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Multiresource Inventories: Woody Biomass in Virginia

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ABSTRACT

Virginia's 25.4 million acres of land area support 1.5 billion tons of woody biomass. Of this total, 93 percent is on timberland, 5 percent on reserved timberland and woodland areas, and 2 percent on nonforest areas. Over the next two decades, more than 9 million tons of woody biomass could be harvested annually from timberland without adversely affecting timber supplies.

Keywords: Growing stock, timberland, multiple use.

Wood is being used for domestic and industrial fuel, and there is considerable interest in any opportunity to rid timberland of vast quantities of wood and bark in low-quality trees. There is also concern that large-scale use of wood for energy could jeopardize supplies of growing stock counted on for other products. Although this uncertainty makes it difficult to differentiate between energy wood and growing stock, it is imperative that the quantity, composition, distribution, and prospective availability of total woody biomass be evaluated.

Traditionally, State and regional forest inventories have been designed to estimate the volume of wood from a 1-foot stump to a 4.0-inch top diameter outside bark (d.o.b.) for trees 5.0 inches and larger in diameter at breast height (d.b.h.). Recently prepared statistical reports for Virginia focus primarily on volume of growing-stock timber measured to these standards (Bechtold and others 1987; Brown 1985, 1986a, 1986b, 1986c, 1986d; Brown and Craver 1985). Because of the growing interest in woody biomass as a source of energy, however, the additional amount of wood and bark in all trees on timberland and the total wood and bark biomass on reserved timberland and woodland and nonforest areas must be analyzed.

The Forest Inventory and Analysis (FIA) Research Work Unit at the Southeastern Forest Experiment Station is in a particularly favorable position to make a statewide biomass assessment because it has a permanent set of sample plots uniformly scattered across all forest and nonforest areas in Virginia, South Carolina, Florida, Georgia, and North Carolina. The advantages in having permanent sample plots are that they can be revisited, subsampled, or used as a proportionate sample of the entire area.

Woody biomass is defined as the green weight of aboveground wood and bark in live trees 1.0 inch d.b.h. and larger, from the ground to the top of the tree. All foliage is excluded. The weight of wood and bark in lateral limbs, secondary limbs, and twigs less than 0.5 inch in diameter at the point of occurrence on sapling-size trees is included, but that of poletimber and sawtimber-size trees is excluded.

The primary objective of this Paper is to present the distribution and quantity of woody biomass on forest lands and nonforest areas. Other objectives are to compare total biomass including bark,

as defined, with conventional growing stock; to quantify the unutilized sources of forest biomass in recently harvested areas where wood is left as residues; and to identify stands in need of regeneration. Finally, new opportunities are identified for studying forest yields in terms of site, stocking and age classes, timber utilization, and successional trends.

Methods

The 1986 multiresource inventory of Virginia provided a full array of biomass data from all land in Virginia. The techniques and procedures used are not the only methods available, but their value has been demonstrated in the most recent biomass inventory of Florida (Cost and McClure 1982). The method of inventory is a sampling procedure designed to provide reliable area, volume, growth, and removal statistics primarily at the State and Survey Unit levels. Little is known about degree of precision or number of samples needed for biomass inventories. Since the associated errors were unknown, breakdowns were not made by Survey Unit.

On forest land, numbers of trees, sizes, and quality were recorded at each sample plot. Trees 5.0 inches d.b.h. and larger were measured at 3 to 5 points where variable-radius plots were defined by a prism with a basal area factor of 37.5. Trees less than 5.0 inches d.b.h. were tallied on 1/300-acre plots around the point centers. Biomass was measured at 4,266 timberland locations, 128 reserved timberland locations, and 8 woodland locations across the State. From a crown-closure stratification of all nonforest plots, 322 subsample locations representing different crown-closure classes and land uses were visited on the ground. At each location, numbers and diameters of trees 1.0 inch d.b.h. and larger, were recorded on 1-acre circular plots. Nonforest areas include those in nonforest uses and narrow stringers of trees, and small patches of forest and remnant parcels of forest land not qualifying as timberland. These sample counts were expanded to represent the total population of trees on land classified as forest and nonforest. Volume equations, based on detailed measurements of standing and felled trees in Virgina and on similar measurements taken from other trees throughout the Southeast, were used to compute merchantable and total cubic volume (Cost 1978). Weight equations provided by the Utilization of Southern Timber Research Unit of the Southeastern Forest Experiment Station in Athens, GA, made it possible to convert volume to weight. The procedures used for collecting and reporting detailed biomass data were outlined by Saucier (1979) and Clark (1979).

Bechtold and others (1987) described timberland in terms of six broad management classes: (1) nonstocked forest, (2) pine plantation, (3) natural pine, (4) oak-pine, (5) upland hardwood, and (6) lowland hardwood. Nonstocked forest is timberland less than 16.7 percent stocked with growing-stock trees. The other broad management classes are based on forest type, determined by the stocking of all live trees. In all stands where pines made up a plurality of the stocking, the broad management class was either pine plantation or natural pine. Where there was evidence of planting or artificial regeneration, the stand was classed as plantation. Oak-pine was the classification assigned to stands where hardwoods accounted for a plurality of the stocking but pines made up 25-50 percent of the stocking. In all other stands, hardwoods and cypress constituted a plurality of the stocking, and forest type was used to distinguish between upland and lowland hardwood classes. Upland hardwoods included oak-hickory and scrub oak. Oak-gum-cypress and elm-ash-cottonwood forest types were classed as lowland hardwood.

Since assignment of forest types is based on the stocking of all live trees except those overtopped rather than on the stocking of growing-stock trees, the broad management classes are quite meaningful for evaluation of biomass. In this study of woody biomass, the broad management class "nonstocked

forest" used in the timber evaluation was distributed among the other classes, based on forest type. Although these stands contain insufficient growing stock to be considered stocked, many contain substantial amounts of biomass in rough and rotten trees.

Acreage of timberland by broad management class was further defined by stand-age classes. Stand age was estimated to the nearest year. Ten-year age classes were selected for this analysis because very little merchantable-size timber accrues in a stand before age 10 and many pine stands are managed on 30-year rotations.

There are difficulties in determining a meaningful age in some natural stands. An understanding of these difficulties is important to the interpretation of some data reported here. Often natural timber stands are a mixture of residual trees from a former stand and younger trees established after the most recent harvest or disturbance. In these cases, field crews recorded the average age of trees of common origin that accounted for a plurality of the stocking as long as they were of sufficient number to form a manageable stand for timber production--normally 60 percent or more of the minimum number required for full stocking. Where insufficient trees of common origin were present for a manageable stand, the age was an average based on all trees present.

The acreage within each broad management class was also broken down by site and stocking class. The stocking classes were based on all live trees rather than on growing stock. Average green weight of woody biomass per acre was compiled for each subdivision. The equations predict weight from species, d.b.h., and total height. Additional variation in weight attributable to geographical differences, stand origin (planted vs. natural), or tree section were not considered.

Results and Discussion

Total Biomass

The quantity of biomass in each broad use category is highly dependent on the acres within the category as well as the concentration of material on these acres. In interpreting biomass quantities, therefore, it is helpful to know how many acres are in each category.

Use category	Thousand acres	Percent
Timberland	15,435.8	61
Reserved timberland & woodland	532.6	2
Nonforest	9,441.4	37
Total	25,409.8	100

The 25.4 million acres of timberland, reserved timberland and woodland, and nonforest land in Virginia support almost 1.5 billion tons of woody biomass. Figure 1 shows the distribution of biomass by land use category.

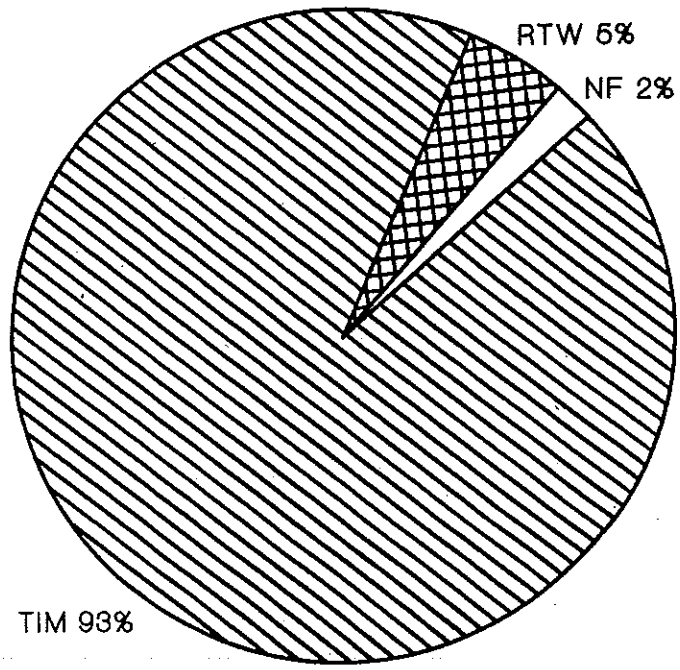

Figure 1.--Percentage distribution of green weight of aboveground woody biomass on timberland (TIM), reserved timberland and woodland (RTW), and nonforest (NF) in Virginia, 1986.

Timberland Biomass Resource

A compilation of acreage of timberland by broad management and stand-age classes provides a good basis for examining the quantity, composition, distribution, and prospective availability of woody biomass in Virginia (table 1). Table 1 shows a large concentration of pine plantations between 0 and 20 years old and natural pine between 31 and 50 years old. Over the last 20 years, the area in pine plantations increased by 900,000 acres and totals almost 1.2 million acres. During the late 1950's and early 1960's, extensive acreage of idle cropland reverted naturally to pine. Since 1966, Virginia has experienced a sharp reduction in acreage of idle cropland rotating back to forest. For example, between the 1957 and 1966 inventories, almost 650,000 acres reverted to forest. Between 1977 and 1986, only 367,000 acres of such land reverted. Of the total acreage reverted between 1977 and 1986, only 38 percent was classed as pine plantation or natural pine.

Among oak-pine and upland hardwood stands, the greatest acreage is in the stand-age classes from 31 through 70. Many of these stands are on sites that previously supported pine, but where pine was not adequately regenerated at the time of harvest. Lowland and upland hardwood stands account for over 87 percent of all stands 71 years old and older. Most of these stands are located throughout the Mountains on steep slopes and in the Coastal Plain in deep swamps. Over the years, the large and good-quality trees have been high-graded from these stands, leaving the smaller and poorer quality trees.

Total biomass and biomass of conventional growing stock. On the 15.4 million acres classed as timberland, green weight of conventional growing stock averages 55.8 tons per acre (table 2); green weight of all woody biomass averages 87.6 tons per acre, or 57 percent more (table 3). By broad management class, the largest difference between average weight of conventional growing stock and average weight of all woody biomass per acre is in hardwood stands. Across all ages combined, the average weight of total biomass in upland hardwood stands exceeds average weight of conventional growing stock by 33 tons per acre, or 55 percent. In lowland hardwood stands, the average weight difference is more than 34 tons per acre.

Table 2 provides measures of the average accumulation of biomass within each broad management class over time. As one would expect, conventional growing stock accumulates somewhat faster in pine stands, especially pine plantations, than in oak-pine and hardwood stands. Control over both species composition and spacing in pine plantations shortens the time required to grow merchantable timber products. By broad management class across all age classes, average weight of conventional growing stock ranges from a low of 28.7 tons per acre in pine plantations to a high of 65.3 tons per acre in lowland hardwood stands. The low value for pine plantations is attributable to their low average age.

Table 3 shows that natural pine, oak-pine, upland hardwood, and lowland hardwood stands keep pace with the more intensively managed pine plantations in production of biomass up to age 10. Beyond age 10, woody biomass accumulates much faster in the intensively managed pine plantations. Once again, the low overall average for pine plantations is attributed to the large proportion (96 percent) of these stands less than 31 years old. In contrast, more than 72 percent of the lowland hardwood stands were 31 years old or older. The relatively low production of biomass indicated for the oak-pine management class can be attributed in part to the origin of many of these stands. A large portion of these acres were once sparsely stocked with the upland hardwoods left after harvest of pines.

Living logging residues. As part of the inventory in Virginia, field crews at each sample location noted any primary treatment or disturbance that had occurred between 1977 and 1986. Bechtold

and others (1987: tables V, VI) reported the results, by broad management and ownership classes. As part of this evaluation of woody biomass, these acreage estimates were recompiled, eliminating ownership class (table 4).

From 1977 to 1986, almost 414,000 acres annually experienced significant treatment or disturbance; timber harvesting was the most common forestry activity observed. On the average, about 125,000 acres underwent a final harvest annually, exclusive of intermediate cutting, commercial thinning, harvesting with artificial regeneration, and land clearing. Green weight of woody biomass left in standing trees in these harvested stands averages 24.8 tons per acre (table 5).

Since all of these treatments occurred throughout 1977-1986, the average elapsed time between treatment and measurement was about 5 years. For the analysis, we examined broad management class assigned in 1977. Average weight of woody biomass left after harvesting without artificial regeneration ranged from 18.1 tons per acre in natural pine stands to 42.3 tons per acre in lowland hardwood stands. Much of the biomass in these stands is in rough, rotten, and small trees that compete for growing space, thereby inhibiting the development of a productive new stand. These stands contain an average 501 stems per acre. Figure 2 shows that more than 89 percent of these trees are between 1.0 and 5.0 inches d.b.h.

The absence of residual living biomass from harvested plantations reflects areas clearcut, site prepared, and planted within the 10-year period. The high average for lowland hardwood reflects the large quantities of biomass left after high-grading of these stands within the same period.

The 24.8 tons per acre of woody biomass following other harvesting (table 5) include only material in living trees. Stumps, tops, and limbs of cut trees left as conventional logging residues are excluded. Even in pine plantations,

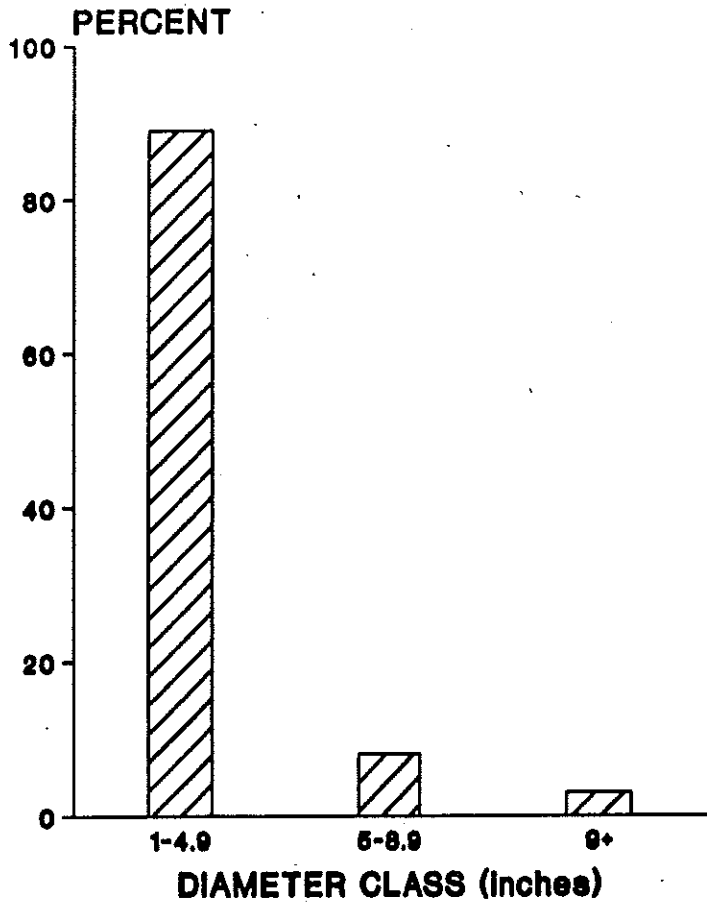

Figure 2.--Distribution of living residues in harvested stands, by diameter class, Virginia, 1986.

substantial quantities of such residues are commonly pushed into windrows when sites are prepared for replanting.

Poorly stocked stands. Field crews noted obvious opportunities for increasing prospective timber growth on sample plots. Bechtold and others (1987: table VII) reported acreages providing these management opportunities. For our study, we recompiled the acreage, eliminating ownership class and idle cropland and redistributing nonstocked forest among the other management classes (table 6).

There are 1.5 million acres of timberland in Virginia too poorly stocked with acceptable trees to manage for timber production. These acres represent the backlog of needed regeneration on manageable sites in Virginia. They contain an average of 46.1 tons of woody biomass per acre (table 7). Biomass on

these poorly stocked acres is mostly rough, rotten, and other low-quality trees. The biomass in these stands can be characterized much like the biomass in recently harvested stands. On the average these stands contain 520 trees per acre. More than 82 percent of the trees are between 1.0 and 5.0 inches d.b.h., and 91 percent of the biomass is in hardwood. Altogether, these acres contained over 5 percent of the total woody biomass in the State. Practically all of this biomass could be removed and used for energy without adversely affecting prospective timber supplies.

Another 152,000 acres support manageable stands that will contribute very little net annual growth unless converted to species more suitable to the sites. Such areas contained an average of 55.1 tons of woody biomass per acre.

Over 106,000 acres support seriously damaged stands that needed to be salvaged and regenerated. These stands contain substantial volume of merchantable timber seriously damaged by fire, insects, disease, wind, ice, or other destructive agents. Woody biomass in these stands averages 103.3 tons per acre, plus an undetermined amount of wood and bark in dead trees.

Finally, about 1.8 million acres of immature stands are too densely stocked with small merchantable-size trees or are receiving serious competition from rough trees or other inhibiting vegetation. Without some treatment, growth of these stands quite likely will be reduced by suppression. Removal of biomass during thinning or cleaning would not adversely affect prospective timber supplies.

More than 67 percent of the woody biomass in Virginia is either in stands in good condition needing no treatment or in stands on sites limited by steep slopes or year-round water problems. More than 7.4 million acres support immature stands in relatively good condition. These stands are at least 60 percent stocked with trees of acceptable quality and free from significant damage or competition. These acres support an average of 86.6 tons per acre of biomass. An additional 2.9 million acres have year-round water problems or slopes of at least 40 percent. On these adverse sites, weight of woody biomass averages 98.1 tons per acre. Since 1976, the annual rate of timber cutting on these sites has been one-fourth of that for stands considered operable. Hardwoods dominate on a majority of these sites. Such stands probably will not be cut in large quantities at any particular time.

About 33 percent of the woody biomass in Virginia is in stands where large quantities of energy wood could be harvested without adversely affecting timber supplies.

Rough and rotten trees. Virginia's timberland supported 1,351.6 million tons of woody biomass in 1986. Growing-stock trees accounted for 86 percent of the woody biomass (table 8). The remaining 14 percent was in trees 1.0 inch d.b.h. and larger which failed to meet minimum standards for growing stock because of species, poor form, or roughness. Theoretically, this biomass could be removed without adversely affecting existing or prospective supplies of timber. Over 50 percent of the biomass in rough and rotten trees 5.0 inches d.b.h. and larger was in the bole portion. This biomass could be harvested with conventional equipment. The remaining 50 percent was in saplings, stumps, tops, and limbs, which would require specialized harvesting methods.

Other potential sources of woody biomass are stumps, tops, and limbs of growing-stock trees 5.0 inches d.b.h. and larger. Since this material would normally not be available before harvest, the 15 percent of woody biomass in stumps, tops, and limbs of growing-stock trees in table 8 probably overestimates the amount of this kind of material at any given time. From a practical standpoint, the 7-percent biomass in growing-stock saplings should be excluded from estimates of energy wood because saplings are needed to replace current growing-stock supplies.

Table 8 simplifies the comparison of growing stock and total woody biomass among the major species groups. For example, hardwoods account for more than 76 percent (887.4 million tons) of the total biomass of growing stock but 79 percent (1,065.6 million tons) of the total woody biomass.

Totaling energy biomass. A few reasonable assumptions are required to estimate the amount of woody biomass that could be harvested for energy in Virginia. The 1.5 million acres of poorly stocked timberland classified as offering a regeneration opportunity are the primary source of energy wood that could be harvested without adversely affecting prospective timber supplies. This area supports more than 46 tons of woody biomass per acre. If 5 percent of this acreage (75,856) were cleared each year and an average yield of 46.1 tons per acre is assumed, some 3.5 million tons of energy wood could be harvested annually from this land during the next 20 years.

The second major source of prospective energy wood is the 125,000 acres of timberland harvested annually. This area supports about 25 tons per acre of woody biomass left standing after harvest. Some 3.1 million tons of additional energy wood could be harvested annually from these living residues. Based on FIA plot remeasurement data and utilization studies, the estimated weight of logging slash and logging residues remaining in recently harvested stands in Georgia is equivalent to 21.1 tons per acre. A breakdown of this total shows that conventional logging residues represent about 31 percent, or 6.5 tons per acre. Logging residues are the unused merchantable portion of growing-stock trees cut or destroyed during logging. In contrast, logging slash is the unmerchantable portion of growing-stock trees (including saplings) plus all cull trees 1.0 inch d.b.h. and larger cut or destroyed during logging operations and not used. These represent 69 percent of the total, or 14.6 tons per acre. In combination, these residues represent another 2.6 million tons of energy wood available yearly in Virginia. It should be noted that these weights do not include those residues available from stands experiencing cultural practices other than harvest.

Based on these assumptions, at least 9.2 million tons of energy wood could be harvested annually over the next 20 years in harmony with conventional forestry practices and opportunities. On a green-weight basis, this tonnage of energy wood is 63 percent of the annual harvest of industrial products in Virginia for 1976 through 1985.

Hardwood in pine stands. On Virginia's 2.2 million acre of natural pine, woody biomass is 69 percent yellow pine, 25 percent hardwood, and 6 percent other softwoods (table 9). Many pine stands between 10 and 40 years old were established on idle cropland relatively free of hardwood rootstocks. Yellow pine accounted for a higher proportion of the biomass in these stands than in pine stands less than 11 years old. Many young pine stands were established on cutover forest land where the hardwood rootstocks are entrenched. Even with intensive site preparation before planting, hardwoods make up 32 percent of the woody biomass in stand age class 0-10. In oak-pine stands where pines account for only 25 to 50 percent of the stocking, the pine biomass makes up only 28 percent of the total biomass. Pine makes up only 3 percent of biomass in upland hardwood and 2 percent in lowland hardwood stands. These statistics bear out the region's natural successional trends.

Large trees in young stands. As stated earlier, natural pine, oak-pine, upland hardwood, and lowland hardwood stands keep pace with the more intensively managed pine plantations in production of biomass up to age 10. Table 10 provides some indication of how this occurs. More than 65 percent of the biomass in pine plantation 0-10 years old is in trees less than 5.0 inches d.b.h. In natural pine stands, small trees make up only 50 percent of the total biomass. Small trees make up 33 percent of the biomass in both oak-pine

and upland hardwood stands and 18 percent in lowland hardwood stands. A significant proportion of the biomass in the hardwood stands is in large trees left during harvests of former stands. The large trees in the 0-10 age class in natural pine and oak-pine stands also are residuals from former stands.

Site and stocking affect yield. Within each management class, the production and distribution of woody biomass in Virginia was examined by site, stocking, and age. The site classes are those used in the timber evaluation. Good sites are those capable of annually producing timber growth of 85 cubic feet or more per acre in fully stocked natural stands; medium sites, 50 to 85 cubic feet; and poor sites, 20 to 50 cubic feet. The stocking classes are based on all live trees rather than growing stock:

Stocking class	Stocked (percent)
Fully stocked	100 or more
Medium stocked	60-100
Poorly stocked	Less than 60

Tables 11 to 15 show the distribution of acreage within each broad management class by site, stocking, and age class. Statewide, over 62 percent of the timberland is fully stocked. Across the State, 85 percent of the timberland is in good or medium sites. Among the five broad management classes, natural pine stands have the highest proportion of good sites (36 percent) and pine plantations have the lowest (18 percent). On the other hand, pine plantations have the highest proportion of fully stocked stands (92 percent) and upland hardwood stands have the lowest (56 percent). The low averages for upland hardwood stands reflect both the acreage of scrub oak included in this management class and inadequate regeneration efforts after harvest.

Tables 16 to 20 show the average green weights of woody biomass per acre within each broad management class by site, stocking, and age class. Since more than 96 percent of pine plantations are less than 31 years old, the relatively low value of 48 tons per acre for the 1.2 million acres of planted pine is not surprising (table 16). The number of sample plantations established before 1955 is too small to estimate yields beyond the 41-50 age class. Results show that fully stocked good sites yield 100 tons of biomass per acre in 30 years.

The 2.2 million acres of natural pine contain an average of 94 tons of biomass per acre (table 17). Fully stocked natural pine stands on good sites yield more than 100 tons of biomass per acre in 30 years. For all sites and age classes, fully stocked natural pine stands produce over eight times as much biomass as poorly stocked stands.

The average biomass on the 1.7 million acres of oak-pine is 74 tons per acre (table 18). Many of these stands are on sites from which pines were harvested but not adequately regenerated. Table 18 shows that fully stocked oak-pine stands on good sites can yield 100 tons per acre in 40 years. For all sites and age classes, fully stocked oak-pine stands produce over two times more biomass than poorly stocked stands.

Upland hardwoods occupy 9.8 million acres and account for about two-thirds of Virginia's woody biomass. Like oak-pine, many of these stands are on sites that previously supported pine. Since a large percentage of upland hardwood stands are more than 30 years old, their combined woody biomass averaged 92 tons per acre (table 19). From overall averages, productivity of upland hardwoods appears low because many of these stands were poorly stocked for long periods in their lives. Fully stocked upland hardwood stands between 31 and 40 years old on good sites contain 100 tons of biomass per acre. For all sites and age classes, fully stocked stands produce over three times more biomass than the poorly stocked stands.

Finally, the 600,000 acres classed as lowland hardwood contain almost 100 tons per acre (table 20). The high weight is

attributed to the large proportion (73 percent) of these stands that are 31 years of age or older. Also, more than 49 percent of the stands were fully stocked. Fully stocked lowland hardwood stands on good sites yield 100 tons of biomass per acre by age 30. For all sites and age classes combined, fully stocked stands produce over four times as much biomass as poorly stocked stands.

Reserved Timberland and Woodland Biomass Resource

Virginia's 0.5 million acres of reserved timberland and woodland support about 69.5 million tons of wood and bark in trees 1.0 inch d.b.h. and larger. Over one-half of these forests withdrawn from timber production are in the Shenandoah National Park and the Great Dismal Swamp National Wildlife Refuge, or along the Blue Ridge Parkway. For analysis, each of these areas is further classified by forest type (table 21).

Oak-hickory occupies almost three-fourths of reserved timberland and accounts for 72 percent of the woody biomass (fig. 3). Oak-gum-cypress makes up 14 percent of the acreage and accounts for 19 percent of the biomass. Yellow pine is the third leading type, accounting for 7 percent of the acreage and 3 percent of the biomass. Oak-pine, white pine-hemlock, and elm-ash-cottonwood make up the remainder of acreage and woody biomass on reserved timberland. Oak-hickory stands make up 84 percent of the acreage and account for 95 percent of the biomass on woodland.

Table 21 shows the average green weight per acre, by forest type. On reserved timberland the woody biomass averages 144 tons per acre. By forest type, the average weight per acre ranges from a low of 54 tons in yellow pine stands to a high of 196 tons in oak-gum-cypress stands; however, the latter stands support only 19 percent of the woody biomass because of the small acreage in this type.

Nonforest Biomass Resource

In a comprehensive evaluation of biomass for the State, the material on nonforest land must be considered. In many cases, forest conditions are pres-

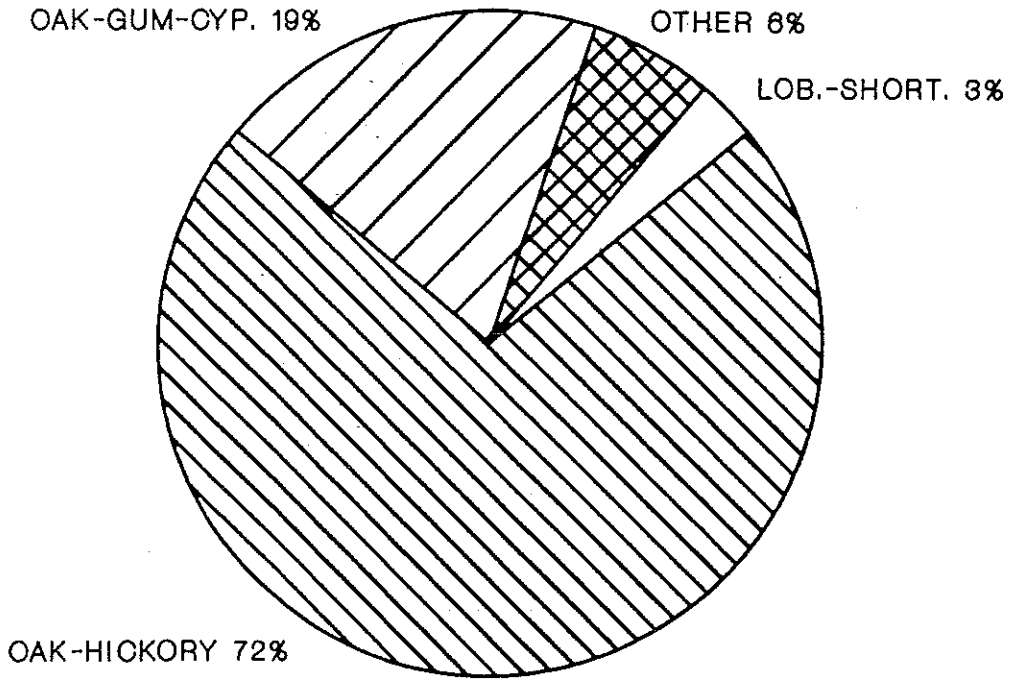

Figure 3.--Percentage distribution of woody biomass on oak-hickory, oak-gum-cypress, loblolly-shortleaf, and other on reserved timberland, Virginia, 1986.

ent in patches that do not meet the definition of forest because of size or configuration. Nonforest trees are found along highways, fencerows, and in riparian zones, pastures, and city parks.

On the nonforest lands, a crown-closure code was assigned to each plot, to reflect the per-acre stocking of trees 1.0 inch d.b.h. and larger. For example, a crown closure of zero would indicate no biomass. At field points, crown closure was estimated to the nearest 10 percent. For this analysis we developed three classes: 1-29, 30-59, and 60+ percent.

The 9.4 million acres of nonforest area in Virginia represent about 37 percent of the State's land area and support over 38 million tons of woody biomass. Of the 9.4 million acres, only 3.6, or about 4 out of every 10 acres of nonforest land, have woody biomass. About 36 percent of the nonforest area is in urban and other related uses, 35 percent is improved pasture, 14 percent is cropland, 6 percent is other farmland and idle farmland, and 3 percent is marsh and water (table 22).

More than 5.8 million acres (61 percent of the nonforest land in Virginia) have no woody biomass. The majority of this nonforest land (73 percent) is currently being used for improved pasture and agricultural crops.

Table 23 shows the average tonnage per acre by crown closure. For nonforest areas with woody biomass (3.6 million acres), the average weight per acre ranges from 7 to 46 tons. For all nonforest areas, the woody biomass averages over 10 tons per acre.

More than 2.9 million acres of nonforest land have crown closures between 1-29 percent. Biomass there averages 7 tons per acre. By land use, average weight of woody biomass ranges from less than 1 ton per acre for noncensus water to 10 tons per acre for urban and other related uses. The biomass associated with noncensus water is primarily in trees standing along canals and on margins of ponds.

About 0.5 million acres of nonforest land have crown closures of 30-59 percent. Woody biomass there averages 16 tons per acre. By land use, average weight of biomass ranges from 10 tons per acre for other farmland to 28 tons per acre for marsh.

Finally, more than 0.2 million acres of nonforest land have crown closures of 60+ percent. These nonforest areas contain an average of 46 tons per acre of woody biomass. By land use, average weight ranges from 8 tons per acre for improved pasture to 57 tons per acre for urban and other related uses.

Table 24 shows the distribution of forest biomass, by land use and selected species groups. On nonforest areas, soft hardwood is the leading species group in terms of total biomass, followed closely by the oaks. Soft hardwoods and oaks combined represent over 60 percent of the total biomass. By land use, urban and other related uses support the largest amount of woody biomass with 56 percent of the total weight; improved pasture supports 20 percent; cropland, 12 percent; other farmland, 5 percent. The remaining 7 percent is distributed among idle farmland, marsh, and noncensus water.

Summary and Conclusions

Virginia's 25.4 million acres of land area support about 1.5 billion tons of woody biomass. Timberland supports 1.4 billion tons of biomass, or an average of 88 tons per acre. Reserved timberland and woodland support over 69 million tons, or an average of more than 130 tons per acre. Nonforest land having woody biomass supports over 38 million tons, or an average of 10 tons per acre.

On timberland, the total woody biomass on a per-acre basis exceeds the green weight of conventional growing stock by 57 percent. Conventional growing stock accumulates somewhat faster in pine stands, especially in pine plantations, than in oak-pine and hardwood stands. By broad management class across all age

classes, average weight of conventional growing stock ranges from a low of 28.7 tons per acre in pine plantations to a high of 65.3 tons per acre in lowland hardwood stands.

Since 1976, about 125,000 acres per year experienced a final harvest and were not artificially regenerated. This average excludes commercial thinning, other intermediate cutting, and land clearing. Woody biomass in standing trees left after harvesting averages approximately 24.8 tons per acre. An examination of these stands shows that more than 89 percent of the trees are between 1.0 and 5.0 inches d.b.h.

More than 1.5 million acres of timberland are too poorly stocked with acceptable trees to manage for timber production unless regenerated. This acreage supports an average of 46.1 tons per acre of woody biomass composed mostly of rough, rotten, and other low-quality trees. Most of this biomass could be removed and used for energy without adversely affecting prospective timber supplies.

About 33 percent of the woody biomass is in stands where energy wood could be harvested while enhancing future timber growth. The remaining 67 percent was in stands either exhibiting no treatment opportunity or on adverse sites.

More than 14 percent of the biomass was in rough and rotten trees and could be removed without adversely affecting existing supplies of sawtimber. Over 50 percent of the woody biomass in rough and rotten trees was in the boles of trees 5.0 inches d.b.h. and larger; 50 percent was in saplings, stumps, tops, and limbs.

Given a few reasonable assumptions about the removal of biomass from recently harvested stands and poorly stocked stands, an estimated 9.2 million tons of woody biomass could be harvested annually in Virginia over the next two decades without adversely affecting timber supplies. The green weight of this energy wood is 63 percent of the total green weight of harvest of industrial roundwood in Virginia between 1976 and 1985.

For all management classes, fully stocked stands across all sites yield about four times as much biomass as the poorly stocked stands. Fully stocked yellow pine and lowland hardwood stands on good sites can produce 100 tons of forest biomass per acre in 30 years. Well-stocked oak-pine and upland hardwood stands on good sites take about 40 years to produce this tonnage.

Reserved timberland and woodland make up about 2 percent of the land area in Virginia and support over 69 million tons of woody biomass, or an average of 130 tons per acre. Of the 0.5 million acres of reserved timberland and woodland, over 88 percent is classed as reserved timberland. Oak-hickory is the leading forest type and accounts for over 72 percent of the biomass. By forest type, the average tons per acre range from 54 for yellow pine stands to 196 for oak-gum-cypress.

Over one-third of the 9.4 million acres of nonforest land in Virginia support woody biomass. On nonforest with crown closure of 60 percent or more, woody biomass averages 46.3 tons per acre. Soft hardwood is the leading species group on nonforest. On nonforest, urban and other related uses support the largest amount of total biomass.

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Table 1.--Area of timberland, by broad management and stand-age classes, Virginia, 1986

Broad management class	All age classes	Stand-age class (years)									
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91+
						Acres					
Pine plantation	1,170,053	446,158	463,207	219,480	41,108	100	—	—	—	—	—
Natural pine	2,185,598	203,549	328,234	304,248	419,493	412,077	266,249	143,816	63,057	10,646	34,229
Oak-pine	1,689,191	338,925	212,882	137,085	174,968	193,702	198,746	193,542	110,849	29,540	98,952
Upland hardwood	9,772,460	901,265	698,267	590,232	839,422	1,244,413	1,710,258	1,421,899	1,007,569	561,411	797,724
Lowland hardwood	618,534	66,638	34,386	68,365	71,408	110,899	98,101	80,467	38,336	30,896	19,038
All classes	15,435,836	1,956,535	1,736,976	1,319,410	1,546,399	1,961,191	2,273,354	1,839,724	1,219,811	632,493	949,943

Table 2.--Average green weight of conventional growing stock[a] per acre of timberland, by broad management and stand-age classes, Virginia, 1986

Broad management class	All age classes	Stand-age class (years)									
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91+
						Tons/acre					
Pine plantation	28.7	1.2	30.4	67.1	104.6	(b)	—	—	—	—	—
Natural pine	64.3	2.2	23.9	54.7	80.8	89.9	90.3	81.6	76.4	71.2	98.1
Oak-pine	47.7	6.0	22.8	42.2	55.3	67.2	73.6	66.2	79.9	83.0	64.8
Upland hardwood	59.4	7.4	19.6	32.2	48.0	66.5	73.7	75.7	77.3	74.9	80.6
Lowland hardwood	65.3	11.7	16.7	34.2	45.3	74.6	77.8	90.0	113.8	120.5	115.8
All classes	55.8	5.3	23.6	44.3	59.1	71.9	75.8	75.8	78.6	77.5	80.3

[a]Includes wood and bark between a 1-foot stump and 4-inch top d.o.b. in growing-stock trees 5.0 inches d.b.h. and larger.

[b]Sample was too small to provide a reliable estimate.

Table 3.—Average green weight of forest biomass per acre of timberland, by broad management and stand-age classes, Virginia, 1986

Broad management class	All age classes	Stand-age class (years)									
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91+
						Tons/acre					
Pine plantation	48.5	5.6	57.6	100.8	132.3	(a)	—	—	—	—	—
Natural pine	94.2	7.9	50.8	93.6	113.8	122.3	122.2	113.7	106.9	97.0	126.2
Oak-pine	74.5	14.0	49.6	74.2	88.6	96.1	106.6	96.9	117.2	117.7	98.8
Upland hardwood	92.3	17.5	46.3	64.5	80.8	100.9	109.4	111.0	113.9	113.4	123.5
Lowland hardwood	99.8	21.6	42.7	62.7	72.8	115.8	110.3	131.5	170.0	174.2	168.3
All classes	87.6	13.3	50.5	78.2	91.7	105.8	110.7	110.6	115.6	116.3	121.9

[a] Sample was too small to provide a reliable estimate.

Table 4.--Area of timberland treated or disturbed annually and retained in timberland, by treatment or disturbance and broad management class, Virginia, 1977 to 1986

Recent past treatment or disturbance	All management classes	Broad management class[a]				
		Pine plantation	Natural pine	Oak-pine	Upland hardwood	Lowland hardwood
			Acres			
Harvesting followed by artificial regeneration	58,163	1,503	25,649	12,641	17,942	428
Other harvesting	124,977	--	34,589	12,119	68,412	9,857
Selection cutting and high-grading	33,689	--	3,528	3,487	26,395	279
Commercial thinning	14,560	5,088	5,033	634	3,510	295
Other cutting[b]	37,986	1,551	4,622	2,489	24,919	1,405
Natural disturbance	144,393	3,435	33,756	14,502	83,108	9,592

[a]Classification before treatment or disturbance.

[b]Includes stand improvement, cleaning, release, intermediate cutting, and other miscellaneous treatments.

Table 5.--Average green weight of forest biomass per acre of timberland, by treatment or disturbance and broad management class, Virginia, 1977 to 1986

Recent past treatment or disturbance	All management classes	Broad management class[a]				
		Pine plantation	Natural pine	Oak-pine	Upland hardwood	Lowland hardwood
		Tons/acre				
Harvesting followed by artificial regeneration	3.6	0.1	3.1	3.6	4.3	3.4
Other harvesting	24.8	--	18.1	23.6	26.3	42.3
Selection cutting and high-grading	90.0	--	79.6	107.4	90.2	(b)
Commercial thinning	94.4	97.2	102.2	(b)	73.5	(b)
Other cutting[c]	82.6	32.6	106.8	66.1	84.7	75.1
Natural disturbance	101.0	86.8	120.0	101.1	98.0	68.1

[a]Classification before treatment or disturbance.

[b]Sample was too small to provide a reliable estimate.

[c]Includes stand improvement, cleaning, release, intermediate cutting, and other miscellaneous treatments.

Table 6.--Area of timberland, by treatment opportunity and broad management classes, Virginia, 1986

Treatment opportunity class	All management classes	Broad management class				
		Pine plantation	Natural pine	Oak-pine	Upland hardwood	Lowland hardwood
			Acres			
Salvage	106,331	--	24,097	8,348	73,886	--
Harvest	1,553,816	--	149,097	162,571	1,158,702	83,446
Commercial thinning	567,761	284,580	228,800	7,656	39,237	7,488
Other stand improvement	1,185,401	98,607	200,646	203,347	650,347	32,454
Stand conversion	152,223	--	6,470	12,228	133,525	--
Regeneration	1,517,114	2,148	93,855	126,199	1,136,653	158,259
None[a]	7,433,264	779,984	1,352,740	949,769	4,129,060	221,711
Adverse sites[b]	2,919,926	4,734	129,893	219,073	2,451,050	115,176
All stands	15,435,836	1,170,053	2,185,598	1,689,191	9,772,460	618,534

[a]Immature stands sufficiently stocked with growing-stock trees relatively free from damage or competition.

[b]Areas where harvesting and timber management opportunities are severely limited because of steep slopes or water problems.

Table 7.--Average green weight of forest biomass per acre of timberland, by treatment opportunity and broad management classes, Virginia, 1986

Treatment opportunity class	All management classes	Broad management class				
		Pine plantation	Natural pine	Oak-pine	Upland hardwood	Lowland hardwood
			Tons/acre			
Salvage	103.3	--	100.4	118.6	102.5	--
Harvest	129.0	--	140.1	123.4	124.7	180.1
Commercial thinning	112.1	98.2	125.6	124.0	129.8	125.2
Other stand improvement	57.6	45.7	62.8	59.3	56.3	75.1
Stand conversion	55.1	--	38.2	76.5	54.0	--
Regeneration	46.1	(a)	16.6	44.5	47.6	55.1
None[b]	86.6	31.1	95.4	72.1	96.5	105.7
Adverse sites[c]	98.1	16.7	80.3	76.2	101.2	97.2
All stands	87.6	48.5	94.2	74.5	92.3	99.8

[a]Sample was too small to provide a reliable estimate.

[b]Immature stands sufficiently stocked with growing-stock trees relatively free from damage or competition.

[c]Areas where harvesting and timber management opportunities are severely limited because of steep slopes or water problems.

Table 8.--Green weight and percentage distribution of wood and bark biomass on timberland, by major species group and biomass component, Virginia, 1986

Biomass component	All species	Species group				
		Yellow pine	Other softwood	Soft hardwood	Oaks	Other hardwoods
		Percent of green weight				
Growing stock						
Bole	64.8	74.5	71.7	63.4	68.3	47.3
Stumps, tops, and limbs	14.7	15.2	14.8	12.1	17.7	11.9
Saplings	6.8	8.3	9.5	10.4	4.1	5.4
Total	86.3	98.0	96.0	85.9	90.1	64.6
Rough & rotten						
Bole	6.9	1.1	1.8	7.0	6.7	14.2
Stumps, tops, and limbs	2.2	.3	.6	2.0	1.9	4.9
Saplings	4.6	.6	1.6	5.1	1.3	16.3
Total	13.7	2.0	4.0	14.1	9.9	35.4
All classes	100.0	100.0	100.0	100.0	100.0	100.0
Green weight (million tons)	1,351.6	246.6	39.4	331.7	503.4	230.5

Table 9.--Percentage distribution of forest biomass per acre of timberland, by species group and by broad management and stand-age classes, Virginia, 1986

Broad management class and species group	All age classes	Stand-age class (years)									
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91+
		Percent									
Pine plantation											
Yellow pine	74	68	77	77	52	--	--	--	--	--	--
Other softwoods	7	--	6	3	33	--	--	--	--	--	--
Oaks	6	9	6	6	1	--	--	--	--	--	--
Other hardwoods	13	23	11	14	14	--	--	--	--	--	--
All species	100	100	100	100	100	--	--	--	--	--	--
Natural pine											
Yellow pine	69	49	73	74	78	70	67	54	63	52	44
Other softwoods	6	19	7	4	2	6	7	13	4	3	19
Oaks	9	6	6	6	5	8	11	16	17	18	18
Other hardwoods	16	26	14	16	15	16	15	17	16	27	19
All species	100	100	100	100	100	100	100	100	100	100	100
Oak-pine											
Yellow pine	28	29	30	33	35	32	29	20	21	27	16
Other softwoods	8	5	6	5	3	4	5	14	12	11	15
Oaks	35	22	26	31	25	25	41	42	44	40	49
Other hardwoods	29	44	38	31	37	39	25	24	23	22	20
All species	100	100	100	100	100	100	100	100	100	100	100
Upland hardwood											
Yellow pine	3	4	6	5	4	3	3	3	3	2	1
Other softwoods	1	3	2	2	2	1	1	1	1	1	2
Oaks	48	29	30	32	30	38	45	54	57	63	62
Other hardwoods	48	64	62	61	64	58	51	42	39	34	35
All species	100	100	100	100	100	100	100	100	100	100	100
Lowland hardwood											
Yellow pine	2	1	2	5	4	1	2	4	2	--	1
Other softwoods	3	7	--	2	--	1	2	4	1	5	29
Oaks	12	5	8	5	13	4	19	11	15	22	5
Other hardwoods	83	87	90	88	83	94	77	81	82	73	65
All species	100	100	100	100	100	100	100	100	100	100	100

Table 10.—Percentage distribution of forest biomass per acre of timberland, by tree diameter, broad management, and stand-age classes, Virginia, 1986

Broad management and diameter classes (inches)	All age classes	Stand-age class (years)									
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91+
		Percent									
Pine plantation											
1.0-4.9	23	65	29	16	5	—	—	—	—	—	—
5.0-8.9	53	29	61	54	20	—	—	—	—	—	—
9.0-12.9	19	2	7	26	49	—	—	—	—	—	—
13.0+	5	4	3	4	26	—	—	—	—	—	—
All classes	100	100	100	100	100	—	—	—	—	—	—
Natural pine											
1.0-4.9	14	50	37	24	12	9	10	9	9	10	2
5.0-8.9	32	20	44	47	40	27	20	19	18	20	8
9.0-12.9	31	15	15	22	34	37	37	30	30	29	15
13.0+	23	15	4	7	14	27	33	42	43	41	75
All classes	100	100	100	100	100	100	100	100	100	100	100
Oak-pine											
1.0-4.9	14	33	38	24	18	11	11	7	6	5	3
5.0-8.9	23	26	26	32	29	24	20	21	13	14	10
9.0-12.9	27	27	19	25	27	27	31	32	25	23	21
13.0+	36	14	17	19	26	38	38	40	56	58	66
All classes	100	100	100	100	100	100	100	100	100	100	100
Upland hardwood											
1.0-4.9	10	33	36	24	15	10	8	6	6	6	5
5.0-8.9	19	30	29	30	31	23	20	15	13	13	10
9.0-12.9	26	21	19	26	29	31	29	26	23	23	17
13.0+	45	16	16	20	25	36	43	53	58	58	68
All classes	100	100	100	100	100	100	100	100	100	100	100
Lowland hardwood											
1.0-4.9	8	18	30	18	15	7	6	5	5	4	6
5.0-8.9	16	25	24	29	29	19	12	11	9	9	11
9.0-12.9	26	40	31	32	30	30	21	25	18	20	18
13.0+	50	17	15	21	26	44	61	59	68	67	65
All classes	100	100	100	100	100	100	100	100	100	100	100

Table 11.--Area of timberland supporting pine plantations, by site, stocking, and stand-age classes, Virginia, 1986

Site and stocking classes	All age classes	Stand-age class (years)[a]				
		0-10	11-20	21-30	31-40	41-50
		Acres				
Good sites						
Fully stocked	194,702	54,475	47,117	67,230	25,780	100
Medium stocked	11,752	6,699	--	4,709	344	--
Poorly stocked	3,714	3,714	--	--	--	--
All stands	210,168	64,888	47,117	71,939	26,124	100
Medium sites						
Fully stocked	842,112	330,381	377,810	128,068	5,853	--
Medium stocked	63,231	38,900	5,503	14,431	4,397	--
Poorly stocked	5,009	5,009	--	--	--	--
All stands	910,352	374,290	383,313	142,499	10,250	--
Poor sites						
Fully stocked	42,671	6,980	25,915	5,042	4,734	--
Medium stocked	3,297	--	3,297	--	--	--
Poorly stocked	3,565	--	3,565	--	--	--
All stands	49,533	6,980	32,777	5,042	4,734	--
All sites						
Fully stocked	1,079,485	391,836	450,842	200,340	36,367	100
Medium stocked	78,280	45,599	8,800	19,140	4,741	--
Poorly stocked	12,288	8,723	3,565	--	--	--
All stands	1,170,053	446,158	463,207	219,480	41,108	100

[a]More than 96 percent of pine plantations were less than 31 years old.

Table 12.--Area of timberland supporting natural pine stands, by site, stocking, and stand-age classes, Virginia, 1986

Site and stocking classes	All age classes	Stand-age class (years)									
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91+
						Acres					
Good sites											
Fully stocked	636,030	26,216	56,018	71,435	140,316	166,382	115,137	40,831	14,248	--	5,447
Medium stocked	139,215	--	7,565	15,726	30,407	46,125	22,187	11,747	5,458	--	--
Poorly stocked	10,075	7,351	--	--	--	2,724	--	--	--	--	--
All stands	785,320	33,567	63,583	87,161	170,723	215,231	137,324	52,578	19,706	--	5,447
Medium sites											
Fully stocked	898,456	75,291	179,037	156,074	195,777	136,021	81,246	42,848	12,370	6,248	13,544
Medium stocked	218,898	39,372	44,233	22,733	32,549	26,000	27,184	19,871	3,592	--	3,364
Poorly stocked	64,053	47,326	10,520	3,497	--	--	--	2,710	--	--	--
All stands	1,181,407	161,989	233,790	182,304	228,326	162,021	108,430	65,429	15,962	6,248	16,908
Poor sites											
Fully stocked	135,654	7,993	9,331	28,384	10,618	28,114	12,080	14,633	12,627	--	11,874
Medium stocked	78,405	--	21,530	3,789	9,826	4,509	8,415	11,176	14,762	4,398	--
Poorly stocked	4,812	--	--	2,610	--	2,202	--	--	--	--	--
All stands	218,871	7,993	30,861	34,783	20,444	34,825	20,495	25,809	27,389	4,398	11,874
All sites											
Fully stocked	1,670,140	109,500	244,386	255,893	346,711	330,517	208,463	98,312	39,245	6,248	30,865
Medium stocked	436,518	39,372	73,328	42,248	72,782	76,634	57,786	42,794	23,812	4,398	3,364
Poorly stocked	78,940	54,677	10,520	6,107	--	4,926	--	2,710	--	--	--
All stands	2,185,598	203,549	328,234	304,248	419,493	412,077	266,249	143,816	63,057	10,646	34,229

Table 13.--Area of timberland supporting oak-pine stands, by site, stocking, and stand-age classes, Virginia 1986

Site and stocking classes	All classes	Stand-age class (years)									
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91+
		Acres									
Good sites											
Fully stocked	226,765	42,797	14,679	19,003	21,074	36,463	43,812	18,574	24,926	2,882	2,555
Medium stocked	109,526	—	7,935	7,296	26,150	30,447	13,522	14,618	9,558	—	—
Poorly stocked	5,943	2,518	—	—	—	3,425	—	—	—	—	—
All stands	342,234	45,315	22,614	26,299	47,224	70,335	57,334	33,192	34,484	2,882	2,555
Medium sites											
Fully stocked	746,447	227,542	137,572	68,887	70,744	40,536	67,903	58,080	34,107	8,410	32,666
Medium stocked	277,226	29,517	37,772	20,409	30,714	58,208	39,259	34,654	4,387	4,354	17,952
Poorly stocked	43,291	6,818	4,721	7,111	8,998	4,634	6,348	4,661	—	—	—
All stands	1,066,964	263,877	180,065	96,407	110,456	103,378	113,510	97,395	38,494	12,764	50,618
Poor sites											
Fully stocked	142,063	19,169	10,203	7,901	8,824	8,316	17,018	24,957	9,436	9,540	26,699
Medium stocked	137,930	10,564	—	6,478	8,464	11,673	10,884	37,998	28,435	4,354	19,080
Poorly stocked	—	—	—	—	—	—	—	—	—	—	—
All stands	279,993	29,733	10,203	14,379	17,288	19,989	27,902	62,955	37,871	13,894	45,779
All sites											
Fully stocked	1,115,275	289,508	162,454	95,791	100,642	85,315	128,733	101,611	68,469	20,832	61,920
Medium stocked	524,682	40,081	45,707	34,183	65,328	100,328	63,665	87,270	42,380	8,708	37,032
Poorly stocked	49,234	9,336	4,721	7,111	8,998	8,059	6,348	4,661	—	—	—
All stands	1,689,191	338,925	212,882	137,085	174,968	193,702	198,746	193,542	110,849	29,540	98,952

Table 14.--Area of timberland supporting upland hardwood stands, by site, stocking, and stand-age classes, Virginia, 1986

Site and stocking classes	All age classes	Stand-age class (years)									
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91+
						Acres					
Good sites											
Fully stocked	1,266,398	45,928	34,300	45,969	134,730	272,286	300,555	199,296	147,656	36,794	48,884
Medium stocked	832,525	31,012	21,010	44,654	95,736	150,630	192,687	137,896	63,428	37,956	57,516
Poorly stocked	92,622	16,597	--	12,117	12,937	8,533	14,877	15,388	--	7,447	4,726
All stands	2,191,545	93,537	55,310	102,740	243,403	431,449	508,119	352,580	211,084	82,197	111,126
Medium sites											
Fully stocked	3,271,014	430,189	329,684	219,070	307,162	402,311	532,879	454,490	237,414	166,799	191,016
Medium stocked	2,279,748	135,186	149,278	183,784	201,463	285,623	382,005	367,326	262,252	110,538	202,293
Poorly stocked	344,970	126,758	41,644	19,555	9,858	18,574	61,199	24,012	32,032	--	11,338
All stands	5,895,732	692,133	520,606	422,409	518,483	706,508	976,083	845,828	531,698	277,337	404,647
Poor sites											
Fully stocked	904,783	62,139	87,911	26,049	27,564	63,302	138,098	93,982	138,449	117,527	149,762
Medium stocked	695,484	28,987	34,440	34,272	39,736	38,898	81,916	119,022	106,468	79,556	132,189
Poorly stocked	84,916	24,469	--	4,762	10,236	4,256	6,042	10,487	19,870	4,794	--
All stands	1,685,183	115,595	122,351	65,083	77,536	106,456	226,056	223,491	264,787	201,877	281,951
All sites											
Fully stocked	5,442,195	538,256	451,895	291,088	469,456	737,899	971,532	747,768	523,519	321,120	389,662
Medium stocked	3,807,757	195,185	204,728	262,710	336,935	475,151	656,608	624,244	432,148	228,050	391,998
Poorly stocked	522,508	167,824	41,644	36,434	33,031	31,363	82,118	49,887	51,902	12,241	16,064
All stands	9,772,460	901,265	698,267	590,232	839,422	1,244,413	1,710,258	1,421,899	1,007,569	561,411	797,724

Table 15.--Area of timberland supporting lowland hardwood stands, by site, stocking, and stand-age classes, Virginia, 1986

Site and stocking classes	All age classes	Stand-age class (years)									
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91+
						Acres					
Good sites											
Fully stocked	90,553	5,258	11,501	8,916	12,464	16,802	16,517	9,955	6,798	---	2,342
Medium stocked	73,086	2,739	---	---	10,064	21,011	21,548	3,497	10,662	2,739	826
Poorly stocked	37,015	5,380	---	4,001	7,464	4,661	10,875	4,634	---	---	---
All stands	200,654	13,377	11,501	12,917	29,992	42,474	48,940	18,086	17,460	2,739	3,168
Medium sites											
Fully stocked	183,631	21,584	5,900	11,067	11,486	33,807	11,123	38,737	18,009	24,833	7,085
Medium stocked	110,541	15,828	---	19,478	18,373	12,445	24,381	13,772	2,867	---	3,397
Poorly stocked	40,592	6,702	2,251	9,343	3,813	8,162	3,154	7,167	---	---	---
All stands	334,764	44,114	8,151	39,888	33,672	54,414	38,658	59,676	20,876	24,833	10,482
Poor sites											
Fully stocked	34,427	2,739	5,869	7,236	5,131	4,652	5,476	---	---	3,324	---
Medium stocked	30,580	---	5,350	2,747	2,613	9,359	2,418	2,705	---	---	5,388
Poorly stocked	18,109	6,408	3,515	5,577	---	---	2,609	---	---	---	---
All stands	83,116	9,147	14,734	15,560	7,744	14,011	10,503	2,705	---	3,324	5,388
All sites											
Fully stocked	308,611	29,581	23,270	27,219	29,081	55,261	33,116	48,692	24,807	28,157	9,427
Medium stocked	214,207	18,567	5,350	22,225	31,050	42,815	48,347	19,974	13,529	2,739	9,611
Poorly stocked	95,716	18,490	5,766	18,921	11,277	12,823	16,638	11,801	---	---	---
All stands	618,534	66,638	34,386	68,365	71,408	110,899	98,101	80,467	38,336	30,896	19,038

Table 16.--Average green weight of forest biomass per acre of timberland supporting pine plantations, by site, stocking, and stand-age classes, Virginia, 1986

Site and stocking classes	All age classes	Stand-age class (years)[a]				
		0-10	11-20	21-30	31-40	41-50
		Tons/acre				
Good sites						
Fully stocked	86.5	7.1	82.6	122.8	166.8	(b)
Medium stocked	22.8	(b)	--	56.9	(b)	--
Poorly stocked	(b)	(b)	--	--	--	--
All stands	81.4	6.0	82.6	118.5	164.6	(b)
Medium sites						
Fully stocked	43.6	6.2	56.5	98.7	115.9	--
Medium stocked	20.5	1.6	34.2	46.1	86.4	--
Poorly stocked	(b)	(b)	--	--	--	--
All stands	41.8	5.7	56.2	93.4	103.2	--
Poor sites						
Fully stocked	34.5	2.1	41.8	(b)	(b)	--
Medium stocked	(b)	--	(b)	--	--	--
Poorly stocked	(b)	--	(b)	--	--	--
All stands	33.0	2.1	38.0	(b)	(b)	--
All sites						
Fully stocked	51.0	6.3	58.4	105.8	139.1	(b)
Medium stocked	20.8	1.3	28.7	48.7	80.1	--
Poorly stocked	8.1	(b)	(b)	--	--	--
All stands	48.5	5.6	57.6	100.8	132.3	(b)

[a]More than 96 percent of pine plantations were less than 31 years old.

[b]Sample was too small to provide a reliable estimate.

Table 17.--Average green weight of forest biomass per acre of timberland supporting natural pine stands, by site, stocking, and stand-age classes, Virginia, 1986

Site and stocking classes	All age classes	Stand-age class (years)									
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91+
		Tons/acre									
Good sites											
Fully stocked	126.8	17.4	61.0	111.6	132.2	146.8	149.2	144.1	129.6	--	(a)
Medium stocked	92.1	--	41.9	68.1	85.8	105.1	101.8	83.0	(a)	--	--
Poorly stocked	22.2	1.9	--	--	--	(a)	--	--	--	--	--
All stands	119.3	14.0	58.7	103.7	123.9	137.0	141.6	130.4	131.7	--	(a)
Medium sites											
Fully stocked	93.7	9.9	56.4	104.4	115.2	116.4	110.4	124.4	129.8	131.5	139.9
Medium stocked	55.3	6.1	37.3	43.5	59.7	84.0	91.8	96.3	(a)	--	(a)
Poorly stocked	8.9	2.0	19.6	27.9	--	--	--	(a)	--	--	--
All stands	82.0	6.7	51.1	95.3	107.3	111.2	105.7	113.3	135.2	131.5	120.5
Poor sites											
Fully stocked	79.7	6.9	32.2	62.3	101.5	95.2	94.6	90.8	88.2	--	113.4
Medium stocked	55.9	--	32.0	(a)	(a)	(a)	59.2	67.2	59.2	(a)	--
Poorly stocked	(a)	--	--	(a)	--	(a)	--	--	--	--	--
All stands	70.1	6.9	32.1	59.2	101.5	83.3	80.0	80.6	72.6	(a)	113.4
All sites											
Fully stocked	105.2	11.5	56.5	101.7	121.7	129.9	130.9	127.6	116.4	131.5	135.2
Medium stocked	67.2	6.1	36.2	54.2	76.2	93.5	90.9	85.1	91.3	(a)	(a)
Poorly stocked	12.0	2.0	19.6	26.3	--	60.9	--	(a)	--	--	--
All stands	94.2	7.9	50.8	93.6	113.8	122.3	122.2	113.7	106.9	97.0	126.2

[a]Sample was too small to provide a reliable estimate.

Table 18.--Average green weight of forest biomass per acre of timberland supporting oak-pine stands, by site, stocking, and stand-age classes, Virginia, 1986

Site and stocking classes	All age classes	Stand-age class (years)									
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91+
		Tons/acre									
Good sites											
Fully stocked	104.5	23.6	73.9	92.7	142.0	132.1	125.7	121.8	150.1	(a)	(a)
Medium stocked	89.9	--	20.2	53.1	88.6	98.4	117.5	95.4	104.3	--	--
Poorly stocked	33.8	(a)	--	--	--	(a)	--	--	--	--	--
All stands	98.9	22.3	55.1	81.7	112.4	113.9	123.7	110.2	137.4	(a)	(a)
Medium sites											
Fully stocked	70.0	12.0	50.5	81.0	97.1	99.2	121.3	122.8	147.5	156.2	134.4
Medium stocked	72.5	21.4	52.3	57.3	59.2	90.9	84.9	91.6	90.5	130.9	96.9
Poorly stocked	33.0	5.8	6.1	55.5	26.8	19.8	52.3	64.7	--	--	--
All stands	69.1	12.8	49.7	74.1	80.8	91.0	104.9	108.9	141.0	147.6	121.1
Poor sites											
Fully stocked	73.9	9.6	35.9	90.7	106.2	50.2	100.0	85.2	82.4	71.6	96.9
Medium stocked	55.6	16.6	--	25.1	39.1	66.8	44.2	61.9	72.0	63.4	55.6
Poorly stocked	--	--	--	--	--	--	--	--	--	--	--
All stands	64.9	12.1	35.9	61.1	73.4	59.9	78.3	71.1	74.6	69.0	79.7
All sites											
Fully stocked	77.6	13.5	51.7	84.1	107.3	108.5	120.0	113.4	139.5	126.2	112.7
Medium stocked	71.7	20.1	46.7	50.3	68.3	90.4	84.9	79.3	81.2	97.2	75.6
Poorly stocked	33.1	4.2	6.1	55.5	26.8	36.3	52.3	64.7	--	--	--
All stands	74.5	14.0	49.6	74.2	88.6	96.1	106.6	96.9	117.2	117.7	98.8

[a]Sample was too small to provide a reliable estimate.

Table 19.--Average green weight of forest biomass per acre of timberland supporting upland hardwood, by site, stocking, and stand-age classes, Virginia, 1986

Site and stocking classes	All age classes	Stand-age class (years)									
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91+
		Tons/acre									
Good sites											
Fully stocked	133.0	25.6	64.4	80.3	115.6	128.8	143.9	145.7	156.8	159.3	191.5
Medium stocked	93.0	12.6	56.6	64.8	71.0	87.8	103.1	111.4	109.6	104.3	117.6
Poorly stocked	50.4	15.7	--	44.0	46.4	49.6	67.6	63.2	--	76.3	63.4
All stands	114.3	19.5	61.4	69.3	94.3	112.9	126.2	128.7	142.6	126.4	147.8
Medium sites											
Fully stocked	99.6	22.7	52.8	76.7	87.6	116.0	123.6	125.3	140.0	132.0	157.7
Medium stocked	80.5	11.6	38.1	54.0	66.7	79.7	91.1	94.4	97.6	110.4	112.0
Poorly stocked	29.9	6.0	20.4	20.6	40.1	54.5	49.2	62.1	44.8	--	84.0
All stands	88.1	17.4	46.0	64.2	78.6	99.7	106.2	110.1	113.3	123.4	133.2
Poor sites											
Fully stocked	88.0	23.1	40.3	64.6	72.7	67.6	98.8	97.6	106.4	103.8	113.3
Medium stocked	71.1	12.7	42.1	59.1	47.0	49.6	63.6	81.7	83.8	85.4	84.7
Poorly stocked	26.6	4.0	--	18.3	26.9	38.4	67.5	40.7	36.4	16.6	--
All stands	78.0	16.5	40.8	58.3	53.5	59.8	85.2	86.4	92.1	94.4	99.9
All sites											
Fully stocked	105.4	23.0	51.3	76.2	94.7	116.6	126.4	127.3	135.9	124.8	144.9
Medium stocked	81.5	11.9	40.7	56.5	65.6	79.8	91.2	95.8	96.0	100.7	104.1
Poorly stocked	33.0	6.6	20.3	28.1	38.5	51.0	53.9	57.9	41.6	52.9	78.0
All stands	92.2	17.5	46.3	64.5	80.8	100.9	109.4	111.0	113.9	113.4	123.5

Table 20.--Average green weight of forest biomass per acre of timberland supporting lowland hardwood, by site, stocking, and stand-age classes, Virginia, 1986

Site and stocking classes	All age classes	Stand-age class (years)									
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91+
		Tons/acre									
Good sites											
Fully stocked	135.6	61.3	56.7	121.9	103.3	194.6	157.0	121.3	204.5	--	(a)
Medium stocked	96.2	(a)	--	--	83.2	88.8	103.2	(a)	103.3	(a)	(a)
Poorly stocked	36.6	.4	--	17.2	44.0	67.0	45.4	31.7	--	--	--
All stands	103.0	33.2	56.7	89.4	81.8	128.2	108.5	93.0	142.7	(a)	(a)
Medium sites											
Fully stocked	143.3	30.3	51.7	83.3	87.1	137.9	208.0	179.0	202.8	171.2	228.4
Medium stocked	60.4	4.9	--	54.5	58.2	69.3	73.2	91.6	(a)	--	(a)
Poorly stocked	37.7	3.0	(a)	37.1	(a)	56.8	(a)	59.9	--	--	--
All stands	103.1	17.1	42.5	58.4	64.6	110.0	109.2	144.5	192.9	171.2	171.6
Poor sites											
Fully stocked	121.7	(a)	31.5	100.9	81.5	176.2	191.6	--	--	(a)	--
Medium stocked	73.8	--	48.5	(a)	(a)	62.4	(a)	(a)	--	--	136.9
Poorly stocked	6.6	4.0	(a)	7.7	--	--	(a)	--	--	--	--
All stands	79.0	26.5	32.0	51.6	74.1	100.2	122.8	(a)	--	(a)	136.9
All sites											
Fully stocked	138.6	40.3	49.1	100.6	93.1	158.3	179.9	167.2	203.2	178.4	221.2
Medium stocked	74.5	10.6	48.5	49.1	66.4	77.4	87.4	93.1	109.1	131.3	116.4
Poorly stocked	31.4	2.6	11.9	24.2	38.3	60.5	38.5	48.9	--	--	--
All stands	99.8	21.6	42.7	62.7	72.8	115.8	110.3	131.4	170.0	174.2	168.3

[a]Sample was too small to provide a reliable estimate.

Table 21.--Area and green weight of woody biomass per acre of reserved timberland and woodland, by forest type, Virginia, 1986

Forest type	All lands	Reserved timberland	Woodland	All lands	Reserved timberland	Woodland
	Acres			Tons/acre		
White pine-hemlock	8,311	8,311	--	129.8	129.8	--
Loblolly-shortleaf pine	41,742	34,561	7,181	45.1	54.4	0.5
Oak-pine	18,806	18,806	--	93.9	93.9	--
Oak-hickory	388,680	337,183	51,497	129.3	145.8	21.2
Oak-gum-cypress	68,752	66,013	2,739	196.2	196.2	(a)
Elm-ash-cottonwood	6,314	6,314	--	160.8	160.8	--
All types	532,605	471,188	61,417	130.5	144.0	18.7

[a]Sample was too small to provide a reliable estimate.

Table 22.--Area of nonforest land, by land use and percent crown closure, Virginia, 1986

Land use	All classes	Percent crown-closure class		
		1-29	30-59	60+
		Acres		
Cropland	495,980	408,352	46,494	41,134
Improved pasture	1,290,200	1,172,695	105,195	12,310
Idle farmland	204,044	187,290	14,035	2,719
Other farmland	230,325	190,723	22,078	17,524
Urban and other	1,308,697	884,670	298,438	125,589
Marsh	16,313	13,594	2,719	--
Noncensus water	100,294	71,324	7,426	21,544
All uses	3,645,853	2,928,648	496,385	220,820

Table 23.--Per-acre green weight of wood and bark biomass associated with nonforest land, by land use and percent crown closure, Virginia, 1986

Land use	All classes	Percent crown-closure class		
		1-29	30-59	60+
		Tons/acre		
Cropland	9.0	6.6	14.0	26.4
Improved pasture	6.0	5.5	11.7	7.8
Idle farmland	5.1	4.0	16.2	22.9
Other farmland	8.8	6.3	10.5	33.3
Urban and other	16.4	10.1	18.0	57.1
Marsh	5.8	1.3	28.3	--
Noncensus water	13.2	.2	12.2	56.5
All uses	10.5	6.8	15.8	46.3

Table 24.--Total green weight of aboveground wood and bark biomass on nonforest land, by land use and species group, Virginia, 1986

Land use	All classes	Yellow pine	Other softwoods	Soft hardwood	Oaks	Other hard hardwood	Noncommercial
				Tons			
Cropland	4,448,378	614,800	224,952	2,038,699	499,369	310,245	760,313
Improved pasture	7,733,541	420,876	303,005	2,300,187	1,823,617	2,503,425	382,431
Idle farmland	1,046,532	210,736	203,775	408,041	52,146	154,156	17,678
Other farmland	2,018,870	511,860	252,503	391,057	494,345	350,522	18,583
Urban and other	21,471,577	4,330,167	275,797	6,256,135	8,305,370	1,868,580	435,528
Marsh	94,840	36,855	468	20,988	33,083	3,446	--
Noncensus water	1,321,681	--	--	165,313	296,511	813,245	46,612
All uses	38,135,419	6,125,294	1,260,500	11,580,420	11,504,441	6,003,619	1,661,145

Cost, Noel D.
Multiresource inventories: woody biomass in Virginia. Res. Pap. SE-269. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1988. 35 pp.

Virginia's 25.4 million acres of land area support 1.5 billion tons of woody biomass. Of this total, 93 percent is on timberland, 5 percent on reserved timberland and woodland areas, and 2 percent on nonforest areas. Over the next two decades, more than 9 million tons of woody biomass could be harvested annually from timberland without adversely affecting timber supplies.

KEYWORDS: Growing stock, timberland, multiple use.

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The Forest Service, U.S. Department of Agriculture, is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives—as directed by Congress—to provide increasingly greater service to a growing Nation.