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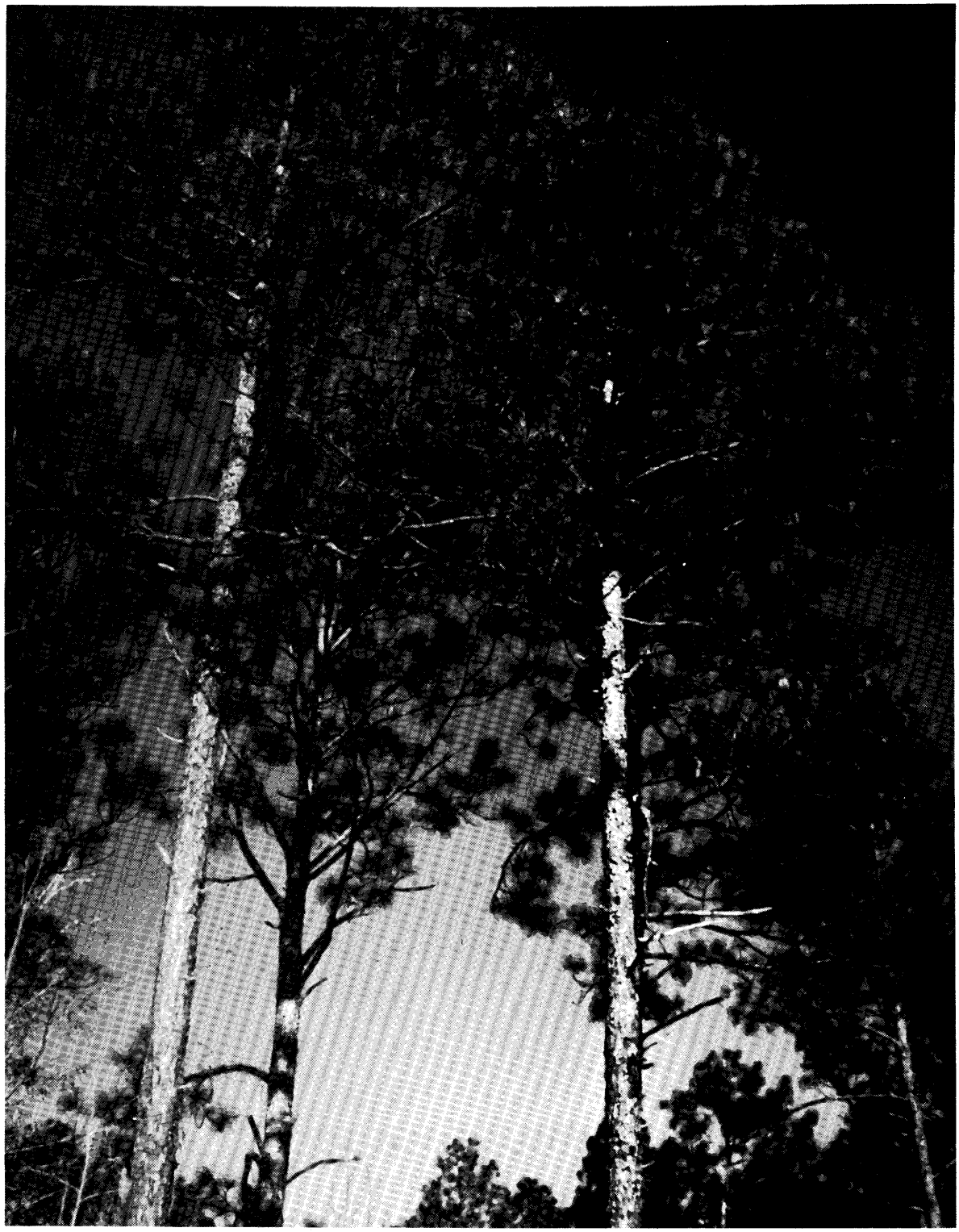
Carbon Storage and Accumulation in United States Forest Ecosystems



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Carbon Storage and Accumulation in United States Forest Ecosystems

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Introduction

Historically, assessments of the forest resource situation have focused on timber supply, and the data used to support the assessments came from traditional forest inventories designed to provide reliable estimates of timber volume, growth, removals, and mortality (U.S. Department of Agriculture, Forest Service 1982). The most recent assessment included data and analysis of forest resources other than timber, including wildlife, range, water, recreation, and other resources associated with the Nation's forest lands (U.S. Department of Agriculture, Forest Service 1989). Future forest resource assessments will include expanded analyses of environmental issues such as the effects of acid deposition on forest health, the prospective effects of global warming on forests, and the impacts of prospective strategies to mitigate or adapt to changing environmental conditions.

A key issue analyzed in the 1989 Resources Planning Act (RPA) Assessment is the impact of climate change on America's forests (Joyce and others 1990). Another issue undergoing intense analysis at this time but not included in the 1989 RPA Assessment is the evaluation of forestry opportunities for mitigating the effects of global warming. Analysis of forestry opportunities requires knowledge of carbon storage and accumulation in forest ecosystems. It is the purpose of this publication to provide estimates of carbon storage and accumulation for U.S. forests. Because it takes years to design and conduct detailed inventories of U.S. forest lands, the only way to satisfy current, expanding information needs is to integrate the best available data from the national inventory sample with data from special studies of selected forest ecosystems.

Forests and the Global Carbon Cycle

Carbon dioxide in the atmosphere has been increasing steadily since at least 1958 (Keeling 1984). Predictions of future climate change as a consequence of increasing atmospheric carbon dioxide vary widely. Under a scenario of equivalent doubling of atmospheric carbon dioxide by the middle of the next century, most predictions show an increase in average global temperature of between 2 and 5 degrees centigrade and an increase in average global precipitation of between 7 and 15 percent (Schneider 1989). These prospective changes have generated interest in strategies to reduce emissions of carbon dioxide to the atmosphere, or to offset emissions by storing additional carbon in forests.

The total amount of carbon in the atmosphere has been estimated at 720 billion metric tons, the total amount of carbon in terrestrial biomass is about 560 billion metric tons, and the total amount of carbon in terrestrial soils is about 1,500 billion metric tons (Solomon and others 1985). Although oceans store a far greater amount of carbon than terrestrial ecosystems, our ability to manage terrestrial ecosystems is greater and likely to have a greater mitigation effect.

Forest ecosystems are capable of storing large quantities of carbon in solid wood and other organic matter. Forests may add to the pool of carbon dioxide in the atmosphere through burning of forest lands, deforestation, or decomposition of wood products and byproducts. Forests may also reduce the amount of carbon dioxide in the atmosphere through increases in biomass and organic matter accumulation. Young, growing forests take up carbon at high rates, while carbon uptake in mature forests is balanced by carbon release from decaying vegetation. The end use of timber harvested from forests is an important factor in evaluating the contributions of forestry to the global carbon cycle. If the end uses of forest products are in long-term durable goods such as furniture or timber bridges, the carbon is stored in those materials. If the end use is for paper products that are rapidly used and discarded to decay, then the carbon is released to the atmosphere. Carbon in waste from the manufacturing process and discarded wood products may be sequestered in landfills for long periods of time. When forest biomass is burned for energy it may be substituted for fossil fuels, which is an effective way to reduce the depletion of nonrenewable fossil carbon.

Because of the relation between forests and atmospheric carbon dioxide, there are opportunities to manage forests in ways that would result in storage of additional carbon and thus reduce atmospheric carbon dioxide. Major forestry opportunities include increasing forest area, increasing the productivity of existing forest lands, reducing forest burning and deforestation, increasing biomass production and utilization, planting trees in urban environments, and increasing use of wood in durable products.

Estimation Methods

Carbon storage was estimated separately for several forest ecosystem components: trees, soil, forest floor, and understory vegetation. The definitions of these components were broad enough to include all sources of organic carbon:

Forest Component	*Definition*
Trees	*All above- and below-ground portions of all live and dead trees, including the merchantable stem; limbs, tops, and cull sections; stump; foliage; bark and rootbark; and coarse tree roots (greater than 2 mm).*
Soil	*All organic carbon in mineral horizons to a depth of 1 meter, excluding coarse tree roots.*
Forest floor	*All dead organic matter above the mineral soil horizons, including litter, humus, and coarse woody debris.*
Understory vegetation	*All live vegetation except that defined as live trees.*

Carbon storage was estimated in a four-stage process corresponding to these four major forest ecosystem components. Separate estimates were generally made at the State level and for major forest types and plantation species in 8 geographic regions (fig. 1). The general approach was to estimate the volume of growing stock from forest inventories, to derive factors from biomass studies and other sources to convert the volume of growing stock to carbon, and to derive estimates for the other ecosystem components from models.

Several principal data sources were used to make estimates of carbon storage in forest trees. Statewide forest inventories, such as those conducted periodically by the USDA Forest Service, typically involve estimation of timber volume, growth, removals, mortality, and forest biomass for the purpose of analyzing current and prospective timber supplies. Data from these inventories were the basis for estimating carbon storage in forest trees. The data were supplemented by information from a special study to estimate the amount of carbon in tree roots and the conversion of volume to carbon (Koch 1989). Because regional forest inventories are based on a statistical sample designed to represent the broad range of forest conditions actually present, estimates of carbon storage in forest trees are representative of the true average values, subject to sampling errors, estimation errors, and errors in converting data from one reporting unit to another. Because of the complexity of making the estimates of tree carbon, the magnitude of the error has not been estimated, but it is likely quite small since the forest inventories used to derive the estimates have very small sampling errors over large areas.

Estimates of carbon storage in the soil, forest floor, and understory vegetation were developed through the use of models based on data from forest ecosystem studies. Although these studies include all of the key forest ecosystem components, they are valid only for the specific ecosystem studied. Uncertainty is introduced into the estimation process by assuming that the results of specific ecosystem studies are representative of regional or national averages without being part of a statistical sample that represents a large geographical area. Therefore, estimates of carbon storage in the soil, forest floor, and understory vegetation are subject to the following errors: bias from applying data from past studies that do not represent all forest conditions, modelling errors (imperfect assumptions), and errors in converting estimates from one reporting unit to another. No attempt has been made to estimate the magnitude of these errors.

Details of the modeling and estimation process for estimating carbon storage are presented in appendix 1.

Estimates of changes in carbon storage over time were limited to estimating carbon changes in live trees. One could assume that carbon changes in trees are correlated with changes in the whole forest ecosystem, since an increasing quantity of tree biomass is likely associated with an increase in soil and forest floor carbon because litter from trees is one of the main inputs of organic matter to the forest floor and soil (Raich and Nadelhoffer 1989; Vogt and others 1986). Carbon changes in live trees were estimated using the same procedures as in estimating carbon storage, but the starting

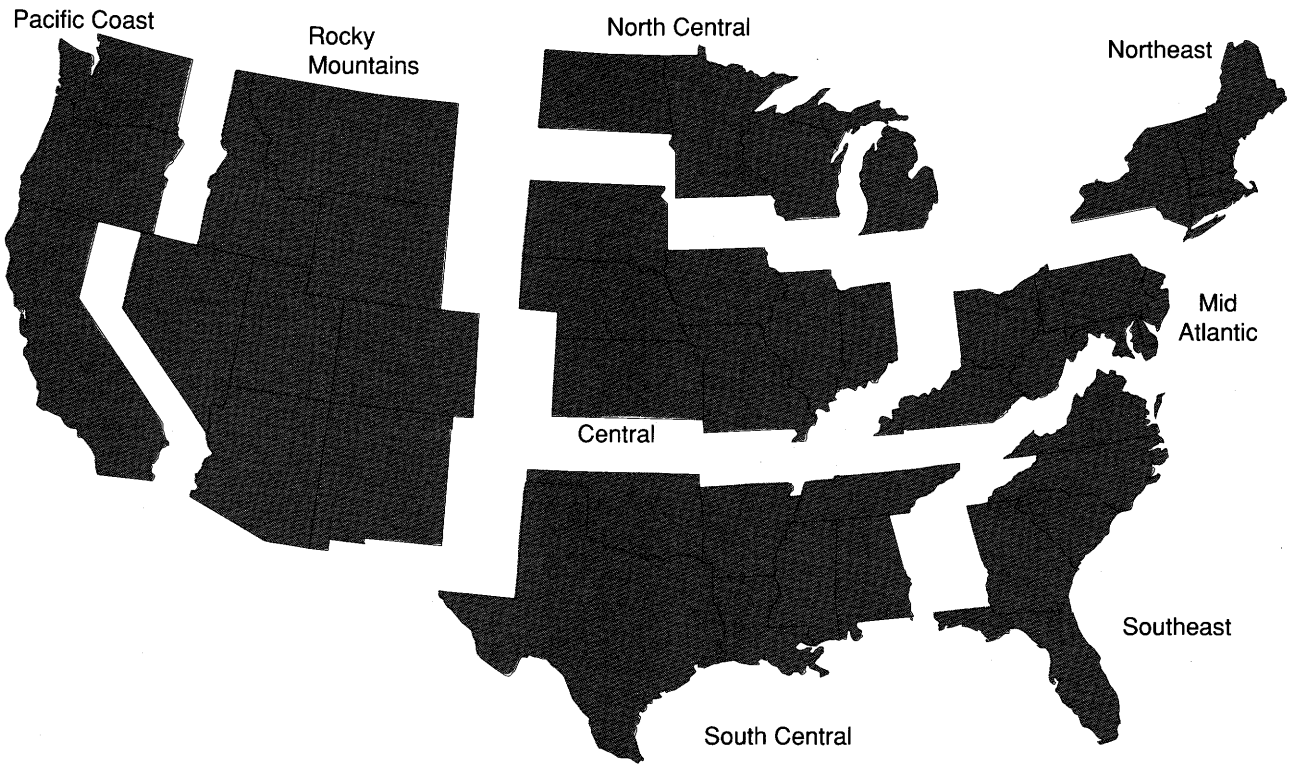

Figure 1—Broad geographical regions used to report estimated carbon storage.

estimates were volume growth, removals, and mortality rather than timber volume. The same conversion factors that were used to convert volume to carbon storage were used to convert volume growth, removals, and mortality to carbon accumulation, removals, and mortality.

Estimates of carbon storage and accumulation for reserved forest land and other forest land (all forest land except that classified as timberland) were made in order to include the entire forest land base of the United States. Forest inventories are less comprehensive for these lands, and volume, growth, removals, and mortality estimates are not routinely aggregated to regional or national totals. Carbon storage in trees on reserved timberland was assumed to equal the average carbon storage on unreserved timberland for each State. Carbon storage in trees on other forest land was based on inventory statistics reported in a variety of Resource Bulletins issued by Forest Service experiment stations, using the conversion process outlined in appendix 1. Estimates for carbon storage in other forest ecosystem components were made using the procedures outlined in appendix 1.

Carbon Storage and Accumulation in U.S. Forests

All of the estimates presented in this section were derived from the detailed tables presented in appendix 2. The tables in appendix 2 were prepared by the methods outlined in previous sections and in appendix 1.

Carbon Storage in the United States

Forest ecosystems in the United States contain approximately 57.8 billion tons (52.5 billion metric tons) of carbon above and below the ground. This is about 4 percent of all the carbon stored in the world's forests (Ajtay and others 1979). The area of U.S. forests is 731 million acres, or 5 percent of the world's forest area.

The average forest in the United States contains 158 thousand pounds per acre (17.7 kg/m^2) of organic carbon. Trees, including tree roots, account for 31 percent of all forest ecosystem carbon (fig. 2). Live and standing dead trees contain 17.7 billion tons (16.1 billion metric tons) of carbon, or an average of 49 thousand pounds per acre (5.5 kg/m^2). Of this total, 51 percent is in live tree sections classified as growing stock volume, 24 percent is in other live solid wood above the ground, 17 percent is in the roots, 6 percent is in standing dead trees, and 3 percent is in the foliage.

The largest proportion of carbon in the average U.S. forest is found in the soil, which contains 59 percent of the carbon in the forest ecosystem, or approximately 93 thousand pounds per acre (10.4 kg/m^2). About 9 percent of all carbon is found in litter, humus, and coarse woody debris on the forest floor, and about 1 percent is found in the understory vegetation. By adding carbon in tree roots to the carbon in the soil, the average proportion of carbon below the ground in the United States is estimated to be 64 percent.

Carbon Storage by Region

The quantity of carbon varies considerably between regions, with Pacific Coast States containing 205 thousand pounds per acre (23.0 kg/m^2) and South Central States containing 117 thousand pounds per acre (13.1 kg/m^2) in the average forest (fig. 3). Of the total 57.8 billion tons (52.5 billion metric tons) of carbon in U.S. forests, 22.6 billion tons (20.5 billion metric tons), or 39 percent, is found in Pacific Coast forests, far more than in any other region (fig. 4). The Rocky Mountains and the Northeast each contain about 15 percent of U.S. forest carbon. The Southeast, South Central, and North Central regions each contain about 10 percent of U.S. forest carbon.

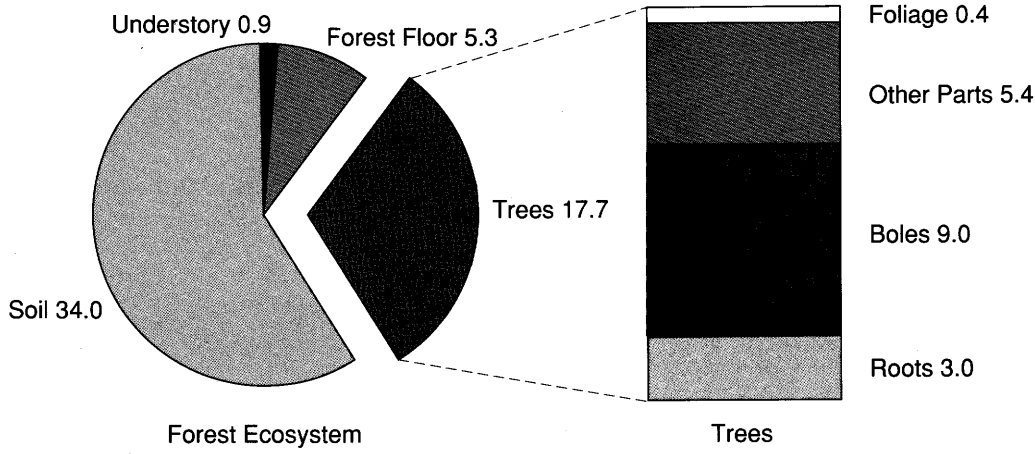

Figure 2—Carbon storage in U.S. forest ecosystems by forest ecosystem component (in billion tons). Total storage in the United States is 57.8 billion tons—about 4 percent of all the carbon stored in the world's forests.

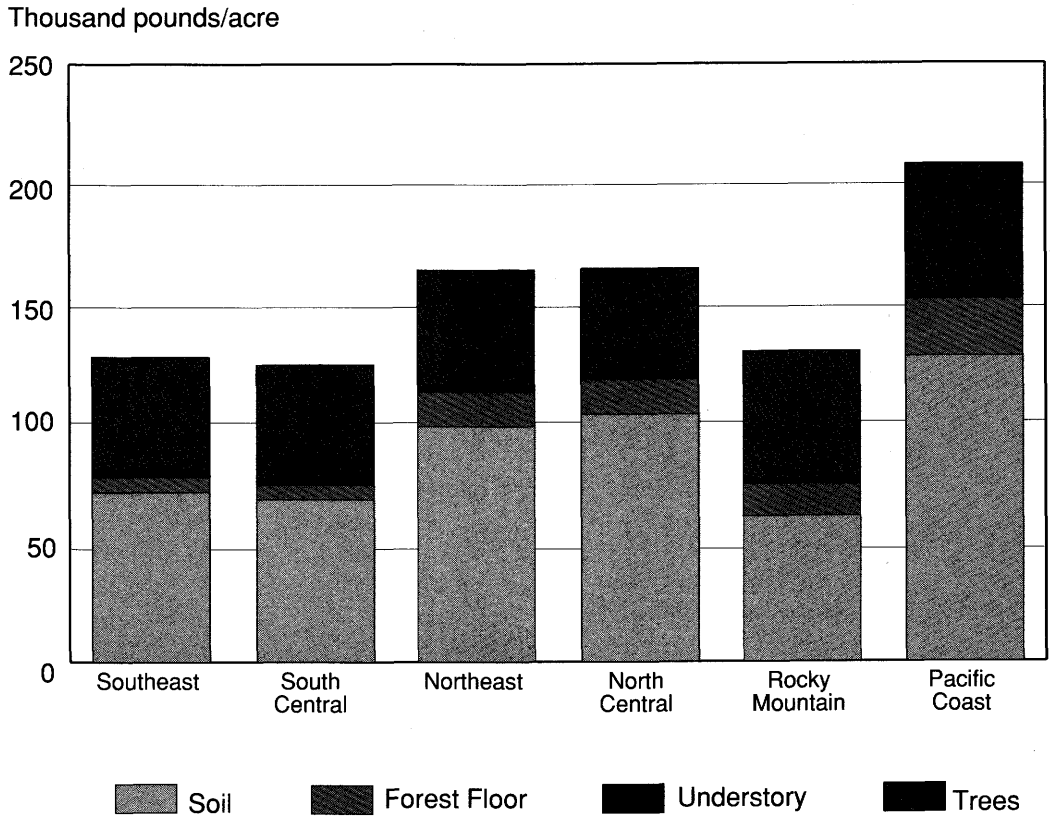

Figure 3—Average carbon storage in U.S. forest ecosystems by forest ecosystem component and region.

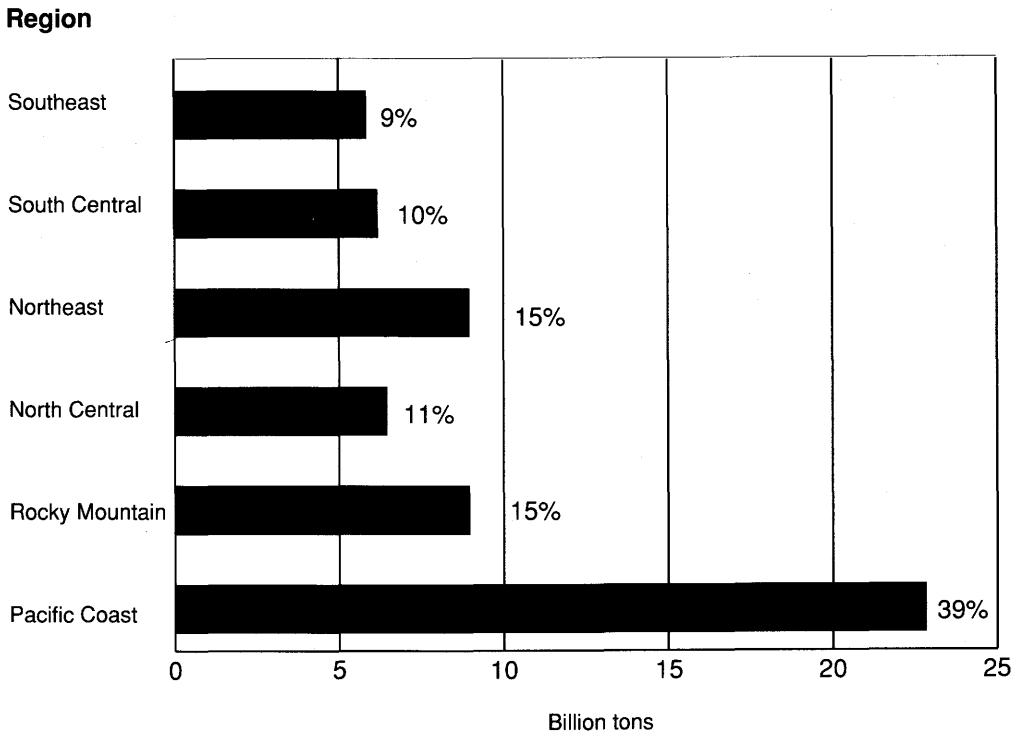

Figure 4—Total carbon storage in U.S. forest ecosystems by region. Total storage in the United States is 57.8 billion tons.

Pacific Coast States, including Alaska, contain the highest average carbon in forest soils, 64 percent of the total. The lowest proportion of soil carbon is found in the Rocky Mountain States, with 49 percent of the total. Soil carbon is closely related to temperature and precipitation, with higher amounts of soil carbon found in regions with cooler temperatures and higher precipitation. The cooler temperatures slow the oxidation of soil carbon, while higher rainfall tends to produce more vegetation and thus the fine roots and litter that are the main sources of organic soil carbon.

Carbon in the forest floor varies by region in a way similar to carbon in the soil. Western and Northern States contain the most carbon on the forest floor, and Southern States contain the least.

There is a clear pattern of increasing forest carbon from Southern to Northern States (fig. 5). The two main factors are climate and average age of the forests. The cooler, wetter climates favor higher retention of carbon on the forest floor and in the soil, and northern forests tend to be older and less frequently disturbed than forests in the South.

Carbon Storage by Forest Type

There are significant differences in carbon storage among forest types. For example, selected eastern softwood types show large differences in total carbon storage and the relative storage by forest ecosystem component (fig. 6). Loblolly pine plantations are younger on average, so there is less carbon in the trees, and since they are mostly located in the South, the soil carbon is lower. Spruce - fir, common in the Northeast, has higher total carbon as a result of the large amount of carbon stored in the soil. Douglas - fir contains the highest average carbon because of the large quantity stored in the trees. Pinyon - juniper has the lowest amount of carbon because it occurs in dry climates that support lower vegetation densities.

Changes in Carbon Storage

U.S. forests are constantly changing. The total area of forest land declined by 4 million acres between 1977 and 1987 (Waddell and others 1989). Most of the loss was from forest clearing for urban and suburban development, highways, and other rights-of-way. Many more million acres were cleared for agricultural use, but this loss was roughly balanced by agricultural land that was planted with trees or allowed to revert naturally to forest. In addition to land-use changes, each year about 4 million acres of timberland are harvested for timber products and regenerated to forests, 4 million acres are damaged by wildfire, and 2.5 million acres are damaged by insects and diseases (estimates based on various unpublished Forest Service data sources). And of course, all forest lands change continually as trees and other vegetation germinate, grow, and die.

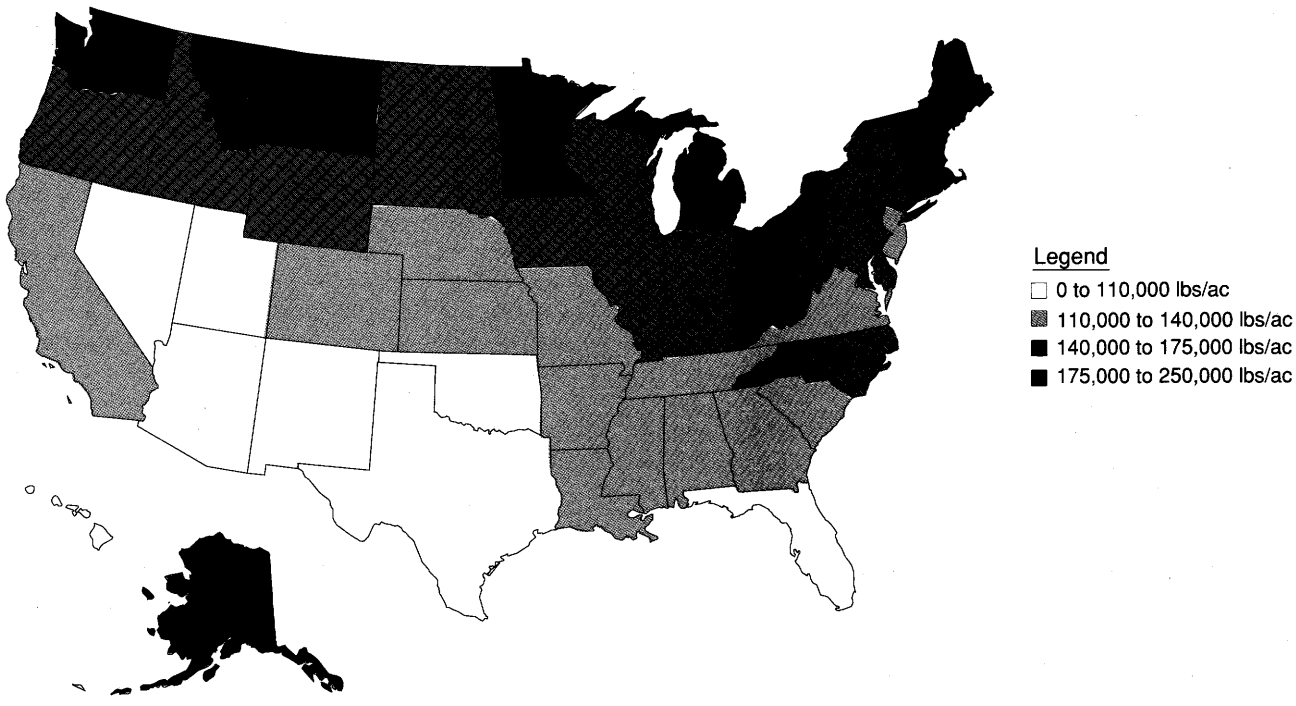

Figure 5—Average carbon storage per acre of forest land in the United States.

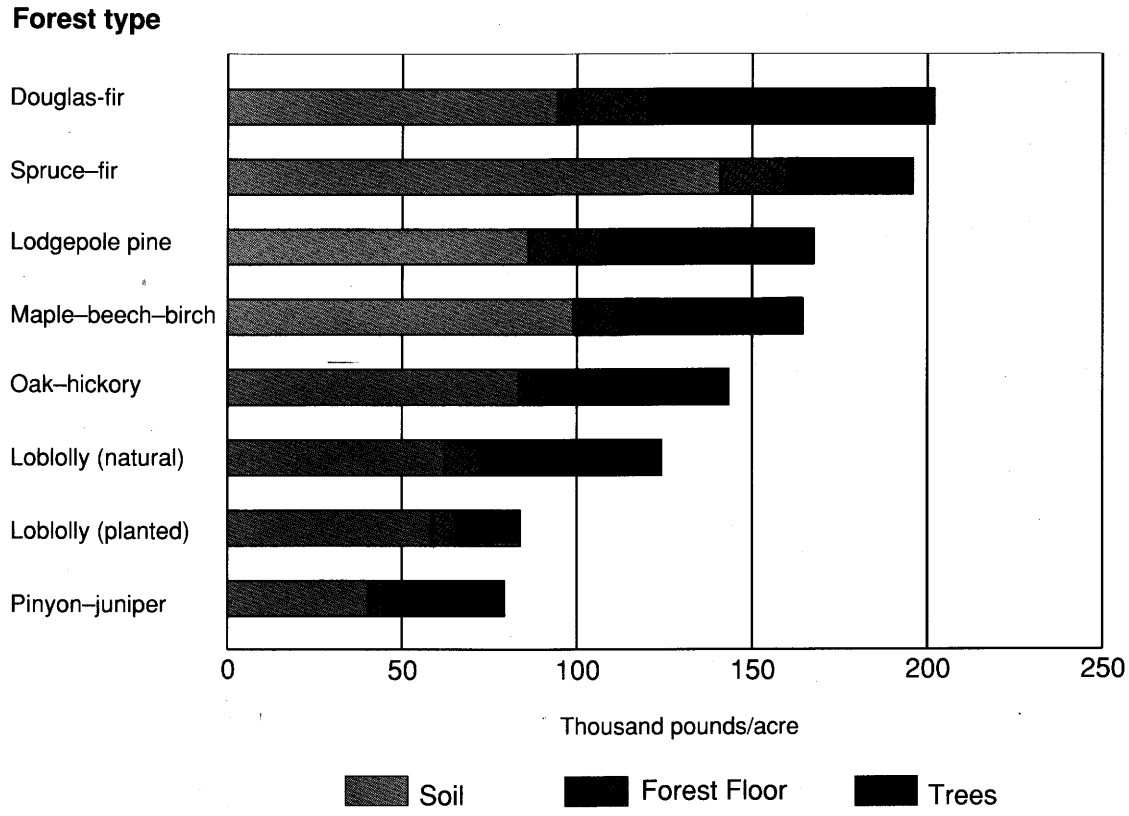

Figure 6—Average carbon storage in the soil, forest floor, and trees for selected forest types.

Changes in carbon storage in the forest ecosystem are primarily related to changes in carbon storage in live trees. The rate of accumulation of carbon in live trees is greatest in the forest areas where trees typically have the fastest volume growth, the Southeast and the Pacific Northwest (fig. 7). On average, live trees are accumulating carbon at a rate of 1,252 pounds per acre per year (0.14 kg/m^2/yr), a rate of increase of 2.7 percent of the amount stored in live trees.

The accumulation of carbon in live and dead trees totals 508 million tons (461 million metric tons) per year, while the total removal of tree carbon from U.S. forests resulting from timber harvest, landclearing, and fuelwood use amounts to 391 million tons (355 million metric tons, fig. 8). A comparison of accumulation and removal suggests that U.S. forest trees are storing additional carbon at a rate of 117 million tons (106 million metric tons) per year. This is equivalent to about 9 percent of the annual U.S. emission of carbon to the atmosphere (1.2 billion metric tons) per year (Boden and others 1990).

Trees dying annually because of insects, diseases, fire, and weather contain about 83 million tons (75 million metric tons) of carbon. Only a portion of tree mortality was deducted from accumulation in the comparison of accumulation and remov-al since much of the carbon remains in the forest ecosystem for some time as standing dead trees, coarse woody debris on the forest floor, and eventually other organic matter in the forest ecosystem.

There are significant regional differences in relative and total estimates of carbon accumulation, removal, and mortality. For softwoods, Pacific coast forests are accumulating the most carbon annually, followed by the Southeast, South Central, and Rocky Mountain regions (fig. 9). Because softwood removal is so low relative to growth in the Rocky Mountains, the increase in carbon storage in softwood species is much greater there than elsewhere. Mortality is the highest in the Rocky Mountains and on the Pacific coast. In the South Central region, tree removal is causing a net loss of carbon storage in softwood trees.

Most of the hardwood resource in located in the Eastern United States. The Northeast has the largest excess of hardwood carbon accumulation over removal, but there are also large increases in hardwood carbon storage occurring in the Southeast and on the Pacific coast (fig. 10).

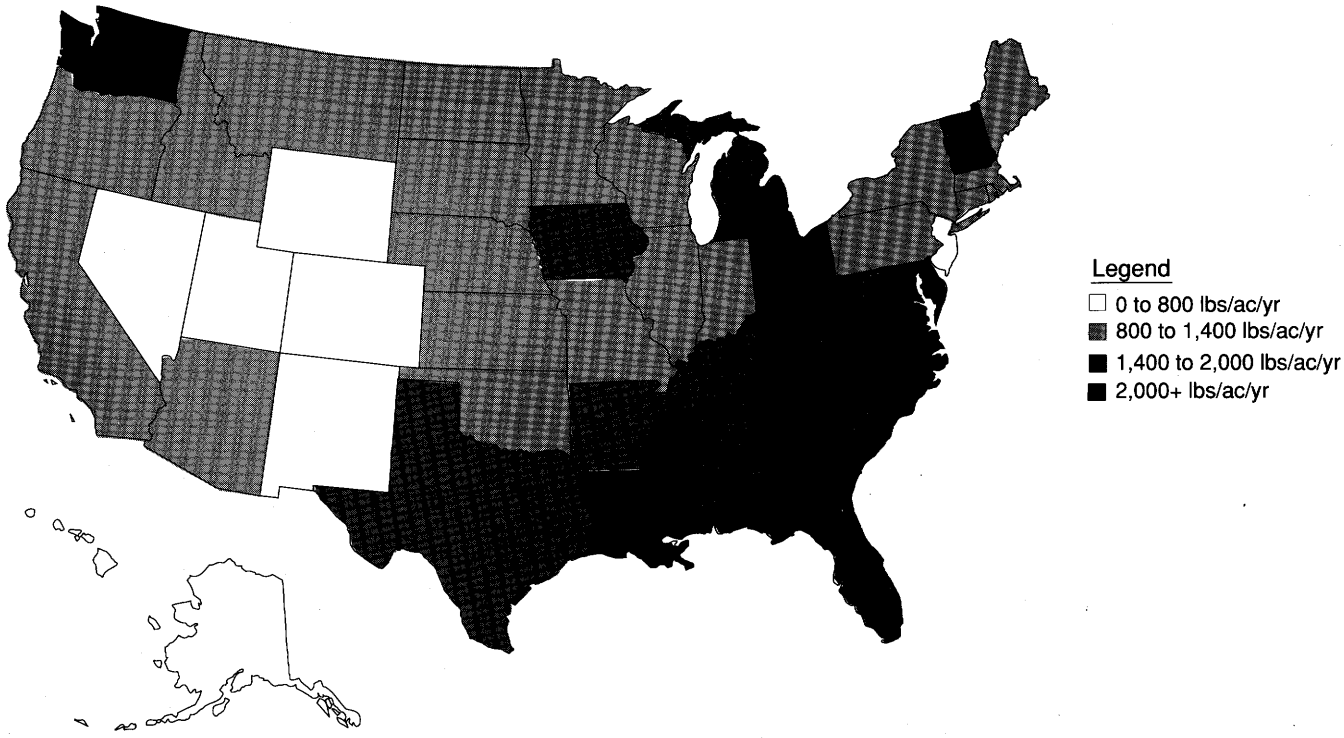

Figure 7—Average carbon accumulation in live trees on forest land in the United States.

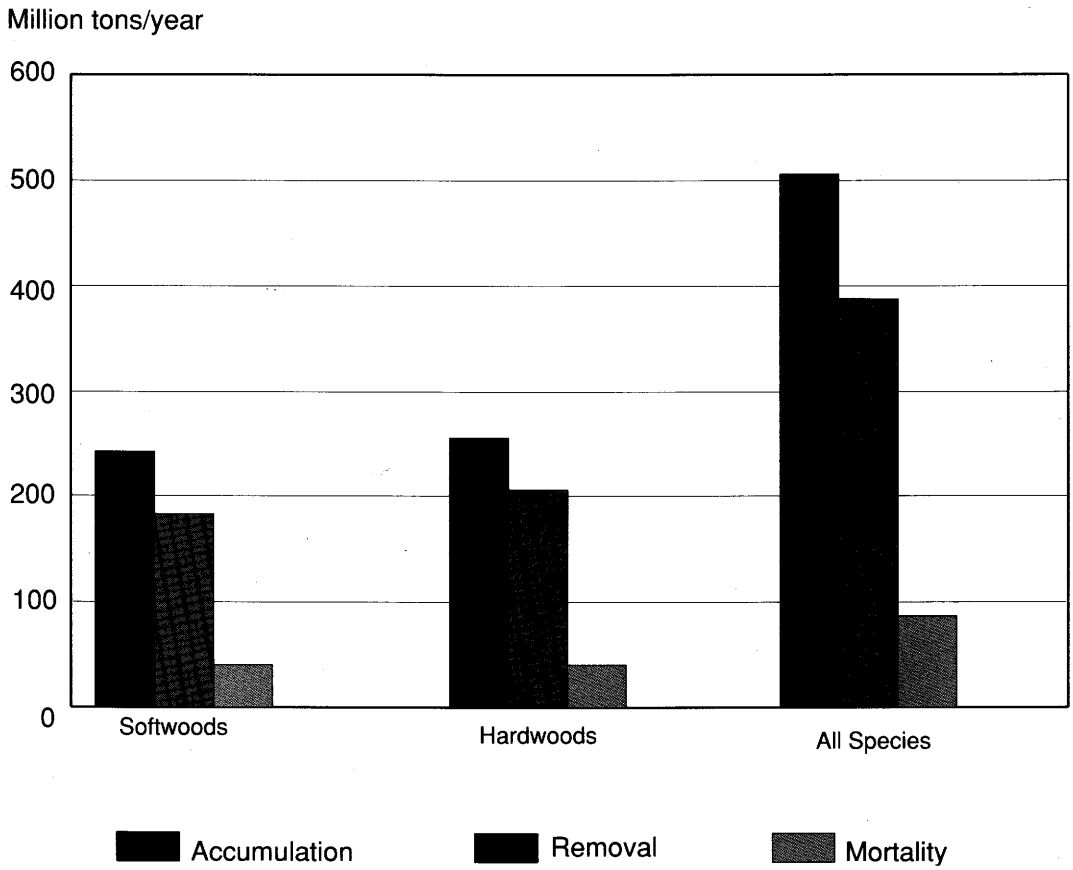

Figure 8—Annual changes in carbon storage in live trees on all forest land by softwoods and hardwoods.

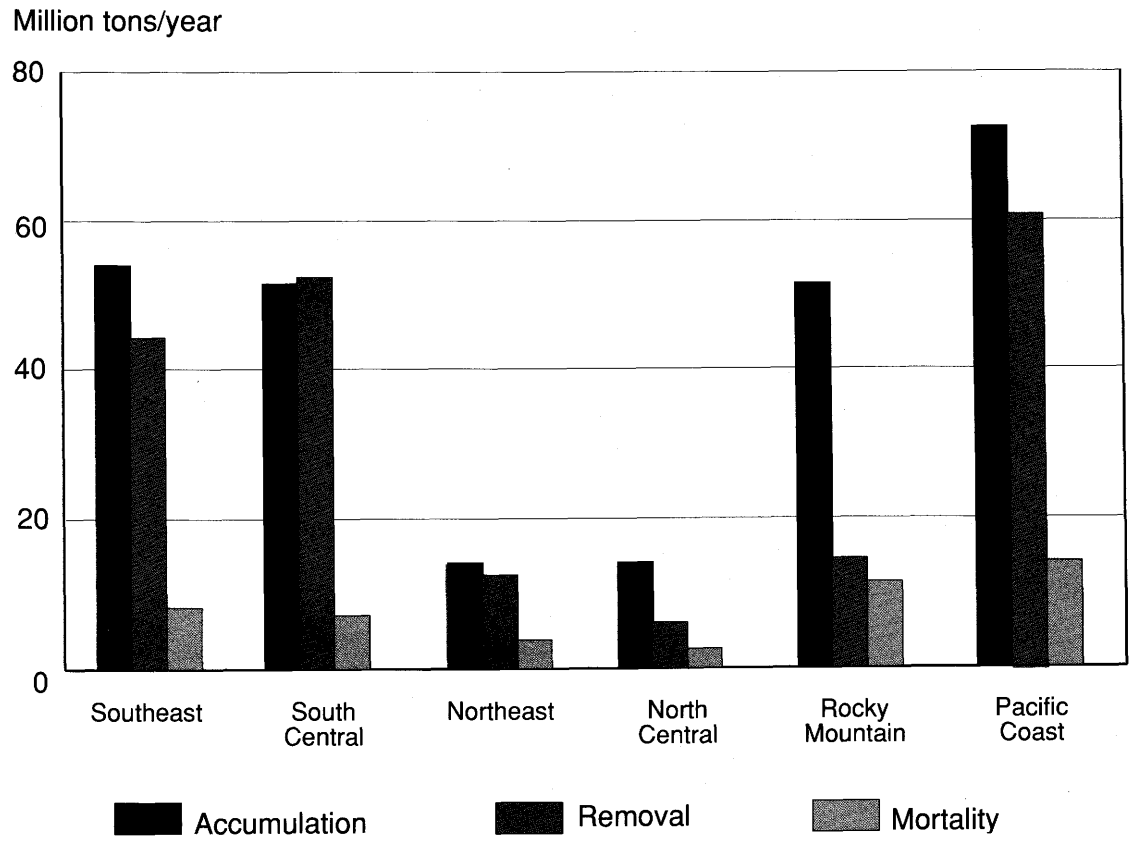

Figure 9—Annual changes in carbon storage in live softwood trees on all forest land by region.

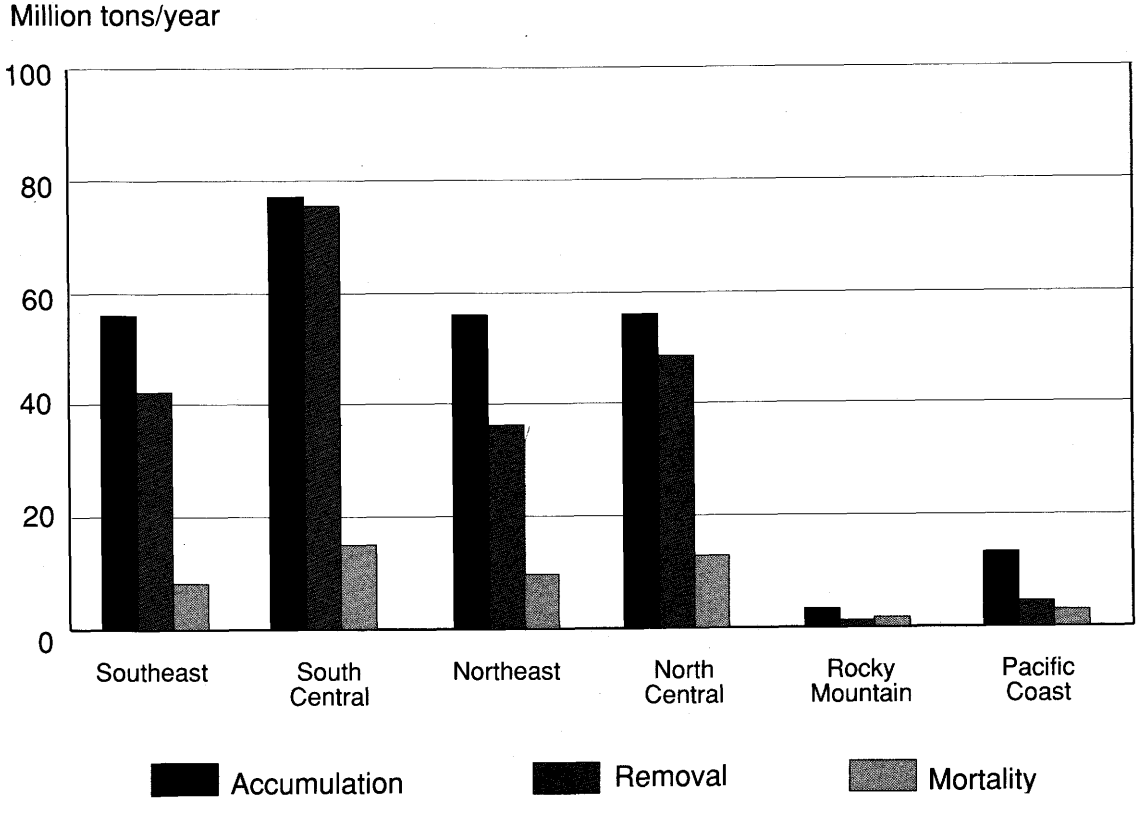

Figure 10—Annual changes in carbon storage in live hardwood trees on all forest land by region.

Glossary

Annual mortality—The volume of sound wood in trees that died from natural causes during a specific year.

Annual removals—The net volume of trees removed from the inventory during a specified year by harvesting, cultural operations such as timber stand improvement, or land clearing.

Cull tree—A live tree, 5.0 inches in diameter at breast height (d.b.h.) or larger, that is unmerchantable for saw logs now or prospectively because of rot, roughness, or species. (See definitions for rotten and rough trees.)

Forest land—Land at least 10 percent stocked by trees of any size, including land that formerly had such tree cover and that will be naturally or artificially regenerated. Forest land includes transition zones, such as areas between heavily forested and nonforested lands that are at least 10 percent stocked with forest trees and forest areas adjacent to urban and built-up lands. Also included are pinyon-juniper and chaparral areas in the West and afforested areas. The minimum area for classification of forest land is 1 acre. Roadside, streamside, and shelterbelt strips of timber must have a crown width of at least 120 feet to qualify as forest land. Unimproved roads and trails, streams, and clearings in forest areas are classified as forest if less than 120 feet wide.

Forest type—A classification of forest land based on the species presently forming a plurality of the live-tree stocking.

Major eastern forest-type groups:

White-red-jack-pine—Forests in which eastern white pine, red pine, or jack pine, singly or in combination, make up a plurality of the stocking. Common associates include hemlock, aspen, birch, and maple.

Spruce–fir—Forests in which spruce or true firs, singly or in combination, make up a plurality of the stocking. Common associates include white-cedar, tamarack, maple, birch, and hemlock.

Longleaf–slash pine—Forests in which longleaf or slash pine, singly or in combination, make up a plurality of the stocking. Common associates include other southern pines, oak, and gum.

Loblolly–shortleaf pine—Forests in which loblolly pine, shortleaf pine, or southern yellow pines, except longleaf or slash pine, singly or in combination, make up a plurality of the stocking. Common associates include oak, hickory, and gum.

Oak–pine—Forests in which hardwoods (usually upland oaks) make up a plurality of the stocking, but in which pine or eastern redcedar makes up 25–50 percent of the stocking. Common associates include gum, hickory, and yellow-poplar.

Oak–hickory—Forests in which upland oaks or hickory, singly or in combination, make up a plurality of the stocking except where pines make up 25-50 percent, in which case the stand is classified as oak-pine. Common associates include yellow-poplar, elm, maple, and black walnut.

Oak–gum–cypress—Bottomland forests in which tupelo, blackgum, sweetgum, oaks, or southern cypress, singly or in combination, make up a plurality of the stocking except where pines make up 25-50 percent, in which case the stand is classified as oak-pine. Common associates include cottonwood, willow, ash, elm, hackberry, and maple.

Elm–ash–cottonwood—Forests in which elm, ash, or cottonwood, singly or in combination, make up a plurality of the stocking. Common associates include willow, sycamore, beech, and maple.

Maple–beech–birch—Forests in which maple, beech, or yellow birch, singly or in combination, make up a plurality of the stocking. Common associates include hemlock, elm, basswood, and white pine.

Aspen–birch—Forests in which aspen, balsam poplar, paper birch, or gray birch, singly or in combination, make up a plurality of the stocking. Common associates include maple and balsam fir.

Major western forest-type groups:

Douglas-fir—Forests in which Douglas-fir makes up plurality of the stocking. Common associates include western hemlock, western redcedar, the true firs, redwood, ponderosa pine, and larch.

Hemlock-Sitka spruce—Forests in which western hemlock or Sitka spruce, or both, make up a plurality of the stocking. Common associates include Douglas-fir, silver fir, and western redcedar.

Redwood—Forests in which redwood makes up a plurality of the stocking. Common associates include Douglas-fir, grand fir, and tanoak.

Ponderosa pine—Forests in which ponderosa pine makes up a plurality of the stocking. Common associates include Jeffrey pine, sugar pine, limber pine, Arizona pine, Apache pine, Chihuahua pine, Douglas-fir, incense-cedar, and white fir.

Western white pine—Forests in which western pine makes up a plurality of the stocking. Common associates include western redcedar, larch, white fir, Douglas-fir, lodgepole pine, and Engelmann spruce.

Lodgepole pine—forests in which lodgepole pine makes up a plurality of the stocking. Common associates include alpine fir, western white pine, Engelmann spruce, aspen, and larch.

Larch—Forests in which western larch makes up a plurality of the stocking. Common associates include Douglas-fir, grand fir, western redcedar, and western white pine.

Fir-spruce—Forests in which true firs, Engelmann spruce, or Colorado blue spruce, singly or in combination, make up a plurality of the stocking. Common associates include mountain hemlock and lodgepole pine.

Western hardwoods—Forests in which aspen, red alder, or other western hardwoods, singly or in combination, make up a plurality of the stocking.

Pinyon-juniper—Forests in which pinyon pine or juniper, or both, make up a plurality of the stocking.

Growing stock—A classification of timber inventory that includes live trees of commercial species meeting specified standards of quality or vigor. Cull trees are excluded. When associated with volume, includes only trees 5.0 inches d.b.h. and larger.

Hardwood—A dicotyledonous tree, usually broad-leaved and deciduous.

Industrial wood—All commercial roundwood products except fuelwood.

Net annual growth—The net increase in the volume of trees during a specified year. Components include the increment in net volume of trees at the beginning of the specific year surviving to its end, plus the net volume of trees reaching the minimum size class during the year, minus the volume of trees that died during the year, and minus the net volume of trees that became cull trees during the year.

Net volume in cubic feet—The gross volume in cubic feet less deductions for rot, roughness, and poor form. Volume is computed for the central stem from a 1-foot-high stump to the point where the diameter of the outside bark equals 4 inches, or to the point where the central stem breaks into limbs.

Nonstocked area—Timberland less than 10 percent stocked with growing stock trees.

Other forest land—Forest land other than timberland and reserved timberland. It includes available and reserved unproductive forest land that is incapable of producing annually 20 cubic feet per acre of industrial wood under natural conditions because of adverse site conditions such as sterile soils, dry climate, poor drainage, high elevation, steepness, or rockiness.

Other removals—Unutilized wood volume from cut or otherwise killed growing stock, from nongrowing stock sources on timberland (for example, precommercial thinnings), or from timberland clearing. Does not include volume removed from inventory through reclassification of timberland to reserved timberland.

Other sources—Sources of roundwood products that are nongrowing stock. These include salvable dead trees, rough and rotten trees, trees of noncommercial species, trees less than 5.0 inches d.b.h., tops, and roundwood harvested from nonforest land (for example, fence rows).

Productivity class—A classification of forest land in items of potential annual cubic-foot volume growth per acre at culmination of mean annual increment in fully stocked natural stands.

Reserved timberland—Forest land that would otherwise be classified as timberland except that it is withdrawn from timber utilization by statute or administrative regulation.

Rotten tree—A live tree of commercial species that does not contain a saw log now or prospectively primarily because of rot (that is, when rot accounts for more than 50 percent of the total cull volume).

Rough tree—**(a)** A live tree of commercial species that does not contain a saw log now or prospectively primarily because of roughness (that is, when sound cull due to such factors as poor form, splits, or cracks accounts for more than 50 percent of the total cull volume) or **(b)** a live tree of noncommercial species.

Softwood—A coniferous tree, usually evergreen, having needles or scalelike leaves.

Stocking—The degree of occupancy of lands by trees, measured by basal area or number of trees by size and spacing, or both, compared to a stocking standard; that is, the basal area or number of trees, or both, required to fully utilize the growth potential of the land.

Timberland—Forest land that is producing or is capable of producing crops of industrial wood and not withdrawn from timber utilization by statute or administrative regulation. (Note: Areas qualifying as timberland are capable of producing in excess of 20 cubic feet per acre per year of industrial wood in natural stands. Currently inaccessible and inoperable areas are included.)

Unreserved forest land—Forest land that is not withdrawn from use by statute or administrative regulation.

Weight—The weight of wood and bark, oven-dry basis (approximately 12 percent moisture content).

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Appendix 1. Methods To Estimate Carbon Storage and Accumulation

Carbon Storage in Trees

Estimates of growing-stock volume in a forest area were converted to estimates of carbon storage in trees in a two-stage process. First, growing-stock volume was converted to total forest tree volume by multiplying by a ratio to account for the additional tree volume excluded from estimates of growing-stock volume: tops and branches, foliage, rough and rotten trees, small trees (less than 5.0 in. dbh), standing

dead trees, stump sections, roots, and bark (table 1.1). Separate ratios were computed for softwoods and hardwoods to account for differences in the average proportion of total volume to growing-stock volume. Ratios were derived from two principal sources: a new nationwide biomass study prepared by the USDA Forest Service containing the latest estimates of above-ground biomass by tree component (Cost and others 1990), and a special report prepared by Koch (1989) containing estimates of the proportion of tree volume that is below the ground. Separate ratios were derived for each of the regions to account for differences in tree form and to be consistent with the data used to estimate growing-stock volume. The validity of this method rests on the assumption that the ratio of total above-ground biomass to merchantable biomass (estimated in dry weight units) is equivalent to the ratio of total above-ground volume to growing-stock volume.

There is considerable variation in the ratios of total volume to growing-stock volume among regions and species groups (table 1.1). For the United States as a whole, the average ratio of total volume to growing-stock volume is 1.91 for softwoods and 2.44 for hardwoods.

The second step involved converting total tree volume in cubic feet to carbon in pounds. Separate factors were developed for major forest types, for softwoods and hardwoods within each forest type, and for broad geographical regions (table 1.2). The volume-to-carbon conversion factor was computed in two steps. First, volume in cubic feet was converted to biomass in dry pounds by multiplying the number of cubic feet times the mean specific gravity times the weight of a cubic foot of water (62.4 lbs.). A weighted mean specific gravity for softwoods or hardwoods was estimated from the relative frequency of the three predominant hardwood and softwood species in each forest type and region. The second step was to multiply the biomass in dry pounds by a factor to account for the average carbon content of the tree. Estimates of the carbon content of trees used in past studies have generally ranged from 45 to 50 percent (Houghton and others 1985); however, Koch (1989) found that, for the United States as a whole, the average percent carbon for softwoods was 52.1 and for hardwoods was 49.1, with some slight regional variations. The final factors used to convert volume to carbon ranged from 11.41 to 17.76 for softwoods, and from 11.76 to to 19.82 for hardwoods (table 1.2).

Carbon Storage in the Soil

To estimate carbon storage in forest soils, a regression model was developed to relate soil carbon in relatively undisturbed, secondary forests to temperature and precipitation. The method was an extension of the model developed by Burke and others (1989) for soil organic carbon in cropland and pasture in the Central Plains grasslands and adjacent areas.

The data in Post and others (1982) were used to estimate regression coefficients for forest lands. They used published sources of data to estimate mean soil carbon density for all of the life zone groups of the Holdridge life zone system (Holdridge 1967). To estimate regression coefficients for forest lands, the mean soil carbon densities were associated with the average precipitation and biotemperature for each of the life zone groups as read from the Holdridge life zone chart.

To apply the regression equations to the United States, temperature and precipitation averages for timberland and other forest land within each State were estimated from published weather records (Ruffner and Bair 1987). Separate estimates for timberland and other forest land allowed some sensitivity to the wide variation within some large States. For example, eastern Texas is largely covered with timberland and has a climate different from that of western Texas, where forests are primarily classified as other forest land. State-level estimates of temperature and precipitation were aggregated to the regional level by weighting the individual State estimates by the areas of timberland and other forest land (table 1.3).

For developing estimates of soil carbon for regional aggregates of forests with different age classes, it was necessary to make some assumptions about when forests reached the level of development represented in the data by Post and others (1982). It was assumed that these levels would be reached at age 50 in the South and at age 55 elsewhere. Then the average per-acre estimate of soil carbon for a State or a region was adjusted to reflect the actual age structure of the forests. This was accomplished by first determining the average age distribution by age classes, and then converting the distribution to percent and computing a weighting factor by comparing the age distribution with a model of soil carbon changes over time. On average, eastern forests are younger than the reference age of 50 or 55, and western forests are older than the reference age. The weighting factor was multiplied by the initial estimate of soil carbon for a State or region to obtain the final estimate used in the tables.

Carbon Storage on the Forest Floor

Estimates of the amount of carbon or organic matter on the forest floor are available for very broad forest classifications (Schlesinger 1977, Vogt and others 1986) and for very specific ecological types. These sources were used to estimate carbon in the forest floor for reference age classes. For State or regional carbon yields, the estimates of Vogt and others (1986) for broad forest ecosystems were applied to the broad forest types common in the area (table 1.4). These reference estimates were assumed to be representative of relatively undisturbed secondary forests.

As was done in estimating soil carbon, a weighting procedure was used to account for the general composition and relative age structure of the State or regional forests. First, area estimates were compiled for hardwood timberland, softwood timberland, reserved timberland, and other forest land for each State. Then the estimated carbon on the forest

floor from Vogt and others (1986) was used for timberland, and other sources were used for other forest land. Then a weighted average for all forest land was computed for each State. The weighted average was multiplied by a factor to account for the actual age distribution of forests within the State. The factor was derived in the same way as the age factor for soil carbon.

Carbon Storage in Understory Vegetation

The understory has such a small percentage of the total carbon stock in forests that it is often ignored or added to the trees in estimates of all live vegetation. Estimates of understory biomass are generally available only from published results of ecological studies of specific forest ecosystems (e.g., Messina and others 1983, Ohmann 1984, Switzer and Nelson 1972, Turner and Long 1975).

It was assumed that there was no carbon in the understory at age 0, and that understory biomass peaked at age 5 for all regions and forest types. It was assumed that understory biomass declined to a reference level by age 50 in the South and age 55 elsewhere. Reference levels were defined as 2 percent of the carbon in the overstory, except for Douglas-fir and red pine, for which a value of 1 percent was used. The distribution of values by age class was compared with the actual age-class distributions of forest land by forest type to estimate a weighted average value for carbon in the understory vegetation in each State.

Table 1.1—*Ratio of total volume[1] to merchantable volume[2]*

Region	Above-ground ratio[3]		Below-ground proportion[4]		Ratio[5]	
	Softwood	Hardwood	Softwood	Hardwood	Softwood	Hardwood
Southeast	1.408	1.793	.163	.197	1.682	2.233
South Central	1.495	2.304	.163	.1971	.7862	.869
Northeast	1.820	1.808	.170	.155	2.193	2.140
Mid Atlantic	1.820	1.808	.170	.155	2.193	2.140
North Central	2.087	2.043	.170	.155	2.514	2.418
Central	2.159	2.240	.170	.155	2.601	2.651
Rocky Mountain	1.898	1.871	.158	.155	2.254	2.214
Pacific Coast	1.410	1.926	.158	.155	1.675	2.279

[1] Volume of all above- and below-ground tree biomass for all live and dead trees, including main stem, branches and twigs, foliage, bark, roots, and root bark.

[2] The gross volume of the central stem from a 1-foot stump to a minimum 4.0 inch top diameter outside bark, or to the point where the central stem breaks into limbs; less deductions for rot, roughness, or poor form; for live trees of commercial species at least 5.0 inches d.b.h., and meeting specified standards of quality.

[3] The ratio of total above-ground tree biomass to merchantable tree biomass from Cost and others (1990) and other Forest Service reports.

[4] The proportion of total above- and below-ground biomass below the ground (Koch 1989).

[5] The ratio of total volume to merchantable volume = data column 1 or 2 adjusted for the below-ground proportion (e.g., col. 5 = col. 1 ÷ [1 - col. 3].

Table 1.2—*Factors to convert tree volume (cubic feet) to carbon (pounds)*

Region	Forest type	Specific gravity[1]		Percent carbon[2]		Factor[3]	
		Softwood	Hardwood	Softwood	Hardwood	Softwood	Hardwood
Southeast and South Central	Pines	.510	.639	.531	.497	16.90	19.82
	Oak–hickory	.536	.639	.531	.479	17.76	19.82
	Oak–pine	.523	.639	.531	.497	17.33	19.82
	Bottomland hardwoods	.460	.580	.531	.497	15.24	17.99
Northeast and Mid-Atlantic	Pines	.378	.543	.521	.498	12.29	16.87
	Spruce–fir	.369	.525	.521	.498	12.00	16.31
	Oak–hickory	.374	.636	.521	.498	12.16	19.76
	Maple–beech–birch	.384	.600	.521	.498	12.48	18.65
	Bottomland hardwoods	.460	.580	.521	.498	14.96	17.99
North Central and Central	Pines	.421	.530	.521	.498	13.69	16.47
	Spruce–fir	.351	.480	.521	.498	11.41	14.92
	Oak–hickory	.416	.632	.521	.498	13.52	19.64
	Maple–beech	.372	.576	.521	.498	12.09	17.90
	Aspen–birch	.370	.465	.521	.498	12.03	14.45
	Bottomland hardwoods	.460	.580	.521	.498	14.96	17.99
Rocky Mountain and Pacific Coast	Douglas-fir	.473	.380	.512	.496	15.11	11.76
	Ponderosa pine	.416	.380	.512	.496	13.29	11.76
	Fir–spruce	.349	.380	.512	.496	9.80	10.67
	Hemlock–Sitka sp.	.434	.433	.512	.496	12.17	12.16
	Lodgepole pine	.423	.380	.512	.496	11.86	10.67
	Larch	.508	.433	.512	.496	14.26	12.16
	Redwoods	.416	.580	.512	.496	11.68	16.29
	Hardwoods	.424	.384	.512	.496	11.90	10.77

[1] Weighted average specific gravity of the three most common (in terms of volume) softwood or hardwood species within the forest type.

[2] From Koch (1989).

[3] Factor = specific gravity times the weight of a cubic foot of water (62.4 lbs) times percent carbon.

Table 1.3. *Estimates of organic soil carbon in relatively undisturbed secondary forests in the United States, by region*[1]

Region	Soil carbon	
	(Kg/m^2)	(Lbs/ac)
Southeast	7.74	69,044
South Central	7.58	67,626
Northeast	16.21	144,703
Mid-Atlantic	11.56	103,173
North Central	13.09	116,791
Central	8.33	74,302
Rocky Mountain	8.02	71,571
Pacific Coast	9.77	87,191

[1] Data from Post and others (1982).

Table 1.4—*Estimates of organic matter and carbon on the forest floor*[1] *by region and forest type*

Region	Forest type	Organic matter[2]	Carbon[3]
		(Kg/ha)	(Lbs/ac)
Southeast	Pines	20,026	10,361
	Oak–pine	15,132	7,829
	Oak–hickory	10,237	5,296
	Bottomland hardwood	11,480	5,939
South Central	Pine	20,026	10,361
	Oak–pine	16,375	8,472
	Oak–hickory	12,723	6,582
	Bottomland hardwood	11,480	5,939
Northeast and Mid-Atlantic	Pines	44,574	23,061
	Spruce–fir	44,693	23,122
	Hardwoods	32,207	16,663
North Central and Central	Pines	44,574	23,061
	Spruce–fir	44,693	23,122
	Oak–hickory and bottomland hardwoods	23,282	12,045
	Maple–beech and Aspen–birch	32,207	16,663
Rocky Mountain and Pacific Coast	Douglas - fir, Redwoods, Larch, Ponderosa pine	44,574	23,061
	Fir–spruce	88,520	45,797
	Lodgepole pine	25,922	13,411
	Hemlock–Sitka spruce	27,490	14,222
	Hardwoods	32,207	16,663

[1] All dead organic matter above the mineral soil horizons, including litter, humus, and other woody debris (excludes standing dead trees).

[2] Most entries from Vogt and others (1986), based on summaries of ecological studies grouped by broad forest ecosystem (e.g., warm temperate deciduous).

[3] Carbon (lbs/ac) = organic matter (kg/ha) x .58 (percent carbon) x .892.

Appendix 2. Basic Carbon Storage and Accumulation Tables

Table 2.1—Area of forest land in the United States by region, State, and forest land class, 1987

Table 2.2—Average storage of carbon in the United States by region, State, and forest ecosystem component, 1987

Table 2.3—Total storage of carbon in the United States by region, State, and forest ecosystem component, 1987

Table 2.4—Average and total storage of carbon in live trees in the United States by region and State, 1987

Table 2.5—Average and total storage of carbon in live trees on timberland in the Southeast, by forest type and productivity class, 1987

Table 2.6—Average and total storage of carbon in live trees on timberland in the South Central, by forest type and productivity class, 1987

Table 2.7—Average and total storage of carbon in live trees on timberland in the Northeast and Mid Atlantic, by forest type and productivity class, 1987

Table 2.8—Average and total storage of carbon in live trees on timberland in the North Central and Central, by forest type and productivity class, 1987

Table 2.9—Average and total storage of carbon in live trees on timberland in the Rocky Mountains, by forest type and productivity class, 1987

Table 2.10—Average and total storage of carbon in live trees on timberland in the Pacific Coast, by forest type and productivity class, 1987

Table 2.11—Annual average and total accumulation of carbon in live trees in the United States by region and State, 1987

Table 2.12—Annual average and total accumulation of carbon in live trees on timberland in the Southeast, by forest type and productivity class, 1987

Table 2.13—Annual average and total accumulation of carbon in live trees on timberland in the South Central, by forest type and productivity class, 1987

Table 2.14—Annual average and total accumulation of carbon in live trees on timberland in the Northeast and Mid Atlantic, by forest type and productivity class, 1987

Table 2.15—Annual average and total accumulation of carbon in live trees on timberland in the North Central and Central, by forest type and productivity class, 1987

Table 2.16—Annual average and total accumulation of carbon in live trees on timberland in the Rocky Mountains, by forest type and productivity class, 1987

Table 2.17—Annual average and total accumulation of carbon in live trees on timberland in the Pacific Coast, by forest type and productivity class, 1987

Table 2.1—*Area of forest land in the United States by region, State, and forest land class, 1987*

Region and State	Forest land class			
	All forest land	Unreserved timberland	Reserved timberland	Other forest land
	(1,000 acres)			
Southeast:				
Florida	16,721	15,238	461	1,022
Georgia	23,906	23,383	505	18
North Carolina	18,892	18,359	490	43
South Carolina	12,257	12,179	78	0
Virginia	15,968	15,436	471	61
Total	87,744	84,595	2,005	1,144
South Central:				
Alabama	21,725	21,659	66	0
Arkansas	16,987	16,673	91	223
Louisiana	13,883	13,873	10	0
Mississippi	16,694	16,673	9	12
Oklahoma	7,284	4,748	23	2,513
Tennessee	13,258	12,839	395	24
Texas	13,656	12,414	120	1,122
Total	103,487	98,879	714	3,894
Northeast and Mid-Atlantic:				
Connecticut	1,815	1,777	21	17
Delaware	398	388	3	7
Kentucky	12,256	11,908	267	81
Maine	17,713	17,175	276	262
Maryland	2,632	2,461	153	18
Massachusetts	3,097	3,010	0	87
New Hampshire	5,021	4,803	70	148
New Jersey	1,985	1,914	41	30
New York	18,775	15,799	2,549	427
Ohio	7,310	7,141	120	49
Pennsylvania	16,996	16,186	532	278
Rhode Island	398	368	8	22
Vermont	4,479	4,424	25	30
West Virginia	11,942	11,799	116	27
Total	104,817	99,153	4,181	1,483

Table 2.1—*Area of forest land in the United States by region, State, and forest land class, 1987, continued*

Region and State	Forest land class			
	All forest land	Unreserved timberland	Reserved timberland	Other forest land
	(1,000 acres)			
North Central and Central:				
Illinois	4,266	4,030	236	0
Indiana	4,439	4,296	143	0
Iowa	1,562	1,459	76	27
Kansas	1,358	1,207	23	128
Michigan	18,221	17,364	623	234
Minnesota	16,583	13,571	1,178	1,834
Missouri	12,523	11,996	224	303
Nebraska	722	536	23	163
North Dakota	460	337	0	123
South Dakota	1,690	1,447	22	221
Wisconsin	15,319	14,727	261	331
Total	77,143	70,970	2,809	3,364
Rocky Mountain:				
Arizona	19,384	3,789	1,090	14,505
Colorado	21,337	11,739	1,714	7,884
Idaho	21,818	14,533	3,051	4,234
Montana	21,910	14,736	1,396	5,778
Nevada	8,927	221	1	8,705
New Mexico	18,527	5,181	1,399	11,947
Utah	16,233	3,078	346	12,809
Wyoming	9,966	4,332	2,943	2,691
Total	138,102	57,609	11,940	68,553
Pacific Coast:				
Alaska	129,045	15,763	5,292	107,990
California	39,381	16,712	2,940	19,729
Hawaii	1,748	700	113	935
Oregon	28,057	22,084	1,777	4,196
Washington	21,857	16,848	2,765	2,244
Total	220,088	72,107	12,887	135,094
U.S. total	731,381	483,313	34,536	213,532

Table 2.2—*Average storage of carbon in the United States by region, State, and forest ecosystem component, 1987*

Region and State	Forest ecosystem component				
	Total	Trees	Soil	Forest floor	Understory
	Lbs/ac				
Southeast:					
Florida	96,393	33,337	54,753	5,679	2,624
Georgia	120,371	47,399	64,637	5,710	2,624
North Carolina	140,870	57,049	75,939	5,258	2,624
South Carolina	124,576	51,719	64,627	5,606	2,624
Virginia	138,744	59,018	72,284	4,818	2,624
Total	124,146	49,515	66,577	5,430	2,624
South Central:					
Alabama	111,016	44,005	58,406	5,677	2,928
Arkansas	122,847	50,085	64,441	5,393	2,928
Louisiana	124,151	57,869	57,794	5,560	2,928
Mississippi	122,179	51,395	62,226	5,630	2,928
Oklahoma	88,818	25,318	55,888	4,684	2,928
Tennessee	134,491	57,694	69,089	4,785	2,924
Texas	101,783	43,474	50,047	5,515	2,747
Total	116,748	48,423	60,019	5,402	2,904
Northeast and Mid-Atlantic:					
Connecticut	178,993	59,118	103,769	14,699	1,406
Delaware	160,940	63,476	83,007	13,051	1,406
Kentucky	151,615	56,804	81,978	11,427	1,406
Maine	198,899	44,071	136,455	17,208	1,165
Maryland	164,791	71,066	79,769	12,551	1,406
Massachusetts	182,673	56,550	108,637	16,079	1,406
New Hampshire	190,440	59,937	112,586	16,544	1,373
New Jersey	137,830	40,235	82,229	13,961	1,406
New York	159,823	46,016	97,309	15,102	1,396
Ohio	149,357	49,391	87,888	10,671	1,406
Pennsylvania	147,234	47,947	86,950	10,931	1,406
Rhode Island	164,521	47,662	100,638	14,815	1,406
Vermont	188,276	57,316	113,995	15,594	1,371
West Virginia	150,212	56,356	81,524	10,926	1,406
Total	165,021	50,955	99,120	13,585	1,360

Table 2.2—*Average storage of carbon in the United States by region, State, and forest ecosystem component, 1987, continued*

Region and State	Forest ecosystem component				
	Total	Trees	Soil	Forest floor	Understory
	Lbs/ac				
North Central and Central:					
Ilinois	158,103	55,978	89,088	11,645	1,391
Indiana	168,576	59,215	95,870	12,100	1,391
Iowa	152,392	50,835	88,442	11,724	1,391
Kansas	123,201	39,007	71,571	11,232	1,391
Michigan	179,724	46,107	115,262	17,238	1,117
Minnesota	178,618	37,470	123,825	16,206	1,117
Missouri	122,662	40,639	68,238	12,394	1,391
Nebraska	139,336	40,933	84,102	12,911	1,391
North Dakota	161,225	33,563	113,466	13,070	1,117
South Dakota	149,313	40,839	87,809	19,273	1,391
Wisconsin	165,950	41,327	106,537	16,695	1,391
Total	162,948	43,446	102,957	15,279	1,266
Rocky Mountain:					
Arizona	106,218	44,658	49,227	11,256	1,077
Colorado	124,993	44,405	62,536	16,975	1,077
Idaho	148,190	60,961	64,417	21,735	1,077
Montana	185,368	67,902	95,732	20,657	1,077
Nevada	83,099	42,658	32,608	6,755	1,077
New Mexico	90,610	30,643	45,790	13,100	1,077
Utah	107,586	38,459	58,225	9,824	1,077
Wyoming	150,012	47,034	81,892	20,009	1,077
Total	128,040	48,316	62,941	15,706	1,077
Pacific Coast:					
Alaska	238,185	39,075	171,994	23,682	3,434
California	127,372	55,672	53,224	15,042	3,434
Hawaii	96,733	8,066	75,253	9,980	3,434
Oregon	172,749	64,469	82,976	21,870	3,434
Washington	202,655	83,073	93,911	22,237	3,434
Total	205,363	49,405	130,871	21,653	3,434
U.S. total	158,225	48,667	92,811	14,456	2,291

Table 2.3—*Total storage of carbon in the United States by region, State, and forest ecosystem component, 1987*

Region and State	Forest ecosystem component				
	Total	Trees	Soil	Forest floor	Understory
	1,000 metric tons				
Southeast:					
Florida	731,093	252,843	415,276	43,073	19,902
Georgia	1,305,250	513,980	700,899	61,917	28,454
North Carolina	1,207,156	488,867	650,746	45,057	22,486
South Carolina	692,604	287,540	359,308	31,168	14,589
Virginia	1,004,920	427,465	523,553	34,897	19,006
Total	4,941,023	1,970,694	2,649,783	216,111	104,435
South Central:					
Alabama	1,093,984	433,640	575,548	55,943	28,853
Arkansas	946,556	385,911	496,531	41,554	22,561
Louisiana	781,809	364,417	363,941	35,013	18,438
Mississippi	925,176	389,180	471,193	42,632	22,172
Oklahoma	293,452	83,649	184,653	15,476	9,674
Tennessee	808,796	346,955	415,480	28,776	17,584
Texas	630,474	269,292	310,002	34,161	17,018
Total	5,480,246	2,273,044	2,817,347	253,554	136,301
Northeast and Mid-Atlantic:					
Connecticut	147,359	48,670	85,430	12,101	1,158
Delaware	29,055	11,459	14,985	2,356	254
Kentucky	842,864	315,789	455,733	63,525	7,816
Maine	1,598,051	354,087	1,096,346	138,258	9,360
Maryland	196,737	84,842	95,233	14,984	1,679
Massachusetts	256,614	79,441	152,611	22,587	1,975
New Hampshire	433,726	136,506	256,413	37,679	3,128
New Jersey	124,100	36,227	74,037	12,570	1,266
New York	1,361,089	391,881	828,706	128,612	11,890
Ohio	495,232	163,770	291,417	35,383	4,662
Pennsylvania	1,135,069	369,640	670,321	84,270	10,839
Rhode Island	29,701	8,604	18,168	2,675	254
Vermont	382,509	116,445	231,598	31,681	2,785
West Virginia	813,671	305,271	441,599	59,184	7,616
Total	7,845,777	2,422,634	4,712,598	645,865	64,680

Table 2.3—*Total storage of carbon in the United States by region, State, and forest ecosystem component, 1987, continued*

Region and State	Forest ecosystem component				
	Total	Trees	Soil	Forest floor	Understory
	1,000 metric tons				
North Central and Central:					
Illinois	305,933	108,319	172,388	22,533	2,692
Indiana	339,428	119,229	193,035	24,363	2,801
Iowa	107,972	36,017	62,662	8,307	986
Kansas	75,889	24,027	44,086	6,919	857
Michigan	1,485,400	381,070	952,627	142,471	9,232
Minnesota	1,343,553	281,845	931,406	121,900	8,402
Missouri	696,764	230,844	387,616	70,402	7,901
Nebraska	45,632	13,405	27,543	4,228	456
North Dakota	33,640	7,003	23,675	2,729	233
South Dakota	114,459	31,306	67,312	14,774	1,066
Wisconsin	1,153,116	287,162	740,282	116,007	9,665
Total	5,701,786	1,520,228	3,602,634	534,633	44,290
Rocky Mountain:					
Arizona	933,916	392,653	432,826	98,968	9,469
Colorado	1,209,722	429,764	605,245	164,289	10,424
Idaho	1,466,560	603,299	637,502	215,100	10,659
Montana	1,842,233	674,826	951,409	205,294	10,703
Nevada	336,485	172,733	132,039	27,353	4,361
New Mexico	761,463	257,516	384,808	110,089	9,051
Utah	792,172	283,184	428,722	72,336	7,930
Wyoming	678,131	212,619	370,192	90,451	4,869
Total	8,020,682	3,026,594	3,942,744	983,879	67,466
Pacific Coast:					
Alaska	13,941,916	2,287,208	10,067,502	1,386,200	201,005
California	2,275,231	994,463	950,732	268,694	61,341
Hawaii	76,698	6,395	59,667	7,913	2,723
Oregon	2,198,481	820,460	1,055,990	278,328	43,703
Washington	2,009,159	823,603	931,049	220,462	34,045
Total	20,501,485	4,932,130	13,064,941	2,161,596	342,817
U.S. total	52,490,999	16,145,324	30,790,047	4,795,639	759,989

Table 2.4—*Average and total storage of carbon in live trees in the United States by region and State, 1987*

Region and State	Average carbon storage in trees				Total carbon storage in trees			
	All forest land	Unreserved timberland	Reserved timberland	Other forest land	All forest land	Unreserved timberland	Reserved timberland	Other forest land
	Lbs/aC				1,000 metric tons			
Southeast:								
Florida	32,941	34,110	34,110	14,988	249,845	235,764	7,133	6,948
Georgia	46,837	46,858	46,858	19,852	507,886	496,990	10,733	162
North Carolina	56,428	56,496	56,496	26,798	483,548	470,468	12,557	523
South Carolina	51,105	51,105	51,105	25,233	284,130	282,322	1,808	0
Virginia	58,376	58,433	58,433	43,422	422,814	409,128	12,484	1,201
Total	48,950	49,377	49,167	17,025	1,948,222	1,894,673	44,715	8,834
South Central:								
Alabama	42,070	42,070	42,070	22,188	414,569	413,310	1,259	0
Arkansas	48,020	48,216	48,216	33,244	370,001	364,648	1,990	3,363
Louisiana	55,377	55,377	55,377	32,847	348,724	348,473	251	0
Mississippi	49,229	49,250	49,250	19,966	372,777	372,468	201	109
Oklahoma	24,274	26,012	26,012	20,975	80,201	56,020	271	23,909
Tennessee	55,368	55,393	55,393	41,943	332,971	322,589	9,925	457
Texas	41,523	43,157	43,157	23,270	257,204	243,012	2,349	11,843
Total	46,366	47,279	50,166	22,465	2,176,44	2,120,520	16,247	39,680
Northeast and Mid-Atlantic:								
Connecticut	57,119	57,145	57,145	54,405	47,024	46,061	544	420
Delaware	61,330	61,330	61,330	61,330	11,072	10,794	83	195
Kentucky	54,990	55,025	55,025	49,739	305,701	297,210	6,664	1,827
Maine	42,254	42,290	42,290	39,856	339,489	329,458	5,294	4,737
Maryland	68,662	68,700	68,700	63,191	81,973	76,689	4,768	516
Massachusetts	54,638	54,902	54,902	45,514	76,754	74,958	0	1,796
New Hampshire	57,799	57,742	57,742	59,659	131,636	125,798	1,833	4,005
New Jersey	38,912	38,972	38,972	35,001	35,036	33,835	725	476
New York	44,503	44,680	44,680	36,877	378,995	320,193	51,660	7,142
Ohio	47,814	47,906	47,906	34,052	158,539	155,174	2,608	757
Pennsylvania	46,416	46,589	46,589	35,992	357,831	342,050	11,242	4,539
Rhode Island	46,095	46,127	46,127	45,548	8,322	7,700	167	455
Vermont	55,378	55,368	55,368	56,789	112,508	111,107	628	773
West Virginia	54,609	54,629	54,629	45,584	295,806	292,373	2,874	558
Total	49,232	49,436	46,978	41,915	2,340,685	2,223,398	89,092	28,195

Table 2.4—*Average and total storage of carbon in live trees in the United States by region and State, 1987, continued*

Region and State	Average carbon storage in trees				Total carbon storage in trees			
	All forest land	Unreserved timberland	Reserved timberland	Other forest land	All forest land	Unreserved timberland	Reserved timberland	Other forest land
	Lbs/aC				1,000 metric tons			
North Central and Central:								
Illinois	54,243	54,243	54,243	38,764	104,961	99,154	5,807	0
Indiana	57,378	57,378	57,378	33,503	115,532	111,810	3,722	0
Iowa	49,258	49,429	49,429	39,581	34,900	32,711	1,704	485
Kansas	37,870	39,369	39,369	23,473	23,327	21,554	411	1,363
Michigan	44,462	44,589	44,589	34,710	367,474	351,189	12,600	3,684
Minnesota	36,168	36,883	36,883	30,418	272,051	227,039	19,708	25,305
Missouri	39,379	39,617	39,617	29,785	223,686	215,567	4,025	4,094
Nebraska	39,549	40,966	40,966	34,686	12,952	9,960	427	2,565
North Dakota	32,586	34,400	34,400	27,614	6,799	5,258	0	1,541
South Dakota	39,006	39,305	39,305	37,018	29,901	25,798	392	3,711
Wisconsin	39,929	40,155	40,155	29,702	277,451	268,238	4,754	4,459
Total	41,983	42,504	42,028	30,936	1,469,034	1,368,279	53,550	47,205
Rocky Mountain:								
Arizona	37,910	47,142	47,142	34,805	333,322	81,022	23,308	228,992
Colorado	37,695	40,344	40,344	33,176	364,825	214,818	31,365	118,641
Idaho	51,749	55,692	55,692	35,378	512,138	367,122	77,072	67,944
Montana	57,642	62,415	62,415	44,316	572,858	417,189	39,522	116,147
Nevada	36,212	42,472	42,472	36,053	146,632	4,258	19	142,355
New Mexico	26,013	31,491	31,491	22,996	218,604	74,005	19,983	124,616
Utah	32,648	36,893	36,893	31,513	240,394	51,509	5,790	183,095
Wyoming	39,927	41,262	41,262	36,320	180,492	81,078	55,081	44,333
Total	41,015	49,405	46,556	32,999	2,569,265	1,291,001	252,141	1,026,123
Pacific Coast:								
Alaska	36,968	61,891	61,891	32,109	2,163,868	442,517	148,563	1,572,788
California	52,670	65,141	65,141	40,247	940,835	493,794	86,869	360,172
Hawaii	7,793	16,756	16,756	0	6,179	5,320	859	0
Oregon	60,877	66,064	66,064	31,382	774,750	661,771	53,250	59,729
Washington	78,519	81,060	81,060	56,313	778,453	619,470	101,664	57,319
Total	46,720	67,963	66,925	33,454	4,664,085	2,222,873	391,205	2,050,008
U.S. total	45,720	50,727	54,065	33,039	15,167,738	11,120,744	846,949	3,200,045

Table 2.5—*Average and total storage of carbon in live trees on timberland in the Southeast, by forest type and productivity class, 1987*

Forest type and productivity class	Area of timberland	Volume of growing stock		Volume of solid wood		Average carbon storage in trees	Total carbon storage in trees
		Softwood	Hardwood	Softwood	Hardwood		
	(1,000 ac)	(1,000,000 cu ft)		(1,000,000 cu ft)		(Lbs/ac)	(1,000 metric tons)
White-red-jack pine							
85 +	365	699	142	1,160	308	55,665	9,216
50 to 85	98	115	56	191	121	46,957	2,088
20 to 50	18	25	6	42	13	42,486	347
Total	480	839	204	1,393	442	53,517	11,652
Spruce-fir							
85 +	0	0	0	0	0	0	0
50 to 85	9	10	5	16	11	44,431	182
20 to 50	9	7	1	12	2	20,486	84
Total	18	17	6	28	13	32,530	266
Longleaf-slash pine (planted)							
85 +	1,347	1,643	23	2,757	53	40,793	24,924
50 to 85	3,671	1,882	24	3,172	60	17,215	28,666
20 to 50	623	120	1	202	3	6,426	1,816
Total	5,641	3,644	50	6,130	120	21,665	55,436
Loblolly-shortleaf pine (planted)							
85 +	1,693	2,081	68	3,445	149	36,137	27,751
50 to 85	3,929	1,747	111	2,898	243	13,689	24,396
20 to 50	290	52	0	87	0	5,058	665
Total	5,913	3,881	180	6,432	395	19,703	52,845
Longleaf-slash pine (natural)							
85 +	1,391	2,675	175	4,503	416	69,205	43,665
50 to 85	3,267	3,767	159	6,352	378	40,297	59,716
20 to 50	1,501	972	10	1,634	24	21,599	14,705
Total	6,160	7,414	345	12,488	820	42,269	118,106
Loblolly-shortleaf pine (natural)							
85 +	5,799	11,672	1,879	19,375	4,132	70,574	185,636
50 to 85	7,600	8,694	1,282	14,431	2,813	39,418	135,886
20 to 50	1,487	1,057	97	1,752	214	22,754	15,347
Total	14,886	21,424	3,259	35,559	7,161	49,895	336,902
Oak-pine							
85 +	2,713	2,441	2,497	4,056	5,516	66,809	82,215
50 to 85	5,453	2,966	2,662	4,944	5,917	37,583	92,960
20 to 50	1,431	533	290	890	640	19,898	12,915
Total	9,598	5,939	5,448	9,889	12,071	43,196	188,058

Table 2.5—*Average and total storage of carbon in live trees on timberland in the Southeast, by forest type and productivity class, 1987, continued*

Forest type and productivity class	Area of timberland	Volume of growing stock		Volume of solid wood		Average carbon storage in trees	Total carbon storage in trees
		Softwood	Hardwood	Softwood	Hardwood		
	(1,000 ac)	(1,000,000 cu ft)		(1,000,000 cu ft)		(Lbs/ac)	(1,000 metric tons)
Oak-hickory							
85 +	7,186	944	13,387	1,567	29,170	84,276	274,699
50 to 85	15,013	1,353	17,868	2,250	39,275	54,478	370,984
20 to 50	3,155	291	2,687	485	5,873	39,599	56,669
Total	25,351	2,587	33,941	4,300	74,316	61,076	702,319
Oak-gum-cypress							
85 +	2,727	759	5,603	1,263	12,485	89,413	110,599
50 to 85	7,056	3,074	10,354	5,172	24,039	72,453	231,888
20 to 50	1,684	1,015	890	1,721	2,121	38,233	29,205
Total	11,467	4,847	16,847	8,155	38,645	71,459	371,681
Elm-ash-cottonwood							
85 +	681	50	1,481	83	3,262	85,683	26,467
50 to 85	706	37	1,018	61	2,264	57,437	18,393
20 to 50	34	1	26	2	56	29,357	453
Total	1,422	88	2,525	146	5,581	70,254	45,314
Maple-beech-birch							
85 +	67	17	170	28	364	107,578	3,271
50 to 85	157	14	289	23	620	76,287	5,434
20 to 50	13	0	22	0	48	68,917	407
Total	236	32	481	53	1,031	85,198	9,121
Non-stocked timberland							
85 +	263	4	12	7	26	422	289
50 to 85	1,394	27	48	46	117	2,251	1,423
20 to 50	1,768	64	16	108	38	1,512	1,212
Total	3,423	97	77	164	184	1,914	2,972
All timberland							
85 +	24,229	22,985	25,437	38,245	55,881	71,768	788,733
50 to 85	48,352	23,685	33,877	39,554	75,858	44,319	972,016
20 to 50	12,012	4,137	4,046	6,934	9,031	24,562	133,827
Total	84,595	50,806	63,361	84,732	140,773	49,377	1,894,673

Table 2.6—*Average and total storage of carbon in live trees on timberland in the South Central, by forest type and productivity class, 1987*

Forest type and productivity class	Area of timberland	Volume of growing stock		Volume of solid wood		Average carbon storage in trees	Total carbon storage in trees
		Softwood	Hardwood	Softwood	Hardwood		
	(1,000 ac)	(1,000,000 cu ft)		(1,000,000 cu ft)		(Lbs/ac)	(1,000 metric tons)
White-red-jack pine							
85 +	0	0	0	0	0	0	0
50 to 85	11	16	6	29	17	60,025	301
20 to 50	0	0	0	0	0	0	0
Total	11	16	6	29	17	60,025	301
Spruce-fir							
85 +	0	0	0	0	0	0	0
50 to 85	0	0	0	0	0	0	0
20 to 50	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0
Longleaf-slash pine (planted)							
85 +	921	1,031	22	1,793	63	39,415	16,467
50 to 85	538	272	13	479	36	18,756	4,577
20 to 50	59	30	0	52	0	17,240	462
Total	1,518	1,333	34	2,324	97	31,195	21,480
Loblolly-shortleaf pine (planted)							
85 +	3,548	3,324	237	5,818	671	31,457	50,625
50 to 85	1,494	707	54	1,245	152	16,102	10,912
20 to 50	179	40	3	70	8	7,480	607
Total	5,217	4,071	295	7,133	834	26,272	62,170
Longleaf-slash pine (natural)							
85 +	953	1,401	91	2,464	254	55,841	24,139
50 to 85	978	955	36	1,698	99	35,932	15,940
20 to 50	242	122	6	218	16	18,946	2,080
Total	2,173	2,480	134	4,383	373	42,831	42,217
Loblolly-shortleaf pine (natural)							
85 +	13,250	21,458	2,862	37,511	8,175	60,060	360,969
50 to 85	5,250	5,225	737	9,065	2,093	37,076	88,291
20 to 50	901	521	90	904	256	22,593	9,234
Total	19,400	27,202	3,690	47,477	10,527	52,103	458,492
Oak-pine							
85 +	10,271	7,444	5,016	13,059	14,257	50,060	233,222
50 to 85	5,685	2,601	1,848	4,548	5,183	32,257	83,180
20 to 50	1,412	437	379	760	1,065	24,494	15,688
Total	17,363	10,484	7,245	18,371	20,511	42,177	332,172

Table 2.6—*Average and total storage of carbon in live trees on timberland in the South Central, by forest type and productivity class, 1987, continued*

Forest type and productivity class	Area of timberland	Volume of growing stock		Volume of solid wood		Average carbon storage in trees	Total carbon storage in trees
		Softwood	Hardwood	Softwood	Hardwood		
	(1,000 ac)	(1,000,000 cu ft)		(1,000,000 cu ft)		(Lbs/ac)	(1,000 metric tons)
Oak-hickory							
85 +	14,317	2,090	11,848	3,677	33,225	50,526	328,119
50 to 85	14,297	1,042	10,473	1,838	29,383	42,991	278,796
20 to 50	7,517	222	4,283	386	12,274	33,252	113,379
Total	36,130	3,356	26,602	5,904	74,875	43,950	720,260
Oak-gum-cypress							
85 +	10,563	1,599	13,344	2,773	37,659	68,131	326,435
50 to 85	4,666	1,123	4,356	1,925	12,496	54,462	115,267
20 to 50	601	176	360	300	1,075	39,795	10,848
Total	15,830	2,895	18,061	4,993	51,234	63,024	452,537
Elm-ash-cottonwood							
85 +	735	29	1,041	50	3,028	73,063	24,359
50 to 85	279	13	162	22	480	31,338	3,966
20 to 50	60	0	44	0	134	38,988	1,062
Total	1,073	42	1,246	72	3,639	60,334	29,365
Maple-beech-birch							
85 +	15	0	19	0	52	65,590	448
50 to 85	33	4	32	7	88	53,100	796
20 to 50	11	0	12	0	33	56,407	283
Total	60	4	63	7	174	56,063	1,527
Non-stocked timberland							
85 +	42	0	0	0	0	0	0
50 to 85	47	0	0	0	0	0	0
20 to 50	13	0	0	0	0	0	0
Total	102	0	0	0	0	0	0
All timberland							
85 +	54,615	38,376	34,478	67,149	7,380	55,092	1,364,783
50 to 85	33,273	11,960	17,720	20,860	50,035	39,890	602,029
20 to 50	10,991	1,546	5,177	2,686	14,862	30,818	153,643
Total	98,879	51,882	57,375	90,692	162,277	47,279	2,120,520

Table 2.7—*Average and total storage of carbon in live trees on timberland in the Northeast and Mid-Atlantic, by forest type and productivity class, 1987*

Forest type and productivity class	Area of timberland	Volume of growing stock		Volume of solid wood		Average carbon storage in trees	Total carbon storage in trees
		Softwood	Hardwood	Softwood	Hardwood		
	(1,000 ac)	(1,000,000 cu ft)		(1,000,000 cu ft)		(Lbs/ac)	(1,000 metric tons)
White-red-jack pine							
85 +	2,164	3,080	888	6,383	1,894	50,971	50,034
50 to 85	3,760	4,323	1,727	9,149	3,782	46,833	79,879
20 to 50	2,144	2,076	1,017	4,468	2,307	43,721	42,523
Total	8,067	9,480	3,631	20,002	7,980	47,122	172,426
Spruce-fir							
85 +	1,558	2,068	437	4,500	1,015	45,279	31,989
50 to 85	5,659	7,191	1,397	15,849	3,369	43,304	111,146
20 to 50	2,794	3,050	569	6,718	1,368	36,826	46,666
Total	10,007	12,310	2,407	27,069	5,760	41,829	189,875
Loblolly-shortleaf pine							
85 +	791	659	246	1,504	549	45,314	16,254
50 to 85	808	538	242	1,191	530	37,424	13,723
20 to 50	1,105	631	173	1,323	359	26,286	13,176
Total	2,704	1,827	660	4,016	1,435	35,153	43,117
Oak-pine							
85 +	841	532	736	1,127	1,566	60,284	22,999
50 to 85	1,600	897	1,236	1,944	2,682	54,430	39,505
20 to 50	1,097	596	697	1,256	1,504	47,156	23,464
Total	3,539	2,022	2,668	4,321	5,750	53,510	85,898
Oak-hickory							
85 +	10,330	333	14,225	712	30,419	59,034	276,615
50 to 85	15,838	609	21,090	1,290	45,081	57,244	411,247
20 to 50	10,560	648	12,480	1,360	26,401	50,975	244,166
Total	36,730	1,591	47,795	3,363	101,901	55,943	932,038
Oak-gum-cypress							
85 +	61	0	57	0	121	35,768	990
50 to 85	149	87	145	196	307	56,854	3,840
20 to 50	233	56	267	123	545	50,144	5,290
Total	444	144	470	320	976	50,457	10,153
Elm-ash-cottonwood							
85 +	1,218	37	1,394	81	3,009	44,308	24,485
50 to 85	2,279	45	1,805	96	3,866	30,364	31,389
20 to 50	1,382	37	918	81	1,963	25,817	16,185
Total	4,879	119	4,117	258	8,838	32,560	72,059

Table 2.7—*Average and total storage of carbon in live trees on timberland in the Northeast and Mid-Atlantic, by forest type and productivity class, 1987, continued*

Forest type and productivity class	Area of timberland	Volume of growing stock		Volume of solid wood		Average carbon storage in trees	Total carbon storage in trees
		Softwood	Hardwood	Softwood	Hardwood		
	(1,000 ac)	(1,000,000 cu ft)		(1,000,000 cu ft)		(Lbs/ac)	(1,000 metric tons)
Maple-beech-birch							
85 +	6,511	986	8,666	2,064	17,961	55,363	163,508
50 to 85	12,971	2,091	15,685	4,407	32,708	51,229	301,415
20 to 50	9,663	1,782	9,776	3,860	22,124	47,651	208,856
Total	29,145	4,861	34,129	10,335	72,797	50,971	673,836
Aspen-birch							
85+	541	72	428	155	929	27,922	6,847
50 to 85	1,454	212	1,180	463	2,646	29,784	19,636
20 to 50	1,248	187	979	413	2,327	30,572	17,300
Total	3,240	471	2,589	1,030	5,906	29,814	43,810
Non-stocked timberland							
85 +	19	0	1	0	2	2,147	19
50 to 85	225	1	4	2	8	877	89
20 to 50	159	0	4	0	9	1,096	79
Total	402	1	9	2	19	1,026	187
All timberland							
85 +	24,028	7,766	27,074	16,524	57,455	54,477	593,739
50 to 85	44,744	15,995	44,517	34,588	94,992	49,857	1,011,869
20 to 50	30,381	9,065	26,880	19,605	58,907	44,824	617,706
Total	99,153	32,825	98,470	70,714	211,352	49,436	2,223,398

Table 2.8—*Average and total storage of carbon in live trees on timberland in the North Central and Central, by forest type and productivity class, 1987*

Forest type and productivity class	Area of timberland	Volume of growing stock		Volume of solid wood		Average carbon storage in trees	Total carbon storage in trees
		Softwood	Hardwood	Softwood	Hardwood		
	(1,000 ac)	(1,000,000 cu ft)		(1,000,000 cu ft)		(Lbs/ac)	(1,000 metric tons)
White-red-jack pine							
85 +	1,274	2,128	227	5,243	547	63,434	36,661
50 to 85	1,582	1,797	240	4,389	573	43,958	31,548
20 to 50	2,452	2,324	123	5,450	296	32,442	36,083
Total	5,307	6,249	590	15,081	1,416	43,324	104,291
Spruce-fir							
85 +	1,268	1,213	449	3,034	1,070	39,869	22,932
50 to 85	1,093	941	222	2,339	528	31,604	15,670
20 to 50	4,457	3,148	480	7,906	1,135	24,025	48,570
Total	6,817	5,303	1,151	13,282	2,734	28,195	87,185
Loblolly-shortleaf pine							
85 +	123	112	47	270	123	56,161	3,135
50 to 85	186	160	37	360	111	43,967	3,713
20 to 50	167	72	14	161	41	20,810	1,578
Total	474	345	100	794	280	39,500	8,494
Oak-pine							
85 +	107	64	68	150	190	59,504	2,897
50 to 85	276	124	108	278	335	41,619	5,211
20 to 50	433	87	85	204	266	20,426	4,012
Total	815	275	259	633	785	32,649	12,071
Oak-hickory							
85 +	2,844	45	3,876	107	9,829	68,357	88,188
50 to 85	6,826	234	6,967	559	18,826	55,255	171,082
20 to 50	9,752	248	5,599	589	16,563	34,161	151,110
Total	19,422	524	16,445	1,245	45,227	46,585	410,397
Oak-gum-cypress							
85 +	121	10	205	22	553	84,993	4,672
50 to 85	104	4	148	9	428	75,388	3,562
20 to 50	166	2	158	5	423	46,322	3,490
Total	391	16	510	36	1,401	65,943	11,698
Elm-ash-cottonwood							
85 +	1,722	38	2,447	92	6,429	66,199	51,707
50 to 85	1,892	84	1,920	206	5,183	49,718	42,668
20 to 50	3,299	339	2,252	842	5,824	35,086	52,502
Total	6,915	462	6,619	1,143	17,438	46,838	146,912

Table 2.8—*Average and total storage of carbon in live trees on timberland in the North Central and Central, by forest type and productivity class, 1987, continued*

Forest type and productivity class	Area of timberland	Volume of growing stock		Volume of solid wood		Average carbon storage in trees	Total carbon storage in trees
		Softwood	Hardwood	Softwood	Hardwood		
	(1,000 ac)	(1,000,000 cu ft)		(1,000,000 cu ft)		(Lbs/ac)	(1,000 metric tons)
Maple-beech-birch							
85 +	3,639	248	5,063	612	12, 306	62,576	103,298
50 to 85	6,202	884	7,956	2,185	18,863	58,713	165,174
20 to 50	4,893	843	4,307	2,093	10,355	43,059	95,566
Total	14,734	1,975	17,327	4,889	41,527	54,474	364,062
Aspen-birch							
85+	4,433	629	4,641	1,580	11,127	40,549	81,537
50 to 85	6,966	1,021	5,582	2,566	13,478	32,381	102,318
20 to 50	3,134	477	1,838	1,200	4,457	25,147	35,748
Total	14,533	2,128	12,061	5,348	29,063	33,316	219,620
Non-stocked timberland							
85 +	82	2	10	5	30	8,179	306
50 to 85	320	3	38	7	113	7,405	1,075
20 to 50	1,145	10	73	23	222	4,199	2,181
Total	1,549	17	119	40	359	5,051	3,549
All timberland							
85 +	15,611	4,489	17,031	11,115	42,198	55830	395,333
50 to 85	25,449	5,251	23,219	12,895	58,443	46,955	542,021
20 to 50	29,908	7,554	14,937	18,484	39,614	31,759	430,839
Total	70,970	17,294	55,186	42,494	140,253	42,504	1,368,279

Table 2.9—*Average and total storage of carbon in live trees on timberland in the Rocky Mountains, by forest type and productivity class, 1987*

Forest type and productivity class	Area of timberland	Volume of growing stock		Volume of solid wood		Average carbon storage in trees	Total carbon storage in trees
		Softwood	Hardwood	Softwood	Hardwood		
	(1,000 ac)	(1,000,000 cu ft)		(1,000,000 cu ft)		(Lbs/ac)	(1,000 metric tons)
Douglas-fir							
85 +	2,904	7,386	69	14,909	163	78,157	102,954
50 to 85	5,619	11,355	210	24,240	416	65,993	168,201
20 to 50	4,779	6,314	70	13,204	137	42,045	91,142
Total	13,304	25,057	350	52,357	718	60,043	362,337
Ponderosa pine							
85 +	769	1,732	11	3,339	22	58,032	20,245
50 to 85	1,951	3,061	26	6,236	62	42,860	37,930
20 to 50	10,995	10,507	120	21,754	273	26,588	132,601
Total	13,715	15,302	159	31,333	362	30,674	190,825
Western white pine							
85 +	240	892	2	1,718	4	86,297	9,400
50 to 85	16	36	0	70	0	51,965	381
20 to 50	4	1	1	2	2	10,678	21
Total	260	929	2	1,790	4	82,974	9,791
Fir-spruce							
85 +	2,899	8,304	159	16,267	306	63,807	83,904
50 to 85	5,046	11,763	592	23,384	1,311	54,727	125,261
20 to 50	3,063	5,536	115	10,930	240	40,708	56,558
Total	11,010	25,603	866	50,581	1,855	53,207	265,718
Hemlock-Sitka spruce							
85 +	1,243	3,992	19	7,555	38	84,574	47,690
50 to 85	226	625	0	1,230	0	75,345	7,729
20 to 50	19	39	0	82	0	58,969	512
Total	1,488	4,656	20	8,867	40	82,882	55,943
Larch							
85 +	1,212	3,595	12	7,204	24	96,726	53,178
50 to 85	506	1,133	1	2,483	2	79,674	18,289
20 to 50	31	42	0	86	0	44,933	633
Total	1,749	4,771	13	9,774	26	90,896	72,113
Lodgepole pine							
85 +	1,276	3,177	36	6,759	71	72,148	41,765
50 to 85	2,983	7,310	39	15,882	79	72,178	97,666
20 to 50	5,137	9,465	64	19,341	131	51,121	119,117
Total	9,396	19,952	140	41,982	284	60,666	258,559

Table 2.9—*Average and total storage of carbon in live trees on timberland in the Rocky Mountains, by forest type and productivity class, 1987, continued*

Forest type and productivity class	Area of timberland	Volume of growing stock		Volume of solid wood		Average carbon storage in trees	Total carbon storage in trees
		Softwood	Hardwood	Softwood	Hardwood		
	(1,000 ac)	(1,000,000 cu ft)		(1,000,000 cu ft)		(Lbs/ac)	(1,000 metric tons)
Redwood							
85 +	0	0	0	0	0	0	0
50 to 85	0	0	0	0	0	0	0
20 to 50	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0
Other softwood types							
85+	60	141	4	327	8	75,871	2,051
50 to 85	72	117	0	237	0	44,274	1,454
20 to 50	170	263	0	520	0	41,394	3,192
Total	301	521	4	1,083	8	49,051	6,697
Western hardwood types							
85 +	285	201	349	394	693	47,599	6,156
50 to 85	1,656	648	1,711	1,262	3,390	34,627	26,010
20 to 50	2,872	587	2,583	1,148	5,111	26,540	34,575
Total	4,810	1,439	4,643	2,810	9,195	30,607	66,777
Non-stocked timberland							
85 +	293	28	5	56	11	3,023	402
50 to 85	358	45	6	89	12	3,779	614
20 to 50	926	88	6	188	15	2,944	1,237
Total	1,576	159	18	330	40	3,134	2,240
All timberland							
85 +	11,184	29,451	669	58,534	1,345	72,491	367,746
50 to 85	18,435	36,095	2,584	75,117	5,271	57,825	483,533
20 to 50	27,993	32,843	2,961	67,255	5,913	34,620	439,587
Total	57,609	98,389	6,214	200,907	12,530	49,405	1,291,001

Table 2.10—*Average and total storage of carbon in live trees on timberland in the Pacific Coast, by forest type and productivity class, 1987*

Forest type and productivity class	Area of timberland	Volume of growing stock		Volume of solid wood		Average carbon storage in trees	Total carbon storage in trees
		Softwood	Hardwood	Softwood	Hardwood		
	(1,000 ac)	(1,000,000 cu ft)		(1,000,000 cu ft)		(Lbs/ac)	(1,000 metric tons)
Douglas-fir							
85 +	13,723	51,448	3,449	80,224	6,367	93,705	583,285
50 to 85	3,632	14,073	431	21,964	817	93,933	154,751
20 to 50	1,938	5,189	111	8,116	212	64,501	56,701
Total	19,294	70,709	3,991	110,302	7,395	90,809	794,727
Ponderosa pine							
85 +	2,548	6,925	740	10,888	1,441	63,444	73,327
50 to 85	4,081	6,841	335	10,694	651	36,705	67,945
20 to 50	4,340	6,153	127	9,618	246	30,118	59,290
Total	10,968	19,920	1,201	31,201	2,336	40,314	200,561
Western white pine							
85 +	12	12	0	19	0	18,550	102
50 to 85	0	0	0	0	0	0	0
20 to 50	2	3	0	5	0	25,593	26
Total	14	15	0	23	0	20,088	128
Fir-spruce							
85 +	3,827	15,868	613	24,911	1,196	76,253	132,371
50 to 85	5,230	16,293	398	25,517	775	56,144	133,191
20 to 50	6,791	9,245	1,545	14,913	4,777	32,759	100,908
Total	15,850	41,406	2,556	65,341	6,748	50,973	366,471
Hemlock–Sitka spruce							
85 +	6,800	37,098	686	59,525	1,357	123,910	382,192
50 to 85	1,528	7,074	66	11,459	167	105,331	73,005
20 to 50	1,168	4,995	8	8,017	22	95,303	50,496
Total	9,497	49,165	761	78,997	1,549	117,391	505,692
Larch							
85 +	523	1,511	63	2,362	114	76,222	18,083
50 to 85	284	636	1	994	2	5,6873	7,327
20 to 50	45	74	0	115	0	41,341	846
Total	852	2,221	65	3,471	117	67,966	26,267
Lodgepole pine							
85 +	157	487	3	763	5	66,009	4,701
50 to 85	534	1,011	1	1,583	2	40,050	9,701
20 to 50	1,488	2,153	7	3,355	14	30,539	20,612
Total	2,179	3,651	11	5,701	21	35,426	35,015

Table 2.10—*Average and total storage of carbon in live trees on timberland in the Pacific Coast, by forest type and productivity class, 1987, continued*

Forest type and productivity class	Area of timberland	Volume of growing stock		Volume of solid wood		Average carbon storage in trees	Total carbon storage in trees
		Softwood	Hardwood	Softwood	Hardwood		
	(1,000 ac)	(1,000,000 cu ft)		(1,000,000 cu ft)		(Lbs/ac)	(1,000 metric tons)
Redwood							
85 +	1,064	5,740	686	9,032	1,339	135,403	65,351
50 to 85	37	52	18	82	35	46,284	780
20 to 50	0	0	0	0	0	0	0
Total	1,102	5,792	704	9,114	1,374	132,294	66,130
Other softwood types							
85+	176	59	91	92	250	23,985	1,916
50 to 85	104	32	25	50	47	11,944	565
20 to 50	211	83	19	135	60	12,008	1,151
Total	491	174	133	278	354	16,216	3,611
Western hardwood types							
85 +	5,329	4,994	9,820	7,815	18,484	61,042	147,551
50 to 85	978	441	1,181	693	2,415	38,899	17,258
20 to 50	4,738	772	2,988	1,248	9,245	26,733	57,454
Total	11,046	6,207	13,989	9,756	30,142	44,359	222,256
Non-stocked timberland							
85 +	508	88	83	137	152	7,200	1,659
50 to 85	143	26	0	41	0	3,850	250
20 to 50	164	14	0	22	0	1,802	134
Total	815	125	83	195	152	5,448	2,014
All timberland							
85 +	34,667	124,229	16,236	195,767	30,708	89,702	1,410,538
50 to 85	16,552	46,479	2,457	73,077	4,914	61,904	464,772
20 to 50	20,888	28,678	4,804	45,538	14,572	36,689	347,619
Total	72,107	199,386	23,496	314,381	50,191	67,963	2,222,873

Table 2.11—*Annual average and total accumulation of carbon in live trees in the United States by region and State, 1987*

Region and State	Average carbon accumulation in trees				Total carbon accumulation in trees			
	All forest land	Unreserved timberland	Reserved timberland	Other forest land	All forest land	Unreserved timberland	Reserved timberland	Other forest land
	Lbs/ac/yr				1,000 metric tons/yr			
Southeast:								
Florida	1,534	1,589	1,589	683	11,634	10,985	332	316
Georgia	2,173	2,174	2,174	960	23,565	23,059	498	8
North Carolina	2,163	2,166	2,166	1,048	18,539	18,037	481	20
South Carolina	1,898	1,898	1,898	1,119	10,554	10,487	67	0
Virginia	2,018	2,021	2,021	1,326	14,618	14,149	432	37
Total	1,983	1,999	1,991	735	78,909	76,717	1,811	381
South Central:								
Alabama	1,741	1,741	1,741	776	17,161	17,109	52	0
Arkansas	1,891	1,903	1,903	992	14,574	14,395	79	100
Louisiana	2,338	2,338	2,338	807	14,722	14,711	11	0
Mississippi	2,209	2,210	2,210	1,113	16,726	16,711	9	6
Oklahoma	804	914	914	595	2,657	1,969	10	678
Tennessee	1,821	1,821	1,821	1,435	10,948	10,606	326	16
Texas	1,911	2,019	2,019	704	11,834	11,366	110	358
Total	1,888	1,937	1,840	656	88,622	86,868	596	1159
Northeast and Mid-Atlantic:								
Connecticut	1,031	1,031	1,031	994	849	831	10	8
Delaware	1,623	1,623	1,623	1,623	293	286	2	5
Kentucky	1,853	1,854	1,854	1,638	10,299	10,014	225	60
Maine	926	926	926	935	7,443	7,216	116	111
Maryland	4,145	4,147	4,147	3,842	4,948	4,629	288	31
Massachusetts	1,188	1,188	1,188	1,164	1,669	1,623	0	46
New Hampshire	1,508	1,504	1,504	1,617	3,434	3,278	48	109
New Jersey	642	643	643	583	578	558	12	8
New York	1,269	1,274	1,274	1,086	10,811	9,128	1,473	210
Ohio	1,959	1,963	1,963	1,459	6,497	6,358	107	32
Pennsylvania	1,164	1,167	1,167	961	8,970	8,567	282	121
Rhode Island	1,084	1,086	1,086	1,060	196	181	4	11
Vermont	1,686	1,686	1,686	1,740	3,426	3,383	19	24
West Virginia	1,686	1,687	1,687	1,462	9,133	9,027	89	18
Total	1,442	1,447	1,409	1,180	68,545	65,078	2,673	794

Table 2.11—*Annual average and total accumulation of carbon in live trees in the United States by region and State, 1987, continued*

Region and State	Average carbon accumulation in trees				Total carbon accumulation in trees			
	All forest land	Unreserved timberland	Reserved timberland	Other forest land	All forest land	Unreserved timberland	Reserved timberland	Other forest land
	Lbs/ac/yr				1,000 metric tons/yr			
North Central and Central:								
Illinois	1,060	1,060	1,060	699	2,051	1,937	113	0
Indiana	1,379	1,379	1,379	838	2,777	2,688	89	0
Iowa	1,828	1,839	1,839	1,196	1,295	1,217	63	15
Kansas	1,026	1,082	1,082	489	632	592	11	28
Michigan	1,549	1,557	1,557	981	12,804	12,260	440	104
Minnesota	1,223	1,266	1,266	872	9,197	7,795	677	725
Missouri	1,279	1,290	1,290	860	7,267	7,018	131	118
Nebraska	913	966	966	730	299	235	10	54
North Dakota	882	967	967	650	184	148	0	36
South Dakota	968	972	972	938	742	638	10	94
Wisconsin	1,318	1,328	1,328	867	9,156	8,869	157	130
Total	1,326	1,348	1,336	855	46,404	43,397	1,702	1,305
Rocky Mountain:								
Arizona	847	909	909	826	7,446	1,562	449	5,434
Colorado	613	625	625	593	5,935	3,328	486	2,120
Idaho	1,112	1,244	1,244	561	11,002	8,203	1,722	1,077
Montana	1,151	1,284	1,284	781	11,443	8,584	813	2,046
Nevada	315	516	516	310	1,275	52	0	1,223
New Mexico	667	791	791	600	5,609	1,858	502	3,249
Utah	463	513	513	450	3,411	717	81	2,614
Wyoming	586	599	599	552	2,651	1,178	800	674
Total	779	975	896	593	48,772	25,482	4,853	18,436
Pacific Coast:								
Alaska	472	478	478	471	27,622	3,417	1,147	23,057
California	986	1,287	1,287	685	17,606	9,760	1,717	6,129
Hawaii	28	60	60	0	22	19	3	0
Oregon	1,357	1,494	1,494	580	17,272	14,965	1,204	1,103
Washington	2,193	2,313	2,313	1,146	21,739	17,673	2,900	1,166
Total	844	1,401	1,193	513	84,261	45,833	6,972	31,456
U.S. total	1,252	1,566	1,188	553	415,513	343,375	18,607	53,532

Table 2.12—*Annual average and total accumulation of carbon in live trees on timberland in the Southeast, by forest type and productivity class, 1987*

Forest type and productivity class	Area of timberland	Net annual growth of growing stock		Net annual growth of solid wood		Average carbon accumulation in trees	Total carbon accumulation in trees
		Softwood	Hardwood	Softwood	Hardwood		
	(1,000 ac)	(1,000,000 cu ft/yr)		(1,000,000 cu ft/yr)		(Lbs/ac/yr)	(1,000 metric tons/yr)
White-red-jack pine							
85 +	365	27,156	4,453	45,094	9,653	2,050	339
50 to 85	98	3,817	1,706	6,344	3,697	1,501	67
20 to 50	18	541	133	901	290	926	8
Total	480	31,514	6,293	52,339	13,641	1,900	414
Spruce-fir							
85 +	0	0	0	0	0	0	0
50 to 85	9	334	234	549	496	1,769	7
20 to 50	9	184	53	302	112	652	3
Total	18	518	287	852	608	1,213	10
Longleaf-slash pine (planted)							
85 +	1,347	136,003	2,119	228,651	5,026	3,392	2,073
50 to 85	3,671	240,567	2,554	405,873	6,188	2,195	3,655
20 to 50	623	21,591	74	36,322	194	1,146	324
Total	5,641	398,161	4,746	670,847	11,406	2,365	6,051
Loblolly-shortleaf pine (planted)							
85 +	1,693	139,981	4,587	231,900	10,055	2,432	1,868
50 to 85	3,929	186,303	7,842	309,130	17,107	1,416	2,523
20 to 50	290	7,425	84	12,418	183	736	97
Total	5,913	333,707	12,510	553,446	27,338	1,673	4,488
Longleaf-slash pine (natural)							
85 +	1,391	142,392	8,384	239,640	20,017	3,653	2,305
50 to 85	3,267	211,437	8,950	356,546	21,396	2,263	3,354
20 to 50	1,501	49,216	619	82,922	1,455	1,099	748
Total	6,160	403,046	17,953	679,109	42,868	2,293	6,407
Loblolly-shortleaf pine (natural)							
85 +	5,799	492,490	89,394	818,134	196,041	3,054	8,032
50 to 85	7,600	459,696	67,771	763,305	148,459	2,084	7,185
20 to 50	1,487	50,274	5,574	83,323	12,193	1,109	748
Total	14,886	1,002,460	162,739	1,664,763	356,695	2,364	15,965
Oak-pine							
85 +	2,713	88,178	97,651	146,659	215,672	2,534	3,118
50 to 85	5,453	130,259	111,487	217,174	248,653	1,610	3,982
20 to 50	1,43	22,401	11,865	37,467	26,390	830	539
Total	9,598	240,840	221,004	401,304	490,718	1,755	7,639

Table 2.12—*Annual average and total accumulation of carbon in live trees on timberland in the Southeast, by forest type and productivity class, 1987, continued*

Forest type and productivity class	Area of timberland	Net annual growth of growing stock		Net annual growth of solid wood		Average carbon accumulation in trees	Total carbon accumulation in trees
		Softwood	Hardwood	Softwood	Hardwood		
	(1,000 ac)	(1,000,000 cu ft/yr)		(1,000,000 cu ft/yr)		(Lbs/ac/yr)	(1,000 metric tons/yr)
Oak-hickory							
85 +	7,186	30,426	444,649	50,536	968,430	2,794	9,108
50 to 85	15,013	50,756	606,656	84,502	1,333,547	1,859	12,662
20 to 50	3,155	8,999	85,789	14,985	187,658	1,262	1,807
Total	25,351	90,179	1,137,093	150,021	2,489,632	2,050	23,576
Oak-gum-cypress							
85 +	2,727	21,400	162,622	35,622	361,592	2,584	3,196
50 to 85	7,056	80,724	286,811	135,649	666,904	1,993	6,379
20 to 50	1,684	25,791	30,136	43,675	72,356	1,168	892
Total	11,467	127,915	479,570	214,946	1,100,853	2,013	10,468
Elm-ash-cottonwood							
85 +	681	1,606	44,240	2,664	97,139	2,556	790
50 to 85	706	926	30,431	1,535	67,319	1,701	545
20 to 50	34	33	844	55	1,803	95	15
Total	1,422	2,565	75,516	4,253	166,261	2,092	1,349
Maple-beech-birch							
85 +	67	351	4,086	577	8,740	2,569	78
50 to 85	157	386	7,408	641	15,879	1,959	140
20 to 50	13	46	462	76	996	1,516	9
Total	236	783	11,956	1,294	25,616	2,116	227
Non-stocked timberland							
85 +	263	159	765	268	1,673	144	17
50 to 85	1,394	1,339	1,438	2,265	3,544	79	50
20 to 50	1,768	3,107	634	5,249	1,432	69	55
Total	3,423	4,605	2,837	7,783	6,649	79	122
All timberland							
85 +	24,229	1,080,140	862,948	1,799,744	1,894,036	2,814	30,925
50 to 85	48,352	1,366,546	1,133,291	228,3518	2,533,193	1,849	40,548
20 to 50	12,012	189,605	136,268	317,690	305,062	962	5,244
Total	84,595	2,636,292	2,132,506	4,400,954	4,732,288	1,999	76,717

Table 2.13—*Annual average and total accumulation of carbon in live trees on timberland in the South Central, by forest type and productivity class, 1987*

Forest type and productivity class	Area of timberland	Net annual growth of growing stock		Net annual growth of solid wood		Average carbon accumulation in trees	Total carbon accumulation in trees
		Softwood	Hardwood	Softwood	Hardwood		
	(1,000 ac)	(1,000,000 cu ft/yr)		(1,000,000 cu ft/yr)		(Lbs/ac/yr)	(1,000 metric tons/yr)
White-red-jack pine							
85 +	0	0	0	0	0	0	0
50 to 85	11	302	71	544	196	9,445	
20 to 50	0	0	0	0	0	0	0
Total	11	302	71	544	196	944	5
Spruce-fir							
85 +	0	0	0	0	0	0	0
50 to 85	0	0	0	0	0	0	0
20 to 50	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0
Longleaf-slash pine (planted)							
85 +	921	76,517	1,913	133,066	5,500	2,943	1,229
50 to 85	538	21,388	990	37,631	2,829	1,471	359
20 to 50	59	2,876	0	4,978	0	1,648	44
Total	1,518	100,781	2,901	175,674	8,323	2,371	1,633
Loblolly-shortleaf pine (planted)							
85 +	3,548	257,010	20,678	449,817	58,663	2,470	3,975
50 to 85	1,494	63,407	5,250	111,714	15,030	1,463	991
20 to 50	179	3,358	356	5,898	986	666	54
Total	5,217	323,772	26,282	567,423	74,673	2,121	5,020
Longleaf-slash pine (natural)							
85 +	953	61,700	3,441	108,079	9,636	2,417	1,045
50 to 85	978	39,244	1,683	69,549	4,625	1,484	658
20 to 50	242	5,488	305	9,764	837	857	94
Total	2,173	106,432	5,399	187,392	15,016	1,823	1,797
Loblolly-shortleaf pine (natural)							
85 +	13,250	1,039,078	121,320	1,814,580	345,462	2,831	17,013
50 to 85	5,250	274,316	32,714	477,222	92,201	1,884	4,486
20 to 50	901	21,447	2,806	37,181	7,856	870	356
Total	19,400	1,334,841	156,839	2,328,983	445,516	2,484	21,855
Oak-pine							
85 +	10,271	422,885	200,626	741,068	570,151	2,380	11,088
50 to 85	5,685	146,769	76,140	256,171	214,133	1,546	3,986
20 to 50	1,412	24,181	13,184	42,001	36,953	1,046	670
Total	17,363	593,284	289,953	1,038,259	821,248	1,998	15,736

Table 2.13—*Annual average and total accumulation of carbon in live trees on timberland in the South Central, by forest type and productivity class, 1987, continued*

Forest type and productivity class	Area of timberland	Net annual growth of growing stock		Net annual growth of solid wood		Average carbon accumulation in trees	Total carbon accumulation in trees
		Softwood	Hardwood	Softwood	Hardwood		
	(1,000 ac)	(1,000,000 cu ft/yr)		(1,000,000 cu ft/yr)		(Lbs/ac/yr)	(1,000 metric tons/yr)
Oak-hickory							
85 +	14,317	197,248	442,601	346,698	1,243,671	2,150	13,965
50 to 85	14,297	84,926	365,235	149,226	1,027,448	1,609	10,433
20 to 50	7,517	12,970	119,883	22,493	343,483	958	3,267
Total	36,130	294,988	927,719	518,151	2,614,602	1,688	27,662
Oak-gum-cypress							
85 +	10,563	41,538	378,215	72,230	1,070,278	1,927	9,232
50 to 85	4,666	23,142	101,521	39,825	288,365	1,242	2,628
20 to 50	601	5,027	12,063	8,579	34,449	1,249	340
Total	15,830	69,706	487,438	120,632	1,381,107	1,685	12,102
Elm-ash-cottonwood							
85 +	735	818	33,574	1,400	99,955	2,406	802
50 to 85	279	637	6,242	1,082	18,476	1,221	155
20 to 50	60	0	2,084	0	6,034	1,755	48
Total	1,073	1,455	40,426	2,482	120,451	1,999	973
Maple-beech-birch							
85 +	15	0	398	0	1,097	1,374	9
50 to 85	33	46	697	83	1,922	1,128	17
20 to 50	11	0	364	0	1,004	1,711	9
Total	60	46	1,458	83	4,020	1,280	35
Non-stocked timberland							
85 +	42	517	702	914	1,984	1,321	25
50 to 85	47	642	821	1,123	2,274	1,381	29
20 to 50	13	0	0	0	0	0	0
Total	102	833	1,522	1,448	4,255	1,078	50
All timberland							
85 +	54,615	2,097,289	1,203,467	3,667,812	3,406,395	2,357	58,384
50 to 85	33,273	654,131	590,397	1,142,927	1,664,862	1,573	23,747
20 to 50	10,991	74,635	145,183	129,639	415,527	979	4,882
Total	98,879	2,826,053	1,939,046	4,940,375	5,486,782	1,937	86,868

Table 2.14—*Annual average and total accumulation of carbon in live trees on timberland in the Northeast and Mid-Atlantic, by forest type and productivity class, 1987*

Forest type and productivity class	Area of timberland	Net annual growth of growing stock		Net annual growth of solid wood		Average carbon accumulation in trees	Total carbon accumulation in trees
		Softwood	Hardwood	Softwood	Hardwood		
	(1,000 ac)	(1,000,000 cu ft/yr)		(1,000,000 cu ft/yr)		(Lbs/ac/yr)	(1,000 metric tons/yr)
White-red-jack pine							
85 +	2,164	64,605	28,599	134,900	61,319	1,243	1,220
50 to 85	3,760	75,212	56,503	160,101	124,335	1,080	1,842
20 to 50	2,144	39,462	31,464	83,973	71,690	1,045	1,016
Total	8,067	179,277	116,569	378,969	257,349	1,115	4,079
Spruce-fir							
85 +	1,557	46,544	14,769	100,646	33,976	1,131	799
50 to 85	5,658	143,871	41,766	316,292	100,275	960	2,463
20 to 50	2,793	68,245	17,759	149,959	42,556	892	1,131
Total	10,007	258,661	74,294	566,900	176,806	968	4,392
Loblolly-shortleaf pine							
85 +	791	37,622	13,675	85,346	29,937	2,541	911
50 to 85	808	27,156	13,811	59,592	29,927	1,957	718
20 to 50	1,105	25,709	9,087	53,473	18,658	1,137	570
Total	2,704	90,486	36,572	198,409	78,520	1,793	2,199
Oak-pine							
85 +	841	16,141	29,622	34,907	62,728	2,203	840
50 to 85	1,600	27,196	47,546	60,216	102,973	1,933	1,403
20 to 50	1,097	14,991	29,691	31,484	63,898	1,656	824
Total	3,539	58,327	106,861	126,605	229,602	1,911	3,067
Oak-hickory							
85 +	10,330	13,231	420,419	28,781	910,212	1,775	8,318
50 to 85	15,838	25,690	645,310	54,963	1,391,381	1,778	12,776
20 to 50	10,560	19,997	385,498	42,202	816,487	1,577	7,552
Total	36,730	58,914	1,451,227	12,5937	3,118,080	1,719	28,646
Oak-gum-cypress							
85 +	60	36	2,213	70	4,728	1,427	39
50 to 85	148	1,707	5,025	3,831	10,567	1,670	112
20 to 50	232	1,307	13,427	2,808	27,276	2,299	242
Total	443	3,050	20,665	6,709	42,571	1,958	394
Elm-ash-cottonwood							
85 +1,218	808	48,117	1,834	105,042	1,533	847	
50 to 85	2,279	1,575	58,932	3,282	126,564	995	1,029
20 to 50	1,382	1,527	32,158	3,309	69,322	917	575
Total	4,879	3,907	139,207	8,418	300,928	1,107	2,451

Table 2.14—*Annual average and total accumulation of carbon in live trees on timberland in the Northeast and Mid-Atlantic, by forest type and productivity class, 1987, continued*

Forest type and productivity class	Area of timberland	Net annual growth of growing stock		Net annual growth of solid wood		Average carbon accumulation in trees	Total carbon accumulation in trees
		Softwood	Hardwood	Softwood	Hardwood		
	(1,000 ac)	(1,000,000 cu ft/yr)		(1,000,000 cu ft/yr)		(Lbs/ac/yr)	(1,000 metric tons/yr)
Maple-beech-birch							
85 +	6,511	23,783	236,468	50,095	494,936	1,513	4,467
50 to 85	12,971	46,367	440,846	96,649	921,485	1,417	8,336
20 to 50	9,663	40,041	262,365	86,327	594,426	1,258	5,513
Total	29,145	110,189	939,682	233,069	2,010,854	1,386	18,317
Aspen-birch							
85+	540	2,423	16,831	5,208	36,299	1,074	263
50 to 85	1,453	5,317	41,339	11,556	91,859	997	657
20 to 50	1,247	5,221	35,191	11,507	83,440	1,065	602
Total	3,239	12,960	93,361	28,269	211,599	1,036	1,522
Non-stocked timberland							
85 +	19	0	93	0	192	205	2
50 to 85	224	30	364	61	794	75	8
20 to 50	158	17	71	34	154	23	2
Total	401	47	528	95	1,141	61	11
All timberland							
85 +	24,028	205,191	810,810	441,783	1,739,379	1,625	17,708
50 to 85	44,744	354,117	1,351,445	766,535	2,900,165	1,446	29,344
20 to 50	30,381	216,516	816,711	465,074	1,787,907	1,308	18,027
Total	99,153	775,823	2,978,968	1,673,390	6,427,456	1,447	65,078

Table 2.15—*Annual average and total accumulation of carbon in live trees on timberland in the North Central and Central, by forest type and productivity class, 1987*

Forest type and productivity class	Area of timberland	Net annual growth of growing stock		Net annual growth of solid wood		Average carbon accumulation in trees	Total carbon accumulation in trees
		Softwood	Hardwood	Softwood	Hardwood		
	(1,000 ac)	(1,000,000 cu ft/yr)		(1,000,000 cu ft/yr)		(Lbs/ac/yr)	(1,000 metric tons/yr)
White-red-jack pine							
85 +	1,274	110,640	8,288	273,414	20,132	3,200	1,849
50 to 85	1,582	70,703	9,138	174,099	21,792	1,734	1,245
20 to 50	2,452	72,134	3,716	171,067	8,972	1,016	1,130
Total	5,307	253,478	21,141	618,582	50,894	1,755	4,224
Spruce-fir							
85 +	1,268	51,082	14,592	127,997	34,861	1,561	898
50 to 85	1,093	28,910	6,672	72,103	15,924	969	481
20 to 50	4,457	64,971	7,470	162,949	17,842	477	963
Total	6,817	144,963	28,732	363,048	68,619	757	2,342
Loblolly-shortleaf pine							
85 +	123	3,884	1,476	9,496	3,736	1,882	105
50 to 85	186	4,963	1,016	11,296	2,928	1,318	111
20 to 50	167	2,786	731	6,256	1,912	848	64
Total	474	11,631	3,127	27,044	8,269	1,292	278
Oak-pine							
85 +	107	1,863	1,722	4,351	4,880	1,608	78
50 to 85	276	4,368	3,570	9,800	11,125	1,418	178
20 to 50	433	3,812	2,836	8,994	8,951	772	152
Total	815	10,045	7,925	23,151	24,354	1,088	402
Oak-hickory							
85 +	2,844	2,068	104,972	5,065	270,106	1,889	2,436
50 to 85	6,826	10,356	195,662	24,934	541,917	1,608	4,979
20 to 50	9,752	9,852	153,122	23,435	454,776	948	4,194
Total	19,422	22,198	453,753	53,099	1,266,790	1,318	11,607
Oak-gum-cypress							
85 +	121	58	4,262	127	12,261	1,839	101
50 to 85	104	70	3,634	155	11,342	1,984	94
20 to 50	166	51	4,090	126	11,049	1,210	91
Total	391	179	11,986	408	34,652	1,613	286
Elm-ash-cottonwood							
85 +	1,722	1,271	77,246	3,081	206,494	2,127	1,662
50 to 85	1,892	2,918	59,638	7,178	161,143	1,553	1,332
20 to 50	3,299	11,816	60,351	29,416	154,179	964	1,443
Total	6,915	16,006	197,236	39,677	521,822	1,415	4,437

Table 2.15—*Annual average and total accumulation of carbon in live trees on timberland in the North Central and Central, by forest type and productivity class, 1987, continued*

Forest type and productivity class	Area of timberland	Net annual growth of growing stock		Net annual growth of solid wood		Average carbon accumulation in trees	Total carbon accumulation in trees
		Softwood	Hardwood	Softwood	Hardwood		
	(1,000 ac)	(1,000,000 cu ft/yr)		(1,000,000 cu ft/yr)		(Lbs/ac/yr)	(1,000 metric tons/yr)
Maple-beech-birch							
85 +	3,639	8,058	147,850	19,878	357,461	1,825	3,012
50 to 85	6,202	24,049	242,597	59,478	574,143	1,773	4,989
20 to 50	4,893	21,938	117,036	54,508	281,399	1,164	2,584
Total	14,734	53,869	507,442	133,430	1,212,847	1,583	10,581
Aspen-birch							
85+	4,433	32,829	192,266	82,441	459,633	1,721	3,462
50 to 85	6,966	46,235	227,423	116,025	49,162	1,339	4,232
20 to 50	3,134	19,025	70,693	47,877	171,688	9751,386	
Total	14,533	98,090	490,382	246,346	1,180,482	1,377	9,079
Non-stocked timberland							
85 +	82	119	428	283	1,310	375	14
50 to 85	320	624	2,325	1,445	7,019	514	75
20 to 50	1,145	321	2,573	765	7,769	146	76
Total	1,549	1,020	5,186	2,391	15,738	229	161
Timberland							
85 +	15,611	211,786	553,000	525,944	1,370,545	1,923	13,618
50 to 85	25,449	192,343	751,310	474,602	1,895,452	1,535	17,714
20 to 50	29,908	206,536	422,609	504,973	1,118,535	891	12,083
Total	70,970	610,585	1,726,919	1,505,177	4,384,531	1,348	43,397

Table 2.16—*Annual average and total accumulation of carbon in live trees on timberland in the Rocky Mountains, by forest type and productivity class, 1987*

Forest type and productivity class	Area of timberland	Net annual growth of growing stock		Net annual growth of solid wood		Average carbon accumulation in trees	Total carbon accumulation in trees
		Softwood	Hardwood	Softwood	Hardwood		
	(1,000 ac)	(1,000,000 cu ft/yr)		(1,000,000 cu ft/yr)		(Lbs/ac/yr)	(1,000 metric tons/yr)
Douglas-fir							
85 +	2,904	168,981	1,258	338,586	2,494	1,770	2,332
50 to 85	5,619	195,445	2,746	422,290	5,372	1,146	2,920
20 to 50	4,779	94,485	2,103	201,373	4,184	646	1,401
Total	13,304	458,914	5,861	962,255	11,570	1,102	6,651
Ponderosa pine							
85 +	769	39,381	499	75,638	987	1,322	461
50 to 85	1,951	61,456	1,440	126,019	3,218	878	777
20 to 50	10,995	238,838	1,358	497,095	2,745	604	3,011
Total	13,715	339,677	2,755	698,756	5,867	682	4,244
Western white pine							
85 +	240	20,536	10	39,487	20	1,980	216
50 to 85	16	717	0	1,444	0	1,076	8
20 to 50	4	63	4	116	8	349	1
Total	260	21,317	14	41,048	28	1,900	224
Fir-spruce							
85 +	2,899	178,461	1,935	348,689	3,579	1,356	1,783
50 to 85	5,046	165,434	4,133	331,900	9,275	755	1,728
20 to 50	3,063	62,213	2,746	123,021	5,414	469	651
Total	11,010	406,107	8,476	803,609	17,593	833	4,158
Hemlock-sitka spruce							
85 +	1,243	96,802	451	181,538	893	2,032	1,146
50 to 85	226	13,563	7	26,282	14	1,610	165
20 to 50	19	814	0	1,640	0	1,186	10
Total	1,488	111,181	458	209,465	907	1,958	1,321
Larch							
85 +	1,212	100,342	274	202,238	543	2,714	1,492
50 to 85	506	20,938	36	46,383	71	1,489	342
20 to 50	31	1,029	0	2,196	0	1,147	16
Total	1,749	122,308	300	250,815	594	2,332	1,850
Lodgepole pine							
85 +	1,276	98,402	586	208,063	1,158	2,211	1,280
50 to 85	2,983	149,008	787	323,540	1,586	1,470	1,989
20 to 50	5,137	163,047	1,910	330,325	3,857	877	2,043
Total	9,396	410,302	3,282	861,646	6,599	1,246	5,311

Table 2.16—*Annual average and total accumulation of carbon in live trees on timberland in the Rocky Mountains, by forest type and productivity class, 1987, continued*

Forest type and productivity class	Area of timberland	Net annual growth of growing stock		Net annual growth of solid wood		Average carbon accumulation in trees	Total carbon accumulation in trees
		Softwood	Hardwood	Softwood	Hardwood		
	(1,000 ac)	(1,000,000 cu ft/yr)		(1,000,000 cu ft/yr)		(Lbs/ac/yr)	(1,000 metric tons/yr)
Redwood							
85 +	0	0	0	0	0	0	0
50 to 85	0	0	0	0	0	0	0
20 to 50	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0
Other softwood types							
85+	60	1,320	0	2,938	0	668	18
50 to 85	72	1,395	2	2,864	4	536	18
20 to 50	170	1,943	3	3,785	6	302	23
Total	301	4,658	1	9,587	2	431	59
Western hardwood types							
85 +	285	5,817	8,288	11,537	16,536	1,236	160
50 to 85	1,656	13,776	39,411	26,723	77,982	778	584
20 to 50	2,872	15,596	63,466	30,798	125,856	666	867
Total	4,810	35,194	111,162	69,068	220,369	738	1,611
Non-stocked timberland							
85 +	293	772	147	1,507	327	83	11
50 to 85	358	1,858	265	3,658	542	156	25
20 to 50	926	2,431	308	5,004	819	84	35
Total	1,576	3,721	616	7,327	1,455	74	53
All timberland							
85 +	11,184	710,376	12,201	1,409,242	23,988	1,754	8,898
50 to 85	18,435	622,121	47,801	1,308,047	96,046	1,023	8,557
20 to 50	27,993	576,953	71,350	1,188,552	141,670	635	8,059
Total	57,609	1,909,451	131,347	3,905,843	261,696	975	25,482

Table 2.17—*Annual average and total accumulation of carbon in live trees on timberland in the Pacific Coast, by forest type and productivity class, 1987*

Forest type and productivity class	Area of timberland	Net annual growth of growing stock		Net annual growth of solid wood		Average carbon accumulation in trees	Total carbon accumulation in trees
		Softwood	Hardwood	Softwood	Hardwood		
	(1,000 ac)	(1,000,000 cu ft/yr)		(1,000,000 cu ft/yr)		(Lbs/ac/yr)	(1,000 metric tons/yr)
Douglas-fir							
85 +	13,723	1,406,206	109,585	2,192,913	200,239	2,584	16,084
50 to 85	3,632	191,455	11,460	298,985	21,596	1,313	2,162
20 to 50	1,938	100,524	1,949	157,216	3,580	1,246	1,096
Total	19,294	1,698,185	122,994	2,649,115	225,415	2,210	19,342
Ponderosa pine							
85 +	2,548	171,859	13,406	270,226	26,053	1,530	1,768
50 to 85	4,081	130,327	6,852	204,007	13,307	703	1,301
20 to 50	4,340	120,434	2,499	188,277	4,804	590	1,161
Total	10,968	422,619	22,757	662,508	44,164	850	4,230
Western white pine							
85 +	12	622	0	970	0	963	5
50 to 85	0	0	0	0	0	0	0
20 to 50	2	8	0	13	0	68	0
Total	14	631	0	984	0	844	5
Fir-spruce							
85 +	3,827	228,324	275	358,691	515	1,047	1,817
50 to 85	5,230	229,853	592	360,079	1,113	770	1,827
20 to 50	6,791	122,460	17,298	196,818	56,828	422	1,299
Total	15,850	580,636	18,166	915,586	58,457	687	4,943
Hemlock-sitka spruce							
85 +	6,800	567,297	21,985	894,382	40,977	1,902	5,868
50 to 85	1,528	19,816	1,591	31,237	3,278	312	216
20 to 50	1,168	42,325	160	66,711	321	795	421
Total	9,497	629,383	23,736	992,240	44,576	1,510	6,504
Larch							
85 +	523	45,555	1,940	71,223	3,495	2,300	546
50 to 85	284	15,834	95	24,705	169	1,420	183
20 to 50	45	1,500	0	2,330	0	838	17
Total	852	62,889	2,035	98,258	3,665	1,929	746
Lodgepole pine							
85 +	157	11,892	345	18,640	614	1,648	117
50 to 85	534	24,877	27	38,935	48	985	239
20 to 50	1,488	37,962	2	59,164	4	537	362
Total	2,179	74,733	373	116,742	664	727	718

Table 2.17—*Annual average and total accumulation of carbon in live trees on timberland in the Pacific Coast, by forest type and productivity class, 1987, continued*

Forest type and productivity class	Area of timberland	Net annual growth of growing stock		Net annual growth of solid wood		Average carbon accumulation in trees	Total carbon accumulation in trees
		Softwood	Hardwood	Softwood	Hardwood		
	(1,000 ac)	(1,000,000 cu ft/yr)		(1,000,000 cu ft/yr)		(Lbs/ac/yr)	(1,000 metric tons/yr)
Redwood							
85 +	1,064	144,332	23,487	227,113	45,821	3,610	1,742
50 to 85	37	1,096	627	1,725	1,224	1,209	20
20 to 50	0	0	0	0	0	0	0
Total	1,102	145,428	24,114	228,837	47,045	3,526	1,763
Other softwood types							
85+	176	3,021	864	4,715	1,566	468	37
50 to 85	104	937	289	1,474	539	253	12
20 to 50	211	475	998	764	3,279	233	22
Total	491	4,433	2,152	6,954	5,386	322	72
Western hardwood types							
85 +	5,329	204,215	344,663	319,244	634,046	2,224	5,376
50 to 85	978	15,536	35,747	24,365	74,011	1,236	548
20 to 50	4,738	15,923	82,434	25,667	251,025	702	1,510
Total	11,046	235,673	462,840	369,275	959,073	1,484	7,433
Non-stocked timberland							
85 +	508	4,241	2,891	6,591	5,287	299	69
50 to 85	143	506	0	789	0	75	5
20 to 50	164	833	4	1,305	7	108	8
Total	815	5,143	2,895	8,000	5,294	210	78
All timberland							
85 +	34,667	2,787,511	519,439	4,364,621	958,610	2,126	33,429
50 to 85	16,552	629,999	57,282	985,929	115,289	868	6,514
20 to 50	20,888	441,082	105,345	696,130	319,850	622	5,895
Total	72,107	3,858,590	682,065	6,046,677	1,393,747	1,401	45,833