P.L.; Tymcio, R.P. 2008. Mapping U.S. forest biomass using nationwide forest inventory data and moderate resolution information. Remote Sensing of Environment. 112: 1658–1677. https://www.fs.usda.gov/treesearch/pubs/29860. [Date accessed: 29 May 2018].

Conservation Biology Institute (CBI). 2010. PAD-US 1.1 (CBI Edition). https://consbio.org/products/projects/pad-us-cbi-edition. [Date accessed: 29 May 2018].

Nelson, M.D.; Liknes, G.C.; Butler, B.J. 2010. Forest ownership in the conterminous United States: ForestOwn_v1 geospatial dataset. Newtown Square, PA: USDA Forest Service, Northern Research Station. http://dx.doi.org/10.2737/RDS-2010-0002. http://www.fs.usda.gov/rds/archive/Product/RDS-2010-0002/. [Date accessed: 29 May 2018].

Graph Sources
Oswalt, S.N.; Smith, W.B.; Miles, P.D.; Pugh, S.A. 2014. Forest Resources of the United States, 2012: a technical document supporting the Forest Service 2015 update of the RPA Assessment. Gen. Tech. Rep. WO-91. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office. 218 p. https://www.fs.usda.gov/treesearch/pubs/47322. [Date accessed: 29 May 2018].

The Property Right Paradigm Source
Alchian, A.A.; Demsetz, H. 1973. The Property Right Paradigm. The Journal of Economic History. 33(1): 16–27.

The Property Right Paradigm Photo
Linda R. Smith, RedCastle Resources, Inc.

Photographs
Conservation and preservation rights: Blaine Potts, Bureau of Land Management, flickr.com. *Recreation rights:* Kaibab National Forest, AZ, flickr.com. *Timber harvest and sale rights:* James R. Fierek, flickr.com. *Wild or released game hunting rights:* Tina Shaw, U.S. Fish and Wildlife Service, flickr.com. *Belowground resource rights:* Don Shall, flickr.com. *Owners of rights can sell or give away those rights:* Mario Tama, iStock by gettyimages.com.

AMERICA'S PRIVATE FOREST OWNERS

Author
Butler, Brett J. USDA Forest Service, Amherst, MA.

General Reference
Butler, B.J.; Tyrrell, M.; Feinberg, G.; VanManen, S.; Wiseman, L.; Wallinger, S. 2007. Understanding and reaching family forest owners: Lessons from social marketing research. Journal of Forestry. 105(7): 348–357. https://www.fs.usda.gov/treesearch/pubs/13248. [Date accessed: 29 May 2018].

Map Sources
Blackard, J.A.; Finco, M.V.; Helmer, E.H.; Holden, G.R.; Hoppus, M.L.; Jacobs, D.M.; Lister, A.J.; Moisen, G.G.; Nelson, M.D.; Riemann, R.; Ruefenacht, B.; Salajanu, D.; Weyermann, D.L.; Winterberger, K.C.; Brandeis, T.J.; Czaplewski, R.L.; McRoberts, R.E.; Paterson, P.L.; Tymcio, R.P. 2008. Mapping U.S. forest biomass using nationwide forest inventory data and moderate resolution information. Remote Sensing of Environment. 112: 1658–1677. https://www.fs.usda.gov/treesearch/pubs/29860. [Date accessed: 29 May 2018].

Conservation Biology Institute (CBI). 2010. PAD-US 1.1 (CBI Edition). https://consbio.org/products/projects/pad-us-cbi-edition. [Date accessed: 29 May 2018].

Environmental Systems Research Institute Inc. 2006. ESRI Data & Maps. Redlands, CA: Environmental Systems Research Institute Inc.

Hewes, J.H., Butler, B.J., Liknes, G.C., Nelson, M.D., Snyder, S.A. 2014. Map of forest ownership across the conterminous United States. Res. Map. NRS-6. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. https://www.fs.usda.gov/treesearch/pubs/46386. [Date accessed: 29 May 2018].

Graph Source
Butler, B.J. 2008. Family forest owners of the United States, 2006. Gen. Tech. Rep. NRS-27. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 73 p. https://www.fs.usda.gov/treesearch/pubs/15758. [Date accessed: 29 May 2018].

Photographs
Family/individual (Frontispiece): U.S. Department of Agriculture, flickr.com. *Other Private, Native American (Frontispiece):* Jon Ivy; Coquille Tribe.com. *Corporate:* Northwest Advanced Renewables Alliance Staff. *Family/Individual:* Pradeep Edussuriya for National Network of Forest Practitioners. *Other private (Frontispiece):* Liba Pejchar, The Nature Conservancy. *Corporate:* Dennis Schroeder, National Renewable Energy Laboratory (NREL).

AMERICA'S PUBLIC FOREST OWNERS

Author
Butler, Brett J. USDA Forest Service, Amherst, MA.

General References
Conservation Biology Institute. 2012. PAD-US (CBI Edition), Version 2. http://consbio.org/products/projects/pad-us-cbi-edition. [Date accessed: 05 June 2014].

Smith, W.B.; Miles, P.D.; Perry, C.H.; Pugh, S.A. 2009. Forest Resources of the United States, 2007: a technical document supporting the forest service 2010 RPA Assessment. Gen. Tech. Rep. WO-78. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office. 336 p. https://www.fs.usda.gov/treesearch/pubs/17334. [Date accessed: 04 June 2018].

Map Sources
Hewes, J.H., Butler, B.J., Liknes, G.C., Nelson, M.D., Snyder, S.A. 2014. Map of forest ownership across the conterminous United States. Res. Map. NRS-6. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. https://www.fs.usda.gov/treesearch/pubs/46386. [Date accessed: 29 May 2018].

Illustration
Stewards of public lands timeline: Linda R. Smith and Lou Ann Reineke; RedCastle Resources, Inc.

Photographs
Forest Service, Boundary Waters Canoe Area Wilderness, MN: Hobie Perry, USDA Forest Service. *Bureau of Land Management: St Anthony Sand Dunes, ID:* Bob Wick, Bureau of Land Management, flickr.com. *National Park Service: Lake Clark National Park, AK:* Donald T. Evans. *U.S. Fish and Wildlife Service: Farm field back to wetland restoration, NC:* Gary Peeples, U.S. Fish and Wildlife Service, flickr.com. *State: Webster Forest Nursery Department of Natural Resources, WA:* Washington Department of Natural Resources, flickr.com. *Public Forests: Local; Morton Arboretum, IL:* Michael Kappel, flickr.com.

Timeline Photograph
Roosevelt and Muir: Library of Congress.

Timeline Icons
1812 General Land Office: Public domain, Wikipedia.org. *1876 First forest assessment:* Guvnor Co, Noun Project, Inc. *1881 Division of Forestry:* Public domain—Edited by Linda R. Smith, RedCastle Resources, Inc. *1891 Forest Reserve Act:* Thinkstock by gettyimages.com. *1897 Organic Act:* Karen Tyler, Noun Project, Inc. *1905 Transfer Act:* Public domain, Noun Project, Inc. *1911 Weeks Act:* Adam Whitcroft, Noun Project, Inc. *1916 National Park Service Organic Act:* Public domain—Edited by Linda R. Smith, RedCastle Resources, Inc. *1940 Fish & Wildlife Service:* Carta symbol font—Edited by Linda R. Smith, RedCastle Resources, Inc. *1944 Smokey Bear:* Albert Staehle, smokeybear.com. *1946 Bureau of Land Management*: Luke Anthony Firth, Noun Project, Inc. *1960 Multiple-Use Sustained Yield Act:* Luis Prado, Noun Project, Inc. *1964 Wilderness Act:* Marco Micheli, Noun Project, Inc. *1969 National Forest Management Act:* Juan Pablo Bravo, Noun Project, Inc. *1973 Endangered Species Act:* Vectorig, iStock by gettyimages.com. 1*976 National Environmental Policy Act:* Iconathon, Noun Project, Inc.

FORESTS AND THE CARBON CYCLE

Authors
Woodall, Christopher W. USDA Forest Service, Durham, NH.; Domke, Grant M.; Walters, Brian F. USDA Forest Service, St. Paul, MN.

General References
Behrens, C.E.; Ratner, M.; Glover, C. 2011. U.S. fossil fuel resources: terminology, reporting, and summary. R40872. Washington, DC: Congressional Research Service. 26 p. https://fas.org/sgp/crs/misc/R40872.pdf. [Date accessed: 06 June 2018].

U.S. Environmental Protection Agency. 2016. U.S. Greenhouse Gas Inventory Report: 1990–2014. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks. [Date accessed: 29 May 2018].

Map Source
U.S. Department of Agriculture, Forest Service. 2016. Forest Inventory and Analysis program data and tools. http://www.fia.fs.fed.us/tools-data/index.php. [Date accessed: 29 May 2018].

Illustration Source
U.S. Environmental Protection Agency, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2018. EPA 430-R-20-002.

Illustration
Linda R. Smith and Lou Ann Reineke, RedCastle Resources, Inc.

Icon
Sprout: Sasha Willins, Noun Project, Inc.

FORESTS ON THE MOVE

Authors
Matthews, Stephen N.; Iverson, Louis R.; Prasad, Anantha M.; Peters, Matthew P. USDA Forest Service, Delaware, OH.; Woodall, Christopher W. USDA Forest Service, Durham, NH.

General References
Iverson, L.R.; Prasad, A.M.; Matthews, S.N.; Peters, M.P. 2011. Lessons learned while integrating habitat, dispersal, disturbance, and life-history traits into species habitat models under climate change. Ecosystems. 14: 1005–1020. https://www.fs.usda.gov/treesearch/pubs/38757. [Date accessed: 29 May 2018].

Matthews, S.N.; Iverson, L.R.; Prasad, A.M.; Peters, M.P.; Rodewald, P.G. 2011. Modifying climate change habitat models using tree species-specific assessments of model uncertainty and life history factors. Forest Ecology and Management. 262: 1460–1472. https://www.fs.usda.gov/treesearch/pubs/38643. [Date accessed: 29 May 2018].

Williams, J.W.; Shuman, B.N.; Webb, T.; Bartlein, P.J.; Leduc, P.L. 2004. Late-quaternary vegetation dynamics in North America: Scaling from taxa to biomes. Ecological Monographs. 74: 309–334. https://doi.org/10.1890/02-4045. [Date accessed: 29 May 2018].

Woodall, C.; Oswalt, C.M.; Westfall, J.A.; Perry, C.H.; Nelson, M.D.; Finley, A.O. 2009. An indicator of tree migration in forests of the Eastern United States. Forest Ecology and Management. 257: 1434–1444. https://www.fs.usda.gov/treesearch/pubs/19546. [Date accessed: 29 May 2018].

Map Sources
Iverson, L.R.; Prasad, A.M.; Matthews, S.N.; Peters, M.P. 2008. Estimating potential habitat for 134 eastern U.S. tree species under six climate scenarios. Forest Ecology and Management. 254: 390–406. http://www.treesearch.fs.fed.us/pubs/13412. [Date accessed: 29 May 2018].

Prasad, A.M.; Iverson, L.R.; Matthews, S.N.; Peters, M.P. 2007-ongoing. A climate change atlas for 134 forest tree species of the Eastern United States. Delaware, OH: U.S. Department of Agriculture, Forest Service, Northern Research Station. [database]. http://www.nrs.fs.fed.us/atlas/tree. [Date accessed: 29 May 2018].

Williams, J.W., et al. 2003. Late quaternary North American vegetation dynamics data. International Geosphere-Biosphere Programme Past Global Changes /World Data Center for Paleoclimatology. Data Contribution Series # 2003–089. Boulder CO: National Oceanic and Atmospheric Administration/National Geophysical Data Center Paleoclimatology Program. ftp://ftp.ncdc.noaa.gov/pub/data/paleo/pollen/na_gridded/. [Date accessed: 29 May 2018].

Graph Sources
Woodall, C.; Oswalt, C.M.; Westfall, J.A.; Perry, C.H.; Nelson, M.D.; Finley, A.O. 2009. An indicator of tree migration in forests of the eastern United States. Forest Ecology and Management. 257: 1434–1444. https://www.fs.usda.gov/treesearch/pubs/19546. [Date accessed: 29 May 2018].

Photographs
Engelmann spruce: Joe Rocchio, flickr.com. *Western hemlock:* John, flickr.com. *American beech:* Dan Mullen, flickr.com. *Sugar maple:* Blue Ridge Kitties, flickr.com. *Shortleaf pine:* Kyle Spradley, University of Missouri College of Agriculture, Food and Natural Resources, flickr.com. *Mixed forest types:* Blue Ridge Kitties, flickr.com.

Icon
Sugar maple fruit: Linda R. Smith, RedCastle Resources, Inc.