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# A Model of Forest Floor Carbon Mass for United States Forest Types

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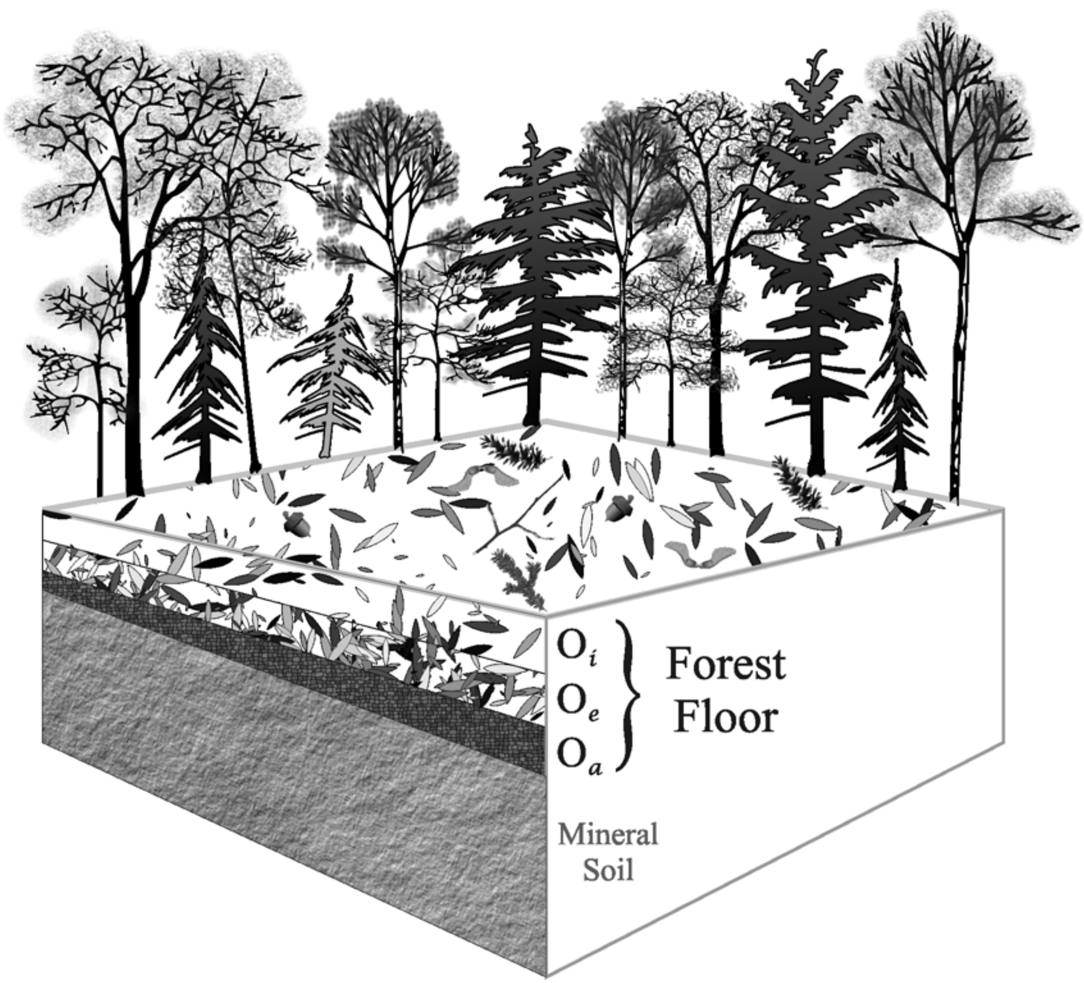

## Abstract

We summarize a large set of published values of forest floor mass and develop large-scale estimates of carbon mass according to region and forest type. Published values of forest floor carbon mass or information relevant to compiling such summaries are scarce. We present a simulation model based on observations obtained from literature surveys for use in the 2002 version of FORCARB, a carbon budget model for U.S. forests. The forest floor is the distinct layer of dead and decaying plant material that accumulates on the soil surface, which lies above the mineral soil and includes small woody debris. Estimates of average forest floor carbon mass per hectare of forest applied to a 1997 summary forest inventory, sum to 4.5 Gt carbon stored in forests of the 48 contiguous United States.

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Metric units and conversions

| | | |
|---|---|---|
| Mg | = | megagram, or metric tonne |
| | = | 1.102 U.S. ton, or 2,205 pounds |
| Mt | = | megatonne, $10^6$ tonne, or teragram |
| Gt | = | gigatonne, $10^9$ tonne, or petagram |
| 1 hectare | = | 2.471 acre |

## Introduction

The role of forests and land-use change in the global carbon cycle interests scientists and policy makers because of the contribution forests make to the large annual carbon flux between terrestrial ecosystems and the atmosphere (Tans and White 1998). Forests and forest management projects have been a central component of proposed actions to help mitigate greenhouse gas emissions because forests can be an economical carbon sink (Rotter and Danish 2000). Our objective is to develop equations to estimate forest floor carbon for U.S. forests based on common forest inventory variables. Little comprehensive data exists for forest floor carbon pools of the U.S.

The development of these equations is part of a larger project to estimate forest carbon using a simulation model called FORCARB (Plantinga and Birdsey 1993; Heath and Birdsey 1993). The FORCARB model accounts for carbon in U.S. forests (Birdsey and Heath 1995) and forest products (Heath and others 1996; Skog and Nicholson 1998), has been used to produce projections for the 2001 U.S. Submission to the United Nations Framework Convention on Climate Change on Land Use, Land Use Change and Forestry (U.S. State Department 2000), and has been used to examine uncertainty in U.S. forest carbon budgets (Smith and Heath 2000; Heath and Smith 2000). FORCARB produces separate estimates for all forest carbon pools such as live trees, down dead wood, and soil organic carbon.

Predictions of forest floor carbon mass based on comprehensive sampling are not currently available, but such data are likely to accompany future forest inventories. In this study, we attempt to meet current needs for forest floor carbon information by developing estimates of forest floor carbon based on deriving relationships developed from published data. Our goal is to develop and present a transparent and readily updated simulation model to estimate forest floor carbon mass based on forest type, regional characteristics, and forest age since a major disturbance. "Transparent" means that it is possible for users to understand how any part of the estimate affects results, that is, all parts of the equations are clearly outlined. These estimates are applicable to developing a forest carbon budget of the entire U.S. or for estimating regional averages, and can be used at the stand level in the absence of local information.

## Forest Floor

Sparse information and the immediate need for tractable carbon estimates are the principal considerations in this study. Our approach is (1) to define the forest floor, (2) to develop a simple conceptual structure for making quantitative estimates, (3) to compile useful data from the literature, and (4) to sort and summarize data to develop estimates.

Forest floor definitions vary and have evolved over time. Establishing a working definition and conceptual structure help to identify relevant information. We are interested in broad classification variables to serve as useful predictors of forest floor carbon. These variables and their relative usefulness are discussed in detail below. Values summarized from the directly measured observations are assigned as representative of similarly classified forest land. Our approach is conceptually similar to other approaches that extracted data and made broad generalizations from published measurements of forest ecosystems (Vogt and others 1995; Vogt and others 1996; Johnson and others 2000). We identify important predictors of forest floor mass from literature reviews, use these relationships and published values to make model-based estimates, and update estimates where possible.

The forest floor includes nonliving plant mass in various states of mechanical and chemical decay. Large vertebrate detritus may sometimes be included in forest floor samples, but it is generally a small part of the forest floor. Plant material includes leaves, twigs, bark, and woody stems on the forest floor. Some forests also contain a significant amount of fine roots in the forest floor. Accumulation of plant material can form identifiable layers above the mineral soil. Layer identities are based on states of decomposition ranging from freshly fallen leaves and twigs, which are easily identified, to lower layers of humus that are at an advanced state of decomposition. The lowest layer can be amorphous and sometimes almost indistinguishable from upper layers of mineral soil (Waring and Schlesinger 1985). Organic layers above the mineral soil are usually identified as $O_i$, $O_e$, and $O_a$ (upper to lower) or L, F, and H according to a previous classification system (Federer 1982).

Distinctions among pools of coarse woody debris, the forest floor, and soil organic matter are necessary to avoid over- or under-counting carbon when separate estimates are made for each. Reconciling differences in forest floor data collection was difficult as many studies featured different protocols. For example, distinctions between coarse woody debris and the small woody material that is considered part of the forest floor are based on diameters of recently fallen branches and stems. Diameters ranging from less than a centimeter to more than 7 cm are reported as the distinction between coarse woody debris and forest floor (Rollinger and others 1998). Also, many reports either do not specify how a distinction was made, or they fail to identify the presence or absence of woody material. The state of decomposition is also a basis for distinguishing coarse woody debris from the forest floor because rotting logs eventually become classified as forest floor. The distinction between the lowest layers of forest floor and upper (generally A horizon) layers of mineral soil is sometimes clear. However, purely organic layers of forest floor and organic-rich layers of the mineral soil are sometimes difficult to discern. This can be even more difficult when mechanical mixing of layers has occurred (Ryan and others 1992). Field classifications are usually based on morphology and are closely related to an individual researcher's experience (Federer 1982).

Accumulation of forest floor mass depends on rates of detrital inputs and the rates of loss through processes such as decomposition or physical damage or removal. Accumulation and loss can be spatially (Simmons and others 1996) and temporally (Nemeth 1973) heterogeneous. Processes can be influenced by season, climate, and edaphic factors, as well as stand composition, age and disturbance history (Schlesinger 1977; Mattson and Smith 1993; Binkley 1995).

Forest floor carbon mass is related to total biomass accumulation, but additional factors control specific carbon content. Specific carbon content of forest floor mass can vary by origin of material as well as history of decay or residence time in the forest floor. For example, freshly fallen wood usually contains more carbon per gram dry weight than fresh leaf litter, approximately 50 percent versus 45 percent (Fassnacht and Gower 1999). Loss of carbon through respiration and changes in chemical composition with decay result in progressively decreasing carbon content of the more decomposed material of lower forest floor layers (Huntington and others 1989; Schiffman and Johnson 1989). Decomposition rates are principally affected by quality and quantity of material as well as a favorable microenvironment (Schlesinger 1977; Hendrickson and others 1989; Berg and others 1996). Though quantity and quality of inputs affect carbon mass stored in forest floors, factors controlling carbon loss appear to be somewhat more important in controlling the carbon level in temperate forests (Vogt and others 1996). We assume that factors affecting gain and loss co-vary with forest type, location, and other general descriptors, and that such generalizations are useful for developing simple estimates at large scales.

## Regional characteristics

Numerous reviews report forest location and composition are associated with average amount of forest floor mass (Schlesinger 1977; Vogt and others 1986; Vogt and others 1995; Vogt and others 1996; Rollinger and others 1998). For example, Vogt and others (1995) reviewed a number of broad influences on soil and forest floor carbon. The goal was to identify influences on large-scale estimates. Their results demonstrated a trend of greater forest floor accumulation along a climatic gradient from tropical to temperate to boreal forests. The result of adding evergreen and deciduous classifications suggested their usefulness for predicting forest floor mass. Evidence further suggests that additional predictor variables such as soil type, stocking, productivity, or management intensity can affect forest floors, but these variables are not as consistently useful as region or forest type for making large-scale estimates (Vogt and others 1995; Vogt and others 1996).

Climate affects accumulation and loss of forest floor mass. Longer growing seasons and warmer temperatures are associated with greater productivity and litterfall, but they also are associated with more rapid decomposition, especially if litter retains sufficient moisture and aeration. Within a specific forest type or region, latitude or elevation gradients may be analogous to climate gradients. Estimating forest floor mass with latitude may depend on considering a wide range of either latitude or local environments (Vogt and others 1986; Vogt and others 1995; Simmons and others 1996).

## Forest Type by Region

Forests dominated by conifers usually accumulate more forest floor mass than deciduous forests (Schlesinger 1977; McClaugherty and others 1985; Finzi and others 1998). However, a number of exceptions to this trend also have been noted (Perala and Alban 1982a; Grigal and Ohmann 1992; Vogt and others 1995). The accumulation in softwoods is partly due to more decay-resistant litter, conditions that favor fungal decomposers, and cooler temperatures and microenvironmental conditions that slow decomposition. Rates of litter decomposition are usually lower for softwoods than for hardwoods. Vogt and others (1995) found generally greater forest floor mass in needle-leaved evergreen forests than in broadleaved deciduous forests in warm temperate regions. However, forest floor accumulation was greater in cold temperate climates with the two forest types having similar forest floor mass. Mixed forests of both needle-leaved evergreen and broadleaf deciduous species had significantly more forest floor mass than either type alone.

Forest type, as described by major component species, is clearly an important factor in accumulation of forest floor mass (Lang and Forman 1978; Cole and Rapp 1981; Vitousek and others 1982; Vogt and others 1986; Vogt and others 1996; Rollinger and others 1998). However, there are enough exceptions to predictive ability within forest types to suggest that classification by type alone might not be sufficient to develop a simulation model. For example, forest floor mass sampled from 40-year-old stands of aspen, white spruce, jack pine, and red pine were within a similar range. This included no substantial differences between hardwood and conifer species (Perala and Alban 1982b). Species composition alone also can produce apparently contradictory results. For example, sometimes the presence of alder leads to substantially greater forest floor mass in Douglas-fir stands in the Pacific Northwest, and sometimes inclusion of alder does not affect accumulation (Binkley and others 1992). Including bigleaf maple in Douglas-fir stands along the coastal range in Oregon had no affect on forest floor mass. Bigleaf maple did, however, increase measured litterfall and rates of decomposition (Fried and others 1990). Despite the many documented exceptions, location (region) and stand composition are probably the most useful estimators for forest floor mass.

## Development with Age

Forest age, in years since afforestation or a major disturbance, is assumed to be the next most useful predictor of forest floors after location-by-type influences. A change in land use to forests, such as afforestation of agricultural soils, often is associated with a rapid increase in forest floor mass (Schlesinger 1977; Binkley 1995). The surface organic layer, which becomes forest floor with afforestation, is generally greater in forests than in recently abandoned agricultural land or old-fields (Schiffman and Johnson 1989; Homann and Grigal 1996). Net forest floor mass accumulates at a relatively rapid rate during forest development. This rate slows considerably as the forest floor reaches a more mature state between 20 and 80 or more years, depending on the forest (Switzer and others 1979; Covington 1981; Means and others 1992; Edmonds and Chappell 1994; Smith and Resh 1999). Relatively slower rates of change characterize the much longer period from maturity through old growth. Forest floors of older undisturbed forests can sometimes be characterized as an approximately steady state.

These estimates depend on assuming a threshold age for mature forest floors based on the overstory age of a stand and assigning an average carbon mass for an approximately steady state. Covington (1981) and others (Federer 1984; Hendrickson and others 1989; Mattson and Smith 1993; Olsson and others 1996) identified forest floor dynamics following harvest, and defined "fully recovered" Northern hardwood forest floors between 40 and 60 years old. Development is much more rapid in Southern pine forests with ages between 15 and 25 years (Nemeth 1973; Switzer and others 1979; Gholz and others 1985; Lockaby and Taylor-Boyd 1986). Evidence suggests that western forests tend to develop forest floor mass more slowly (Smith and Resh 1999). The exceptions in the West are forests of the Pacific Northwest west of the Cascades (Turner and Long 1975); Douglas-fir forests develop forest floor mass relatively rapidly and continue slow increases through old growth. Differences between mature and old-growth forest floor mass vary by forest and region. However, approximate steady-state averages may be useful for long-term estimates for regions where old-growth stands are an increasingly smaller proportion of forest area.

## Effects of Disturbance

Relationships between disturbance and forest floor mass depend on severity of disturbance. Minor disturbances, such as creation of small gaps or low-intensity fires, may have little apparent measurable effect and can result in rapid recovery. For example, windthrow — creating small gaps — had no long-term effect on carbon storage in forest floors of hemlock-hardwood and northern-hardwood forest in the Great Lakes region (Liechty and others 1997). Fire effects on forest floor mass, or carbon, can vary considerably. Some regular or low-intensity fires have little effect in reducing forest floor mass (Alban 1977; Little and Ohmann 1988; Clinton and others 1996), whereas most of the forest floor can be lost in more severe fires (Dyrness and others 1989; Vose and others 1999). Rapid recovery can occur when fire damage to overstory is limited (Bell and Binkley 1989).

Reductions in forest floor carbon are possible following a clearcut harvest. Harvests result in decreased litter input and increased decomposition (Johnson and others 1991; Alban and others 1994; Strong 1997; Rollinger and others 1998). Changes in decomposition are influenced by the altered microenvironment of the soil surface. In addition to rapid decomposition, immediate losses of forest floor with harvest may be due to mounding, mixing, and burial of organic matter (Federer 1984; Ryan and others 1992). Effects of harvesting on forest floor mass and the dynamics accompanying forest regrowth can have important consequences for estimates. If forest floor mass is lost quickly after harvest, then patterns of carbon storage will follow closely those of afforestation. Time-averaged carbon content would be considerably greater, however, if most forest floor mass remains after harvest, followed by slow decay during forest regrowth and accumulation of new forest floor mass.

Covington (1981) described the dynamics of forest floor mass for northern hardwood forests following clearcut harvesting. Forest floor organic matter decreased the first 15 years following clearcutting of northern hardwood forests in New Hampshire. A 50 percent decrease was followed by a slow recovery of forest floor for about 50 years before floor mass was within 5 percent of preharvest levels. These results initiated numerous field measurements and model simulations of this effect. Some reports failed to demonstrate the same dynamics (Hendrickson and others 1989; Schiffman and Johnson 1989), and others repeated the effect (Federer 1984; Snyder and Harter 1987; Mattson and Smith 1993; Johnson and others 1995), principally among northern hardwoods. Differences among most results were usually in the extent or timing of the minimum in forest floor mass. Restoration of forest floor mass with regrowth was due partly to rapid recovery of litterfall, often to preharvest levels within a few years of harvest (Covington and Aber 1980; Schiffman and Johnson 1989; Alban and Perala 1990). Another explanation for the dynamics described by Covington (1981) is that differences among harvest methods over time have impacted sites differently and forest floor mass partly reflects this record (Yanai and others 2000).

### Decomposition

Decomposition, a controlling process for net accumulation of forest floor mass, is affected by quantity and quality of material (Schlesinger 1977; Hyvonen and others 1998). Quantity varies with forest productivity and season. Quality varies with the input material and depth in forest floor, with fresh litter subject to the most rapid decomposition and humus decomposing slowly. Additionally, favorable microenvironments are functions of temperature and moisture. Controls on decomposer activities — temperature, moisture, and tissue chemistry — are reflected in large-scale attributes such as region, annual temperature and precipitation, latitude, elevation, and species composition (Vogt and others 1986). The general observation that forests with lower mean annual temperatures and dominated by evergreen species tended to have greater accumulation of forest floor (Vogt and others 1995; Vogt and others 1996) is consistent with these broad controls. Thus, the same broad forest characteristics that covary with forest floor mass — region and type — also predict decomposition, as expected.

### Literature Bases for Structuring Estimates

Based on literature and the goals of our work, we choose to focus on region and latitude as climate analogs, and forest type (also affected by climate) as the principal predictors of forest floor mass. Forest age, in terms of years since afforestation or a major disturbance, is identified as the third general characteristic used in forming these estimates. The basic assumption about age effects is that greater changes occur in younger forests developing toward maturity than in the years between a mature state and old growth. "Mature" can be a difficult state to define, but it serves to organize the format of these basic estimates.

## Forest Floor Data from Literature

Our goal is to develop a transparent simulation model to estimate the forest floor carbon pool. The model is based on data derived from literature searches and a series of simplifying assumptions. We assume that relatively small-scale numerical relationships obtained from the literature can be applied to determine carbon for large areas. Estimates are based on averages of published values grouped according to forest and location. Relationships among average values are then applied to large areas defined by roughly similar forest composition, history, and regional characteristics.

### Conceptual Organization and Assumptions Based on Literature

Our base assumption is that mature forests, classified according to type and region, achieve an approximately steady state of forest floor carbon (Schlesinger 1977; Switzer and others 1979; Hough 1982; Waring and Schlesinger 1985; Lockaby and Taylor-Boyd 1986). While true steady states are unlikely, this is a necessary simplification. The changes in forest floor mass associated with a progression from mature forests to old growth — 40 to 60 years to hundreds of years — are likely to be much smaller than the accumulation during the first 20 to 60 years following regrowth after harvest. This assumption is most appropriate for large aggregate values (summed over thousands of hectares, for example), whereas individual stands are likely to exhibit greater temporal and spatial heterogeneity with respect to the dynamics of forest floor accumulation.

Our second assertion is that disturbances alter forest floor mass (Schlesinger 1977; Dyrness and others 1989; Johnson and others 1991; Alban and others 1994; Strong 1997; Rollinger and others 1998; Vose and others 1999). Any pattern of decrease or pulse increase in forest floor mass following a disturbance depends on the type and severity of the disturbance. Long-term effects depend on the specifics of the disturbance as well as time since the event. We also assume that over time the forest floor will return to the approximately steady state level of a mature forest.

Dynamics of forest regrowth following disturbance or with afforestation are assumed to affect the forest floor carbon pool. We assume that the early period of growth ends at a threshold age for maturity and the onset of the apparent steady state. This age may vary with forest type and region. We also assume that the forest floor reaches this approximately steady state sooner than soil carbon or annual increment of tree biomass. The same time-to-recovery is applied to afforestation, regrowth, and major disturbances (such as widespread crown fires). We assume afforestation is accompanied by a relatively rapid increase from little or no surface organic layers to the mature level of forest floor mass. Partial cutting may have the same pattern with a more rapid recovery time.

## Specific Value Needs

The structure of all estimates depends on assigning forest area to generally homogeneous groups according to region, forest type, and age. This is the minimum classification scheme for all values extracted from the literature. Classifications are applied to both inputs from forest sector projections and from empirical relationships identified in the literature. Published data are used to determine an average age and carbon content for a mature forest. Published discussions about forest floor maturity and an informal examination of the data were the bases for assigning mature ages.

The transition from age zero to the mature forest is a relatively rapid growth phase for forest floor carbon. Regrowth also includes decaying forest floor material that starts at age zero with the precut mature level of carbon. Decay rates are set according to forest floor mass mean residence times by forest type and region. The initial forest floor carbon in regenerated forests generally reaches zero by the time the forest floor has returned to the mature state. Though it was not our intent, the sum of the two modeled estimates — rapid increase and exponential decay — at the same age qualitatively reproduces the time course described by Covington (1981).

## Identifying Published Values

The search for existing data on forest floor mass included peer-reviewed journals, technical reports, and the Internet. Information varied considerably among publications. A few directly addressed mechanisms of control on forest floor accumulation. However, the forest floor mass data were peripheral to the main purpose of most of these publications. The minimum data requirements were some description of the forest and a measure of forest floor mass.

We made an effort to avoid duplicate observations. Research projects often use the same field site and much of the site data can be reported in more than one publication. Where a number of forest floor values were reported for a single site within a publication, we pooled the values to a single observation. Separate sites in the same forest were counted as separate observations. Thus, publications with a number of values were sometimes used as a few points and sometimes included as a single mean, depending on our interpretation of the data. We made no effort to adjust for possible bias in location of experimental versus actual forest distribution within a forest-type by region classification. Similarly, seasonal influences on forest floor mass can vary, but we did not sort observations accordingly.

The values obtained from publications were as follows: a description of forest type; mass per unit area; mass identified as carbon, organic matter (ash free weight), or dry weight; values for converting organic matter or dry weight to carbon; stand age or time since significant disturbance; site history in terms of management or disturbances; location, including latitude, longitude, and elevation; and a measure of decomposition or mean residence time of forest floor material. Some discussion of forest floor definition and measurement was noted. Additional information, such as more precise species composition, stand density, site productivity, other carbon or biomass pools, or additional site history, was occasionally included in publications.

Our definition of forest floor does not include down coarse woody debris and mineral soil but these might have been included in some observations. Published values overestimate forest floor if larger woody material was considered part of forest floor without being mentioned in the method of collecting forest floor material. Similarly, other estimates will understate forest floor if they exclude all fine woody material from reported values. The same uncertainties exist for the distinction between forest floor and the upper layer of mineral soil. Thus, precise definitions for forest floor were ostensibly primary considerations in extracting data from the literature survey. Most reports provided little information on distinctions among coarse woody debris, forest floor, and the mineral soil pools. For these, we simply relied on the individual researcher's experience for the vast majority of observations. Where possible, we excluded woody material greater than 7.5 cm in diameter, because this was defined as coarse woody debris.

## Forest-type and Region Classification

These estimates are based on region and forest-type classifications shown in Figure 1 and Table 1, respectively. General forest types were formed on the limited number of observations available. For example, a single pine type was formed for the South. Additional subdivision of types is possible in the future. Forest types not explicitly included were not represented in our dataset. Setting a minimum age for a mature forest floor was a somewhat subjective process. Ages were assigned after considering

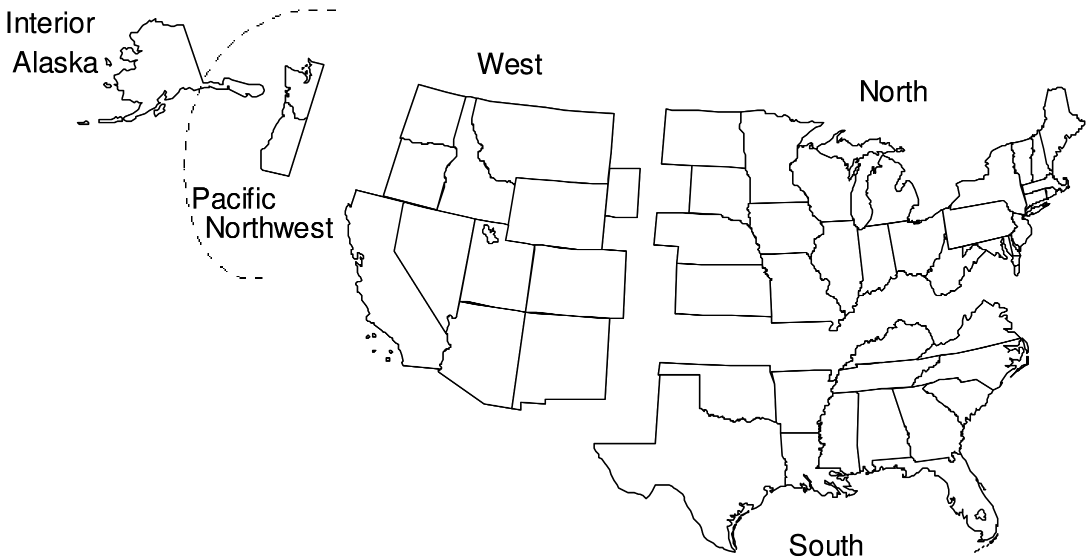


Figure 1.—Regions used to classify forest types. Note that Alaska is not drawn to scale.

reports in the literature and forest ages in growth and yield models.

Northern forest floors were defined as mature when the overstory age was 50 years. Conifers were divided into two groups, pine and other conifer, which were mainly spruce, fir, and hemlock. Aspen-birch and maple-beech-birch formed two distinct groups with a large number of observations in each. Other hardwoods were lumped as a single group that included mostly oaks and some oak-hickory forests as well as miscellaneous hardwoods. A sixth type was mixed conifer-hardwood.

Southern forest floors were defined as mature at overstory age 30 years. Pine was the only conifer classification possible from the dataset. All southern hardwoods were pooled to a single group, which was mostly oak-hickory. Very few bottomland hardwoods were included. A fourth type was mixed conifer-hardwood. The large areas of pine and the likely different effects of management make southern pines a candidate for future subdivision of forest types according to origin or productivity.

Pacific Northwest forest floors were defined as mature when overstory age was 40 years. The west side of the Pacific Northwest — the states of Oregon and Washington west of the Cascade Mountains — has a very different climate than the remainder of the Western United States. It is the only distinct subregion we established for the West. Conifers were divided into two types according to elevation. Higher elevation species were fir and hemlock. Lower elevation and coastal sites were principally Douglas-fir, Western hemlock, and Sitka spruce. All hardwoods were grouped as one type.

The remainder of the West was considered one large region and included the Rocky Mountains, the Intermountain/Great Basin, and California. The age for mature forest floors was set at an overstory age of 80 years. The principal division in the West was between most conifers as pine or mixed conifer groups. Large areas of woodlands in the West including pinyon-juniper were maintained as a separate group due to size of area, however few values were identified. Hardwoods and redwoods/giant sequoia were two additional classifications.

We found some data for Alaska forests. However, too few reports were available for usefully classifying forests by age or type. Thus we do not develop equations for estimating forest floor carbon, but we did summarize values for interior Alaska (Table 1). We assume characteristics of forest floors of southeastern Alaska are more similar to those of the Pacific Northwest than of interior Alaska (Figure 1).

## Model-Based Estimates of Forest Floor Carbon

Most published values for forest floor mass were reported in dry weight. About 20 percent of the values were reported as carbon mass per unit area, with another 20 percent reporting in terms of organic matter (that is, ash-free weight). We converted all values to megagram carbon per hectare based on ratios identified in the dataset, which were consistent with other reported values (Perala and Alban 1982b; Vitousek and others 1982; Huntington and others 1989; Cromack and others 1999; Vose and others 1999). Organic matter was converted to carbon by

**Table 1.—Mean forest floor carbon by region and forest type for forests identified as mature.**

| Region and forest type | Carbon (Mg/ha) | Standard deviation (Mg/ha) | Sample size | Minimum (Mg/ha) | Maximum (Mg/ha) |
|---|---|---|---|---|---|
| North | | | | | |
| pine | 13.8 | 4.6 | 13 | 5.4 | 19.8 |
| spruce, fir, hemlock | 33.7 | 23.2 | 6 | 4.6 | 68.1 |
| mixed conifer-hardwood | 29.7 | 26.6 | 5 | 5.4 | 75.0 |
| aspen-birch | 10.2 | 6.2 | 13 | 2.3 | 20.9 |
| maple-beech-birch | 27.7 | 17.8 | 28 | 2.8 | 89.5 |
| mixed hardwood, oak | 8.2 | 7.3 | 33 | 2.8 | 34.1 |
| South | | | | | |
| pine | 12.2 | 4.6 | 28 | 1.4 | 21.9 |
| mixed conifer-hardwood | 10.3 | 3.6 | 6 | 6.7 | 16.8 |
| mixed hardwood, oak-hickory | 6.0 | 5.7 | 20 | 0.8 | 24.8 |
| Pacific Northwest | | | | | |
| Douglas-fir, western hemlock | 27.5 | 31.3 | 69 | 2.6 | 165.6 |
| fir-hemlock, higher elevation | 29.5 | 16.3 | 7 | 16.8 | 55.3 |
| hardwood | 9.3 | 7.6 | 4 | 0.9 | 16.9 |
| West | | | | | |
| pine | 24.1 | 12.2 | 29 | 3.3 | 46.0 |
| redwood, sequoia | 62.2 | 31.3 | 3 | 35.9 | 96.9 |
| pinyon, juniper | 21.1 | 1.6 | 2 | 20.0 | 22.2 |
| mixed conifer | 37.2 | 11.5 | 24 | 23.3 | 73.9 |
| hardwood | 31.7 | 14.1 | 11 | 4.7 | 51.1 |
| Interior Alaska[a] | | | | | |
| all mature | 32.2 | 19.1 | 13 | 14.2 | 73.3 |

[a]Data for interior Alaska were few and showed no age effect; therefore, values represent all observations, not a subset determined by age.

multiplying by 0.55. Mass of carbon per unit dry mass is likely to vary by region, forest type and layer or state of decomposition. Specific carbon contents reported in our dataset did show distinct layer effects. However, there were too few sites that included separate layers to calculate averages on this basis. The layers were pooled for average forest floor values of the subset of the data that included specific carbon content. No general trends emerged among regional averages or between conifers and hardwoods (Table 2). We multiplied dry weight by 0.37, a ratio obtained from our dataset, to estimate forest floor carbon.

Mean forest floor carbon for mature forests is shown in Table 1. Standard deviation, sample size, minimum and maximum values also are presented to show availability and variability in the data. The mature values represent the averages where age was greater than 90 percent of the minimum age set for mature forest floors or sites where the researchers described the stand as mature. The ratio of forest floor mass to mass of annual input to the forest floor, or mean residence time as described above, is provided in Table 3. The classification system and mean values for forest floor carbon mass generally are consistent with those reported by Birdsey (1992, 1996).

## Latitude or Elevation Effects

Many published values included site-specific information such as latitude and elevation. The expected association with accumulation of forest floor made these variables candidates for an additional level of classification. This information was included with about one-third of the observations identified as mature forest floors. Other reports included enough information about location that allowed us to estimate latitude. If the local topography was relatively flat, we also estimated elevation. Preliminary regression analyses found that neither latitude nor elevation was a useful predictor of forest floor carbon with the set of values we had obtained. Thus, latitude and elevation were not included in our model. Latitude and elevation are, however, included in the appendix of

**Table 2.—Summary of specific carbon content of entire forest floor, all layers grouped together. Values are sorted according to general type or region and were taken from observations extracted from literature (see Table A1).**

| Forest type or region | Ratio of carbon mass to total dry mass | | |
|---|---|---|---|
| | Mean | Standard deviation | Sample size |
| All values | 0.370 | 0.0601 | 59 |
| conifer | 0.365 | 0.0525 | 27 |
| hardwood | 0.361 | 0.0603 | 22 |
| mixed | 0.402 | 0.0737 | 10 |
| North | 0.376 | 0.0490 | 26 |
| South | 0.368 | 0.0834 | 14 |
| Pacific Northwest | 0.355 | 0.0618 | 13 |
| West | 0.379 | 0.0427 | 6 |

**Table 3.—Mean residence time in years (forest floor mass divided by annual biomass input) for entire forest floor. Values reported as carbon, organic matter, or dry weight were pooled for these averages. Values are sorted according to general type or region and were taken from observations extracted from literature (see Table A1).**

| Region and forest type | Mean residence time | Standard deviation | Sample size | Minimum | Maximum |
|---|---|---|---|---|---|
| | (years) | | | (years) | |
| North | | | | | |
| conifer | 8.4 | 6.02 | 18 | 3.2 | 29.1 |
| hardwood | 9.2 | 9.49 | 26 | 1.1 | 35.8 |
| South | | | | | |
| conifer | 3.8 | 3.15 | 19 | 0.9 | 13.7 |
| hardwood | 3.2 | 1.92 | 16 | 0.4 | 6.3 |
| Pacific Northwest | | | | | |
| conifer | 16.0 | 17.44 | 59 | 0.9 | 80.0 |
| hardwood | 3.4 | 0.55 | 4 | 2.9 | 4.2 |
| West | | | | | |
| conifer | 24.1 | 16.04 | 22 | 8.7 | 60.0 |
| hardwood | 19.8 | 11.95 | 2 | 11.4 | 28.3 |
| Alaska | | | | | |
| conifer | 433.0 | 201.0 | 3 | 220.0 | 620.0 |
| hardwood | 24.5 | 5.46 | 5 | 19.7 | 33.2 |

**Table 4.—Coefficients to define modeled relationship between forest age and forest floor carbon mass (Mg/ha) for each combination of forest type by region. Columns A and B define net accumulation with age, and C and D describe the decay curve. Regrowth is the sum of accumulation and decay.**

| Forest type | Accumulation: $\frac{A \times age}{B + age}$ | | Decay: $C \times e^{-\left(\frac{age}{D}\right)}$ | |
|---|---|---|---|---|
| | A | B | C[a] | D[a] |
| North | | | | |
| pine | 19.1 | 25.6 | 13.8 | 8.4 |
| spruce, fir, hemlock | 62.9 | 57.8 | 33.7 | 8.4 |
| mixed conifer-hardwood | 65.0 | 79.5 | 29.7 | 8.4 |
| aspen-birch | 18.4 | 53.7 | 10.2 | 9.2 |
| maple-beech-birch | 50.4 | 54.7 | 27.7 | 9.2 |
| mixed hardwood, oak | 24.9 | 134.2 | 8.2 | 9.2 |
| South | | | | |
| pine | 20.4 | 27.1 | 12.2 | 3.8 |
| mixed conifer-hardwood | 15.4 | 20.1 | 10.3 | 3.8 |
| mixed hardwood, oak-hickory | 15.3 | 61.8 | 6.0 | 3.2 |
| Pacific Northwest | | | | |
| Douglas-fir, Western Hemlock | 87.5 | 116.7 | 27.5 | 16.0 |
| fir-hemlock, higher elevation | 53.9 | 44.3 | 29.5 | 16.0 |
| hardwood | 16.5 | 41.1 | 9.3 | 3.4 |
| West | | | | |
| pine | 43.9 | 87.3 | 24.1 | 24.1 |
| redwood, sequoia | 92.6 | 52.1 | 62.2 | 24.1 |
| pinyon, juniper | | | 21.1 | |
| mixed conifer | 53.6 | 47.0 | 37.2 | 24.1 |
| hardwood | 50.1 | 62.0 | 31.7 | 19.8 |

[a]Values in Columns C and D are from Tables 1 and 3, respectively.

observations because of their expected usefulness in simulation modeling.

## Simulation Based on Stand Age

Our model is in two parts: net accumulation and decay. Net accumulation of forest floor carbon mass with increasing age is represented as a simple model construct. Basic conditions for the model are that it passes through the origin, represents continuous net accumulation with age, and rate of accumulation decreases so that the line approaches an asymptote. We model net accumulation of forest floor carbon mass according to the following relationship:

$$\text{Forest floor carbon (Mg/ha)} = \frac{A \times age}{B + age}$$

Age is stand age in years, and A and B are coefficients describing the line relating age and forest floor carbon mass. This relationship conforms to our conceptual model. The coefficients are assigned according to the basic assumptions discussed above. We assume minimum ages represent mature forest floors and that means of published values are representative of mature forests. We set the upper limit for the model at the 95$^{th}$ percentile of values for forest floor carbon mass. This is the value assigned to coefficient A. Since average carbon mass for mature forest floor represents all ages, we expect the line to pass below the ordered pair for mature forests: (minimum age, mean carbon mass). Preliminary regression analysis for northern hardwoods and southern pines (where many values were available) identified the mean carbon mass at a point approximately 30 percent greater than the assigned minimum age. Therefore, we model the relationship as passing through the ordered pair (minimum age × 1.33, mean carbon mass). Values for coefficients A and B are provided in Table 4.

The model for the decay line is based on the average forest floor of mature forests and regional averages for apparent decay rates. Forest floor carbon mass following clearcutting is assumed to begin at the mature forest floor level of carbon. Decay of forest floor mass existing prior to the clearcut is described as an exponential function of years and mean residence time:

$$\text{Residual forest floor carbon (Mg/ha)} = C \times e^{-\left(\frac{\text{age}}{D}\right)}$$

Coefficient C is average mature forest floor carbon mass from Table 1, coefficient D is the mean residence time from Table 3, and e is the exponential function. Values for coefficients C and D are provided in Table 4.

Total carbon mass during regrowth is the sum of estimates from the two models — accumulation and decay — defined in Table 4. Examples of simulated accumulation, decay, and totals are shown in Figure 2.

### Application of Estimators

Summaries in Tables 1 and 4 provide estimates of forest floor carbon mass per unit area for region by forest type definitions without and with the added influence of age, respectively. Many, but not all, forest inventory summaries provide age or disturbance history. However, total area is common to all forest inventory data and is an essential part of carbon budgets. Estimates presented here complement area and age information. The total carbon pool is the sum across all ages and areas.

Forest types defined for Tables 1 through 4 are based on data available in the literature. Determining estimators for all forest types entails establishing a reasonably close match of types when necessary. For example, northern maple-beech-birch values were combined with mean residence times for northern hardwoods to estimate forest floor response to regrowth. Similarly, the summaries in Tables 1 and 4 must be linked to forest inventory types to estimate total carbon pool sizes.

## Forest Floor Carbon Pool of the United States

Total carbon estimates were based on forest inventory data (Smith and others 2001). The database is a compilation of extensive forest inventory data for the United States. We applied the model summarized in Table 4 to the 1997 forest inventory database. The resulting estimate of forest floor carbon mass density (megagram per hectare), averaged over all forest types

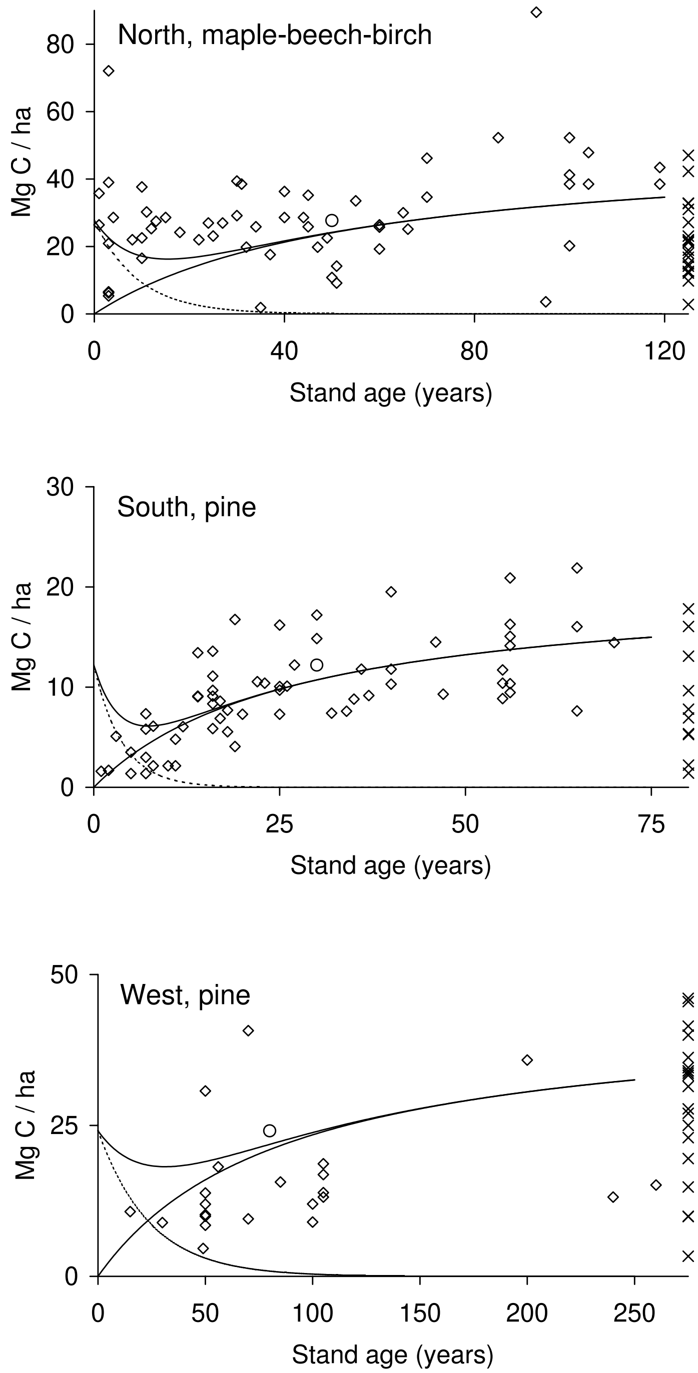


Figure 2.—Examples of forest floor carbon estimated as a function of stand age for three forest types. Diamonds represent observations with age, and x's represent observations not linked to a specific forest age but identified simply as mature. The lower solid line represents estimated forest floor carbon with afforestation. The dashed line is an estimated path of decay following clearcut harvesting. The upper solid line represents net accumulation during regrowth and is the sum of afforestation and decay lines. The open circle represents the average mature forest floor value from Table 1.

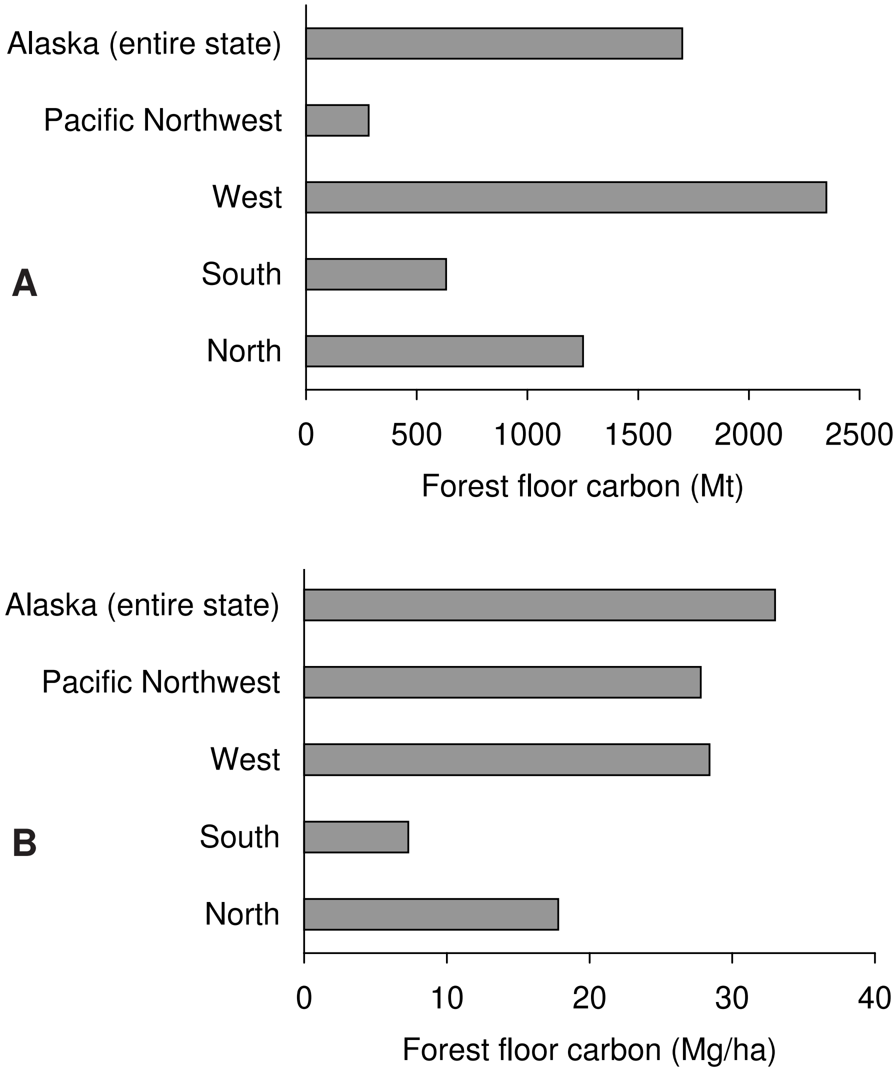


Figure 3.—Total (A) and average forest floor carbon per hectare (B) by region of the U.S., 1997.

per region and totals, are shown in Figure 3. Approximately 4.5 Gt carbon is stored in the forest floor carbon pool in the 48 contiguous United States.

Forest floor carbon data should become increasingly available from the annualized USDA Forest Service Forest Inventory & Analysis Program. Assembling a database that can be readily reclassified and resorted is a quick and simple approach to developing empirical estimates of forest floor carbon, which can be easily updated and revised. This accomplished the goal of tractable and transparent carbon estimates for U.S. forests, which focuses on actual rather than potential vegetation. Estimates are not restricted to any single form. The results provide flexible, transparent forest floor carbon estimators for U.S. forests.

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# Appendix

**Table A1.—Forest floor carbon mass values obtained from literature.**

Column headings:

- R — Regions used for summarizing values (see Figure 1)
- C — Carbon mass used for each observation, Mg C per hectare
- ff — Form of forest floor mass for each observation: c, as carbon; o, as ash-free organic matter converted to carbon by multiplying by 0.55; and d, as dry weight converted to carbon by multiplying by 0.37
- T — Forest type assigned for use in our analysis (see Tables A2, 1, and 4)
- D — Summary of forest composition from publication
- L — State, province, or region (LS=Lake States, IM=Intermountain)
- A — Years since major disturbance, or: m if information suggested mature; y, if information suggested not yet mature; and blank indicates that information was not provided but these were assumed to be mature
- La — Latitude, degrees north
- Lo — Longitude, degrees west
- E — Elevation (km)
- c:dw — Ratio of forest floor carbon mass to dry weight, if given
- mrt — Mean residence time of forest floor, in years (forest floor biomass divided by annual biomass input)
- rf — Form of biomass in mrt, if reported: c, as carbon; o, as ash-free organic matter; and d, as dry weight
- cite — Citation

| R | C | ff | T | D | L | A[a] | La[a] | Lo[a] | E[a] | c:dw | mrt | rf | cite[b] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (Mg/ha) | | | | | (years) | | | (km) | | (years) | | |
| N | | | p | jack pine | LS | | | | | 0.35 | | | 99 |
| N | | | p | red pine | LS | | | | | 0.35 | | | 99 |
| N | 4.5 | d | p | jack pine | MN | | 47 | | 0.4 | | 5.7 | | 138 |
| N | 9.6 | d | p | jack pine | MN | | 47 | | 0.4 | | 12.5 | | 138 |
| N | 8.9 | d | p | jack pine | MN | | 47 | | 0.4 | | 11.9 | | 138 |
| N | 11.5 | d | p | pine | MN | | 47 | | 0.4 | | 13.6 | | 138 |
| N | 7.7 | d | p | white pine | MN | | 47 | | 0.4 | | 10.4 | | 138 |
| N | 15.4 | d | p | pine | MA | 53 | 42 | | 0.4 | | 7.8 | | 139 |
| N | 14.4 | o | p | red pine plantation | MN | 90 | | | | | | | 2 |
| N | 16.5 | o | p | red pine | MN | m | 47 | 95 | 0.4 | | | | 5 |
| N | 18.2 | o | p | jack pine | MN | m | 47 | 95 | 0.4 | | | | 5 |
| N | 11.4 | o | p | red pine plantation | WI | 37 | 44 | 90 | 0.4 | | | | 18 |
| N | 10.1 | o | p | red pine plantation | WI | 37 | 44 | 90 | 0.4 | | | | 18 |
| N | 9.7 | d | p | jack pine plantation | LS | 15-43 | | | | | | | 22 |
| N | 13.6 | d | p | red pine plantation | LS | 21-180 | | | | | | | 22 |
| N | 13.0 | d | p | jack pine | MN | m | 48 | 92 | 0.5 | | | | 45 |
| N | 18.6 | d | p | jack pine | MN | m | 48 | 92 | 0.5 | | | | 45 |
| N | 16.0 | c | p | jack pine | LS | | | | | | | | 50 |
| N | 14.0 | c | p | red pine | LS | | | | | | | | 50 |
| N | 13.1 | d | p | jack pine | North | 83 | | | | | | | 83, v |
| N | 16.0 | o | p | white pine | MA | 34-96 | 42 | 72 | 0.1 | | | | 85 |
| N | 5.5 | o | p | white pine | WI | m | 43 | 40 | 0.3 | | 3.2 | o | 90 |
| N | 16.9 | c | p | jack pine | MN | 39 | 47 | 95 | 0.4 | | 5.8 | c | 104 |
| N | 13.5 | c | p | jack pine | MN | 41 | 47 | 95 | 0.4 | | 5.5 | c | 104 |
| N | 15.8 | c | p | red pine | MN | 39 | 47 | 95 | 0.4 | | 4.7 | c | 104 |
| N | 14.9 | c | p | red pine | MN | 41 | 47 | 95 | 0.4 | | 5.2 | c | 104 |
| N | 22.9 | c | p | red pine plantation | LS | | | | | | | | 105, 112 |
| N | 12.1 | c | p | pine plantation | IL | | | | | | | | 111, 114 |

**Continued**

**Table A1.—Continued**

| R | C | ff | T | D | L | A[a] | La[a] | Lo[a] | E[a] | c:dw | mrt | rf | cite[b] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (Mg/ha) | | | | | (years) | | | (km) | | (years) | | |
| N | 5.4 | d | p | red pine | MN | m | 47 | 93 | 0.4 | | 4.1 | d | 126 |
| N | 19.8 | c | p | red pine plantation | MA | 55 | 43 | 72 | 0.4 | 0.32 | 8.5 | d | 136 |
| N | 7.6 | c | p | shortleaf pine plantation | IN | 33 | 39 | 86 | 0.2 | 0.44 | 3.5 | d | 136 |
| N | | | sf | balsam fir | LS | | | | | 0.36 | | | 99 |
| N | 18.2 | o | sf | spruce | MN | m | 47 | 95 | 0.4 | | | | 5 |
| N | 21.1 | d | sf | hemlock | MI, WI | m | 46 | 89 | 0.5 | | | | 17 |
| N | 35.5 | d | sf | spruce - fir | North | 8 | | | | | | | 28, v |
| N | 35.5 | d | sf | spruce - fir | North | 8 | | | | | | | 28, v |
| N | 45.9 | d | sf | spruce - fir | North | 8 | | | | | | | 28, v |
| N | 42.2 | d | sf | spruce - fir | North | 8 | | | | | | | 28, v |
| N | 41.3 | c | sf | hemlock | CT | | 42 | 73 | 0.4 | | | | 38 |
| N | 23.0 | c | sf | balsam fir | LS | | | | | | | | 50 |
| N | 68.1 | o | sf | eastern hemlock | MI | m | 46 | 89 | 0.5 | | | | 57 |
| N | 43.0 | c | sf | balsam fir | NH | m | 44 | 72 | 1.3 | 0.38 | | | 76 |
| N | 4.6 | o | sf | hemlock | WI | m | 43 | 40 | 0.3 | | 6.5 | o | 90 |
| N | 17.6 | c | sf | spruce | MN | 39 | 47 | 95 | 0.4 | | 7 | c | 104 |
| N | 14.1 | c | sf | spruce | MN | 41 | 47 | 95 | 0.4 | | 5.8 | c | 104 |
| N | 46.5 | o | sf | fir | NH | | 44 | 72 | 1.4 | | | | 108 |
| N | 54.3 | o | sf | fir | NH | | 44 | 72 | 1.4 | | | | 108 |
| N | 54.5 | o | sf | fir | NH | | 44 | 72 | 1.4 | | | | 108 |
| N | 64.4 | o | sf | fir | NH | | 44 | 72 | 1.4 | | | | 108 |
| N | 66.6 | o | sf | fir | NH | | 44 | 72 | 1.4 | | | | 108 |
| N | 45.5 | o | sf | spruce fir | NH | | 44 | 72 | 1.0 | | | | 108 |
| N | 47.0 | c | sf | balsam fir | NH | 75 | 44 | 72 | 1.2 | 0.4 | 29.1 | d | 136 |
| N | 5.4 | d | mx | mixed, oak-pine | RI | m | 42 | 72 | 0.1 | | | | 20 |
| N | 7.3 | o | mx | mixed | WI | | | | | | | | 35 |
| N | 18.4 | o | mx | conifer - hardwood | ON | m | 45 | 77 | 0.2 | | | | 56 |
| N | 22.1 | o | mx | conifer - hardwood | ON | 3 | 45 | 77 | 0.2 | | | | 56 |
| N | 18.0 | o | mx | conifer - hardwood | ON | 3 | 45 | 77 | 0.2 | | | | 56 |
| N | 75.0 | c | mx | hemlock - hardwood | MI | m | 46 | 87 | 0.3 | 0.39 | | | 79 |
| N | 25.0 | c | mx | aspen, jack pine | North | m | | | | | | | 112 |
| N | 24.4 | c | mx | oak - pine | MA | 65 | 42 | 70 | 0.0 | 0.42 | 13.8 | d | 136 |
| N | | | ab | aspen | LS | | | | | 0.32 | | | 99 |
| N | 2.3 | d | ab | paper birch | MN | | 45 | | 0.4 | | 2.3 | | 138 |
| N | 14.9 | o | ab | aspen | MN | m | 47 | 95 | 0.4 | | | | 5 |
| N | 20.9 | d | ab | aspen | MI | 47 | 47 | 89 | 0.5 | | | | 4 |
| N | 7.0 | d | ab | aspen | MN | 60 | 47 | 93 | 0.4 | | | | 4 |
| N | 16.8 | d | ab | aspen | MN | 66 | 47 | 95 | 0.4 | | | | 4 |
| N | 16.6 | c | ab | aspen | MN | 70 | 48 | 94 | 0.4 | | | | 3 |
| N | 13.4 | c | ab | aspen | MN | 70 | 48 | 94 | 0.4 | | | | 3 |
| N | 10.7 | d | ab | aspen - birch | North | | | | | | | | 8, 20 |
| N | 15.0 | c | ab | aspen | LS | | | | | | | | 50 |
| N | 11.8 | d | ab | aspen | North | 81 | | | | | | | 83, v |
| N | 2.9 | o | ab | aspen | WI | m | 43 | 40 | 0.3 | | 1.6 | o | 90 |
| N | 3.1 | d | ab | aspen | WI | m | 46 | 90 | 0.5 | | 1.8 | d | 102 |
| N | 13.5 | c | ab | aspen | MN | 40 | 47 | 95 | 0.4 | | 6.7 | c | 104 |
| N | 11.6 | c | ab | aspen | MN | 49 | 47 | 95 | 0.4 | | 6.1 | c | 104 |
| N | 5.7 | d | ab | trembling aspen | WI | 8 | 45 | 90 | 0.4 | | | | 113 |
| N | 6.3 | d | ab | trembling aspen | WI | 14 | 45 | 90 | 0.4 | | | | 113 |

**Continued**

**Table A1.—Continued**

| R | C | ff | T | D | L | A[a] | La[a] | Lo[a] | E[a] | c:dw | mrt | rf | cite[b] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (Mg/ha) | | | | | (years) | | | (km) | | (years) | | |
| N | 2.7 | d | ab | trembling aspen | WI | 18 | 45 | 90 | 0.4 | | | | 113 |
| N | 6.3 | d | ab | trembling aspen | WI | 32 | 45 | 90 | 0.4 | | | | 113 |
| N | 2.9 | d | ab | trembling aspen | WI | 63 | 45 | 90 | 0.4 | | | | 113 |
| N | 8.6 | d | ab | birch-aspen | MI | m | 48 | 89 | 0.2 | | | | 122 |
| N | 2.3 | d | ab | birch | MN | m | 47 | 93 | 0.4 | | 2 | d | 126 |
| N | | | mb | sugar maple | LS | | | | | 0.29 | | | 99 |
| N | 1.9 | d | mb | maple | WI | 35 | 43 | | 0.3 | | 1.8 | | 139 |
| N | 9.8 | d | mb | sugar maple | MI, WI | | 46 | 89 | | | | | 6, v |
| N | 10.8 | d | mb | sugar maple | MI, WI | 50 | 46 | 89 | | | | | 6, v |
| N | 18.9 | d | mb | northern hardwood | MI, WI | m | 46 | 89 | 0.5 | | | | 17 |
| N | 26.4 | o | mb | maple - beech - birch | NH | 60 | 44 | | 0.6 | | 8.2 | o | 25 |
| N | 35.8 | o | mb | maple - beech - birch | NH | 1 | 44 | 71 | 0.7 | | | | 36 |
| N | 28.6 | o | mb | maple - beech - birch | NH | 4 | 44 | 71 | 0.7 | | | | 36 |
| N | 22.6 | o | mb | maple - beech - birch | NH | 10 | 44 | 71 | 0.7 | | | | 36 |
| N | 27.5 | o | mb | maple - beech - birch | NH | 13 | 44 | 71 | 0.7 | | | | 36 |
| N | 27.0 | o | mb | maple - beech - birch | NH | 24 | 44 | 71 | 0.7 | | | | 36 |
| N | 38.5 | o | mb | maple - beech - birch | NH | 31 | 44 | 71 | 0.7 | | | | 36 |
| N | 25.9 | o | mb | maple - beech - birch | NH | 34 | 44 | 71 | 0.7 | | | | 36 |
| N | 36.3 | o | mb | maple - beech - birch | NH | 40 | 44 | 71 | 0.7 | | | | 36 |
| N | 28.6 | o | mb | maple - beech - birch | NH | 44 | 44 | 71 | 0.7 | | | | 36 |
| N | 46.2 | o | mb | maple - beech - birch | NH | 70 | 44 | 71 | 0.7 | | | | 36 |
| N | 38.5 | o | mb | maple - beech - birch | NH | 100 | 44 | 71 | 0.7 | | | | 36 |
| N | 41.3 | o | mb | maple - beech - birch | NH | 100 | 44 | 71 | 0.7 | | | | 36 |
| N | 52.3 | o | mb | maple - beech - birch | NH | 100 | 44 | 71 | 0.7 | | | | 36 |
| N | 23.1 | c | mb | beech | CT | | 42 | 73 | 0.4 | | | | 38 |
| N | 21.2 | c | mb | red maple | CT | | 42 | 73 | 0.4 | | | | 38 |
| N | 12.1 | c | mb | sugar maple | CT | | 42 | 73 | 0.4 | 0.38 | | | 38 |
| N | 25.7 | o | mb | northern hardwood | NH | 60 | 44 | 72 | 0.7 | | 8.2 | o | 43 |
| N | 18.0 | c | mb | sugar maple, hardwood | LS | | | | | | | | 50 |
| N | 47.0 | o | mb | maple - beech - birch | MI | m | 46 | 89 | 0.5 | | | | 57 |
| N | 30.0 | c | mb | maple - beech - birch | NH | 65 | 44 | 72 | 0.6 | 0.34 | | | 61 |
| N | 31.0 | c | mb | northern hardwood | NH | m | 44 | 72 | 0.6 | | | | 62 |
| N | 39.0 | c | mb | northern hardwood | NH | 3 | 44 | 72 | 0.6 | | | | 62 |
| N | 22.0 | c | mb | northern hardwood | NH | 8 | 44 | 72 | 0.6 | | | | 62 |
| N | 22.0 | c | mb | northern hardwood | MI | m | 46 | 87 | 0.3 | 0.29 | | | 79 |
| N | 10.8 | o | mb | northern hardwood | LS | y | | | | | | | 86 |
| N | 12.6 | o | mb | northern hardwood | LS | m | | | | | | | 86 |
| N | 14.2 | o | mb | northern hardwood | LS | m | | | | | | | 86 |
| N | 2.8 | o | mb | sugar maple | WI | m | 43 | 40 | 0.3 | | 1.3 | o | 90 |
| N | 14.9 | c | mb | maple - birch | ON | 225 | 47 | 84 | | | | | 96 |
| N | 20.2 | c | mb | maple - beech - birch | NY | 100 | 44 | 74 | | | | | 96 |
| N | 9.2 | d | mb | northern hardwood | MI | 51 | 47 | 89 | 0.3 | | | | 97 |
| N | 14.2 | d | mb | northern hardwood | MI | 51 | 47 | 89 | 0.3 | | | | 97 |
| N | 22.5 | d | mb | northern hardwood | MI | 49 | 47 | 89 | 0.3 | | | | 97 |
| N | 5.4 | d | mb | northern hardwood | MI | 3 | 47 | 89 | 0.3 | | | | 97 |
| N | 6.3 | d | mb | northern hardwood | MI | 3 | 47 | 89 | 0.3 | | | | 97 |
| N | 6.5 | d | mb | northern hardwood | MI | 3 | 47 | 89 | 0.3 | | | | 97 |
| N | 16.8 | c | mb | northern hardwood | LS | | | | | | | | 105, 112 |
| N | 118.3 | o | mb | northern hardwood | NH | | 44 | 72 | 0.7 | | | | 108 |

**Continued**

**Table A1.—Continued**

| R | C | ff | T | D | L | A[a] | La[a] | Lo[a] | E[a] | c:dw | mrt | rf | cite[b] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (Mg/ha) | | | | | (years) | | | (km) | | (years) | | |
| N | 42.3 | c | mb | maple - beech - birch | ME | >80 | 47 | 69 | 0.3 | 0.37 | 35.8 | c | 117 |
| N | 32.7 | c | mb | maple - beech - birch | ME | >80 | 45 | 68 | 0.1 | 0.44 | 28.7 | c | 117 |
| N | 32.8 | c | mb | maple - beech - birch | ME | >80 | 44 | 70 | 0.2 | 0.41 | 26.5 | c | 117 |
| N | 27.1 | c | mb | maple - beech - birch | ME | >80 | 44 | 69 | 0.2 | 0.34 | 19 | c | 117 |
| N | 89.5 | c | mb | northern hardwood | NH | 93 | 44 | 71 | 0.7 | 0.47 | | | 120 |
| N | 72.1 | c | mb | northern hardwood | NH | 3 | 44 | 71 | 0.7 | 0.4 | | | 120 |
| N | 37.6 | c | mb | northern hardwood | NH | 10 | 44 | 71 | 0.7 | 0.42 | | | 120 |
| N | 39.4 | c | mb | northern hardwood | NH | 30 | 44 | 71 | 0.7 | 0.33 | | | 120 |
| N | 3.6 | c | mb | maple | IN | 95 | 39 | 86 | 0.2 | 0.37 | 1.9 | d | 136 |
| N | 25.1 | c | mb | northern hardwood | NH | 66 | 44 | 72 | 0.7 | 0.43 | 12.3 | d | 136 |
| N | 21.6 | c | mb | maple - beech - birch | NH | m | 44 | 72 | 0.7 | | 8.4 | c | 144 |
| N | 12.4 | d | oh | oak - maple | MA | 80 | 42 | | 0.4 | | 7.6 | | 139 |
| N | 5.4 | d | oh | black oak | MO | 20 | 38 | 91 | 0.4 | | | | 27 |
| N | 7.4 | d | oh | black oak | MO | 40 | 38 | 91 | 0.4 | | | | 27 |
| N | 1.7 | d | oh | oak | WI | | 43 | | 0.3 | | 1.1 | | 29, 139 |
| N | 5.1 | o | oh | hardwood | WI | | | | | | | | 35 |
| N | 30.7 | c | oh | red oak | CT | | 42 | 73 | 0.4 | | | | 38 |
| N | 12.1 | c | oh | white ash | CT | | 42 | 73 | 0.4 | | | | 38 |
| N | 16.0 | c | oh | broad leaf deciduous | LS | | | | | | | | 50 |
| N | 9.2 | c | oh | oak | MN | 67 | 45 | 93 | 0.2 | | | | 58 |
| N | 6.5 | c | oh | oak | MN | 67 | 45 | 93 | 0.2 | | | | 58 |
| N | 4.7 | c | oh | oak | MN | 67 | 45 | 93 | 0.2 | | | | 58 |
| N | 7.3 | c | oh | oak | MN | 67 | 45 | 93 | 0.2 | | | | 58 |
| N | 7.0 | c | oh | oak | MN | 67 | 45 | 93 | 0.2 | | | | 58 |
| N | 7.5 | c | oh | oak | MN | 67 | 45 | 93 | 0.2 | | | | 58 |
| N | 4.4 | c | oh | oak | MN | 67 | 45 | 93 | 0.2 | | | | 58 |
| N | 8.5 | c | oh | upland deciduous | MN | y | 45 | 93 | 0.2 | | | | 64 |
| N | 4.8 | c | oh | upland deciduous | MN | y | 45 | 93 | 0.2 | | | | 64 |
| N | 8.4 | o | oh | mixed oak | NJ | 250 | 41 | | 0.0 | | 6.2 | o | 77 |
| N | 5.8 | d | oh | oak | MO | 40 | 38 | 91 | 0.4 | | | | 82 |
| N | 4.3 | d | oh | hardwood | WV | 1 | 40 | 80 | 0.6 | | | | 88 |
| N | 4.8 | d | oh | hardwood | WV | m | 40 | 80 | 0.6 | | | | 88 |
| N | 4.1 | d | oh | hardwood | WV | 2 | 40 | 80 | 0.6 | | | | 88 |
| N | 8.1 | d | oh | hardwood | WV | m | 40 | 80 | 0.6 | | | | 88 |
| N | 2.3 | d | oh | hardwood | WV | 2 | 40 | 80 | 0.6 | | | | 88 |
| N | 5.2 | d | oh | hardwood | WV | m | 40 | 80 | 0.6 | | | | 88 |
| N | 2.8 | d | oh | hardwood | WV | 4 | 40 | 80 | 0.6 | | | | 88 |
| N | 3.9 | d | oh | hardwood | WV | m | 40 | 80 | 0.6 | | | | 88 |
| N | 4.6 | d | oh | hardwood | WV | 4 | 40 | 80 | 0.6 | | | | 88 |
| N | 5.9 | d | oh | hardwood | WV | m | 40 | 80 | 0.6 | | | | 88 |
| N | 6.3 | d | oh | hardwood | WV | 6 | 40 | 80 | 0.6 | | | | 88 |
| N | 5.7 | d | oh | hardwood | WV | m | 40 | 80 | 0.6 | | | | 88 |
| N | 2.8 | d | oh | hardwood | WV | 7 | 40 | 80 | 0.6 | | | | 88 |
| N | 4.3 | d | oh | hardwood | WV | m | 40 | 80 | 0.6 | | | | 88 |
| N | 6.5 | d | oh | hardwood | WV | 7 | 40 | 80 | 0.6 | | | | 88 |
| N | 8.8 | d | oh | hardwood | WV | m | 40 | 80 | 0.6 | | | | 88 |
| N | 2.4 | d | oh | hardwood | WV | 8 | 40 | 80 | 0.6 | | | | 88 |
| N | 6.3 | d | oh | hardwood | WV | m | 40 | 80 | 0.6 | | | | 88 |
| N | 5.0 | d | oh | hardwood | WV | 11 | 40 | 80 | 0.6 | | | | 88 |

**Continued**

**Table A1.—Continued**

| R | C | ff | T | D | L | A[a] | La[a] | Lo[a] | E[a] | c:dw | mrt | rf | cite[b] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (Mg/ha) | | | | | (years) | | | (km) | | (years) | | |
| N | 7.6 | d | oh | hardwood | WV | m | 40 | 80 | 0.6 | | | | 88 |
| N | 2.9 | d | oh | hardwood | WV | 20 | 40 | 80 | 0.6 | | | | 88 |
| N | 8.3 | d | oh | hardwood | WV | m | 40 | 80 | 0.6 | | | | 88 |
| N | 2.3 | d | oh | hardwood | WV | 20 | 40 | 80 | 0.6 | | | | 88 |
| N | 3.5 | d | oh | hardwood | WV | m | 40 | 80 | 0.6 | | | | 88 |
| N | 5.6 | d | oh | hardwood | WV | 23 | 40 | 80 | 0.6 | | | | 88 |
| N | 4.0 | d | oh | hardwood | WV | m | 40 | 80 | 0.6 | | | | 88 |
| N | 3.8 | d | oh | hardwood | WV | 23 | 40 | 80 | 0.6 | | | | 88 |
| N | 7.8 | d | oh | hardwood | WV | m | 40 | 80 | 0.6 | | | | 88 |
| N | 5.3 | d | oh | hardwood | WV | 23 | 40 | 80 | 0.6 | | | | 88 |
| N | 9.1 | d | oh | hardwood | WV | m | 40 | 80 | 0.6 | | | | 88 |
| N | 3.0 | o | oh | white oak | WI | m | 43 | 40 | 0.3 | | 1.8 | o | 90 |
| N | 33.7 | o | oh | oak | MN | 50 | 45 | 93 | 0.2 | | 19 | o | 107 |
| N | 34.1 | o | oh | oak | MN | 50 | 45 | 93 | 0.2 | | 14.1 | o | 109, 77 |
| N | 2.8 | o | oh | oak - hickory | MO | 35-92 | 39 | | | | 1.6 | o | 110, 77 |
| N | 8.6 | c | oh | oak | IN | 81 | 39 | 86 | 0.2 | 0.44 | 2.9 | d | 136 |
| N | 19.0 | c | oh | oak - red maple | MA | 50 | 43 | 72 | 0.4 | 0.32 | 12.2 | d | 136 |
| N | 3.8 | d | oh | oak | North | 115-120 | | | | | | | 148, v |
| N | 3.6 | d | oh | oak | North | 115-120 | | | | | | | 148, v |
| N | 2.8 | d | oh | oak | North | 115-120 | | | | | | | 148, v |
| N | 6.9 | o | | conifer | WI | | | | | | | | 35 |
| N | 17.0 | c | | needle leaf evergreen | LS | | | | | | | | 50 |
| N | 10.9 | c | | upland conifer | MN | y | 45 | 93 | 0.2 | | | | 64 |
| N | 100.0 | c | | lowland conifer | MN | y | 45 | 93 | 0.2 | | | | 64 |
| N | 31.4 | c | | black spruce wetland | MI | m | 46 | 87 | 0.3 | | | | 92 |
| N | 8.9 | c | | black spruce wetland | MI | 5 | 46 | 87 | 0.3 | | | | 92 |
| N | 12.7 | c | | black spruce wetland | MI | 5 | 46 | 87 | 0.3 | | | | 92 |
| N | 503.3 | o | | cedar swamp | MN | 100 | 45 | 93 | 0.2 | | 265 | o | 107 |
| N | 172.2 | o | | krummholz spruce - fir | NH | | 44 | 72 | 1.4 | | | | 108 |
| N | 29.9 | o | | krummholz spruce - fir | NH | | 44 | 72 | 1.4 | | | | 108 |
| N | 47.9 | o | | krummholz spruce - fir | NH | | 44 | 72 | 1.4 | | | | 108 |
| N | 53.7 | o | | krummholz spruce - fir | NH | | 44 | 72 | 1.4 | | | | 108 |
| N | 104.0 | c | | lowland deciduous | MN | y | 45 | 93 | 0.2 | | | | 64 |
| S | 3.0 | d | p | pine | FL | 7 | | | | | 3.1 | | 139 |
| S | 12.2 | d | p | pine | FL | 27 | | | | | 6.5 | | 139 |
| S | 6.9 | d | p | loblolly pine | SC | | 34 | | 0.2 | | 3.7 | | 138 |
| S | 5.4 | d | p | loblolly pine | SC | | 34 | | 0.2 | | 3.4 | | 138 |
| S | 9.7 | d | p | shortleaf pine | SC | | 34 | | 0.2 | | 7.9 | | 138 |
| S | 15.1 | o | p | loblolly pine plantation | SC | 56 | 33 | 80 | 0.0 | | | | 10 |
| S | 10.3 | o | p | loblolly pine plantation | SC | 56 | 33 | 80 | 0.0 | | | | 10 |
| S | 9.5 | o | p | loblolly pine plantation | SC | 56 | 33 | 80 | 0.0 | | | | 10 |
| S | 16.3 | o | p | loblolly pine plantation | SC | 56 | | | | | | | 13 |
| S | 14.1 | o | p | loblolly pine plantation | SC | 56 | | | | | | | 13 |
| S | 20.9 | o | p | loblolly pine plantation | SC | 56 | 33 | 80 | 0.0 | | | | 14 |
| S | 1.4 | d | p | longleaf pine | South | m | 31 | 87 | 0.1 | | 1.9 | d | 21 |
| S | 14.9 | o | p | shortleaf pine | TN | 30 | 36 | | 0.3 | | 6.5 | o | 25 |
| S | 17.2 | d | p | pine | TN | 30 | 36 | | 0.3 | | 13.7 | | 29, 139 |
| S | 5.3 | d | p | white pine | NC | | 35 | | 0.8 | | 3.9 | | 29, 139 |

**Continued**

**Table A1.—Continued**

| R | C | ff | T | D | L | A[a] | La[a] | Lo[a] | E[a] | c:dw | mrt | rf | cite[b] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (Mg/ha) | | | | | (years) | | | (km) | | (years) | | |
| S | 7.8 | c | p | loblolly pine | TN | m | 36 | 84 | 0.2 | 0.29 | | | 41 |
| S | 16.1 | o | p | pitch - Virginia pine | South | | | | | | | | 51, v |
| S | 13.1 | o | p | pitch - Virginia pine | South | | | | | | | | 51, v |
| S | 17.8 | o | p | pitch - Virginia pine | South | | | | | | | | 51, v |
| S | 10.1 | o | p | slash pine plantation | FL | 25 | | | | | | | 52 |
| S | 2.2 | d | p | loblolly pine | NC | | 35 | | 0.1 | | 1.2 | | 53, 138 |
| S | 9.2 | c | p | slash - loblolly pine | South | 37 | | | | | | | 60 |
| S | 9.7 | o | p | slash pine plantation | FL | 16 | 31 | 82 | 0.0 | | | | 65 |
| S | 16.8 | c | p | loblolly pine | NC | 19 | 36 | 79 | 0.2 | | 4.3 | c | 66 |
| S | 19.5 | c | p | loblolly pine | NC | 40 | 36 | 79 | 0.2 | | 5.1 | c | 66 |
| S | 9.0 | c | p | loblolly pine plantation | NC | 14 | 36 | | 0.1 | | 3 | | 69 |
| S | 13.4 | d | p | loblolly pine plantation | SC | 14 | | | | | | | 74 |
| S | 7.3 | d | p | loblolly pine | South | 7 | | | | | | | 75, v |
| S | 5.8 | d | p | loblolly pine | South | 7 | | | | | | | 75, v |
| S | 4.1 | d | p | loblolly pine plantation | LA | 19 | 32 | 92 | 0.1 | | 1.7 | d | 81 |
| S | 14.4 | o | p | loblolly pine | SC | 70 | 33 | 80 | 0.0 | | | | 91 |
| S | 7.6 | o | p | longleaf pine | AL | 65 | 31 | 87 | 0.1 | | | | 91 |
| S | 21.9 | o | p | longleaf pine | LA | 65 | 32 | 92 | 0.0 | | | | 91 |
| S | 16.0 | o | p | longleaf - slash pine | FL | 65 | 30 | 82 | 0.0 | | | | 91 |
| S | 7.3 | d | p | loblolly - shortleaf pine | South | 25 | | | | | | | 94, v |
| S | 13.6 | o | p | loblolly pine | VA | 16 | 37 | 79 | 0.2 | | | | 95 |
| S | 8.3 | o | p | shortleaf pine | VA | 16 | 37 | 79 | 0.2 | | | | 95 |
| S | 9.1 | o | p | Virginia pine | VA | 16 | 37 | 79 | 0.2 | | | | 95 |
| S | 5.9 | o | p | white pine | VA | 16 | 37 | 79 | 0.2 | | | | 95 |
| S | 1.4 | d | p | loblolly - slash pine | NC | 5 | 35 | 77 | 0.0 | | | | 98 |
| S | 1.4 | d | p | loblolly - slash pine | NC | 7 | 35 | 77 | 0.0 | | | | 98 |
| S | 2.1 | d | p | loblolly - slash pine | NC | 8 | 35 | 77 | 0.0 | | 1.6 | | 98 |
| S | 2.1 | d | p | loblolly - slash pine | NC | 10 | 35 | 77 | 0.0 | | 1.6 | | 98 |
| S | 2.1 | d | p | loblolly - slash pine | NC | 11 | 35 | 77 | 0.0 | | 1.6 | | 98 |
| S | 10.5 | d | p | slash pine | GA | 22 | 32 | 84 | 0.2 | | | | 103 |
| S | 1.6 | c | p | loblolly & Virginia pine | VA | 1 | 38 | 78 | 0.1 | | | | 114 |
| S | 1.7 | c | p | loblolly & Virginia pine | VA | 2 | 38 | 78 | 0.1 | | | | 114 |
| S | 5.1 | c | p | loblolly & Virginia pine | VA | 3 | 38 | 78 | 0.1 | | | | 114 |
| S | 3.5 | c | p | loblolly & Virginia pine | VA | 5 | 38 | 78 | 0.1 | | | | 114 |
| S | 6.1 | c | p | loblolly & Virginia pine | VA | 8 | 38 | 78 | 0.1 | | | | 114 |
| S | 4.8 | c | p | loblolly & Virginia pine | VA | 11 | 38 | 78 | 0.1 | | | | 114 |
| S | 9.1 | c | p | loblolly & Virginia pine | VA | 14 | 38 | 78 | 0.1 | | | | 114 |
| S | 8.6 | c | p | loblolly & Virginia pine | VA | 17 | 38 | 78 | 0.1 | | | | 114 |
| S | 7.3 | c | p | loblolly & Virginia pine | VA | 20 | 38 | 78 | 0.1 | | | | 114 |
| S | 10.4 | c | p | loblolly & Virginia pine | VA | 23 | 38 | 78 | 0.1 | | | | 114 |
| S | 10.1 | c | p | loblolly & Virginia pine | VA | 26 | 38 | 78 | 0.1 | | | | 114 |
| S | 16.2 | c | p | loblolly & Virginia pine | VA | 25 | 38 | 78 | 0.1 | | | | 114 |
| S | 7.4 | c | p | loblolly & Virginia pine | VA | 32 | 38 | 78 | 0.1 | | | | 114 |
| S | 7.6 | c | p | loblolly & Virginia pine | VA | 34 | 38 | 78 | 0.1 | | | | 114 |
| S | 8.8 | c | p | loblolly & Virginia pine | VA | 35 | 38 | 78 | 0.1 | | | | 114 |
| S | 11.8 | c | p | loblolly & Virginia pine | VA | 36 | 38 | 78 | 0.1 | | | | 114 |
| S | 11.8 | c | p | loblolly & Virginia pine | VA | 40 | 38 | 78 | 0.1 | | | | 114 |
| S | 14.5 | c | p | loblolly & Virginia pine | VA | 46 | 38 | 78 | 0.1 | | | | 114 |
| S | 9.3 | c | p | loblolly & Virginia pine | VA | 47 | 38 | 78 | 0.1 | 0.38 | | | 114 |

**Continued**

**Table A1.—Continued**

| R | C | ff | T | D | L | A[a] | La[a] | Lo[a] | E[a] | c:dw | mrt | rf | cite[b] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (Mg/ha) | | | | | (years) | | | (km) | | (years) | | |
| S | 10.4 | o | p | loblolly pine | NC | 55 | 36 | 79 | | | | | 115 |
| S | 8.9 | o | p | loblolly pine | NC | 55 | 36 | 79 | | | | | 115 |
| S | 11.7 | o | p | loblolly pine | NC | 55 | 36 | 79 | | | | | 115 |
| S | 5.6 | d | p | loblolly pine plantation | MS | 18 | | | | | | | 124, 81 |
| S | 9.7 | c | p | pine | MS | 25 | 33 | 89 | 0.1 | | | | 125 |
| S | 10.3 | c | p | pine | MS | 40 | 33 | 89 | 0.1 | | | | 125 |
| S | 6.9 | d | p | loblolly pine plantation | SC | 17 | | | | | | | 132 |
| S | 7.7 | d | p | loblolly pine plantation | SC | 18 | | | | | | | 134, 81 |
| S | 11.1 | d | p | loblolly pine plantation | NC | 16 | | | | | | | 143, 81 |
| S | 6.1 | d | p | loblolly pine | South | 12 | | | | | | | 146 |
| S | 9.6 | c | mx | conifer - hardwood | NC, TN | m | 36 | 84 | 0.9 | 0.24 | | | 41 |
| S | 16.8 | c | mx | pine - hardwood | NC, TN | m | 36 | 84 | 1.7 | 0.32 | | | 94, v |
| S | 6.7 | d | mx | hardwood - pine | South | 40 | | | | | | | 125 |
| S | 7.6 | c | mx | mixed | MS | 200 | 33 | 89 | 0.1 | | | | 125 |
| S | 9.6 | c | mx | pine - hardwood | MS | 130 | 33 | 89 | 0.1 | | | | 125 |
| S | 11.3 | c | mx | pine - hardwood | MS | 65 | 33 | 89 | 0.1 | | | | 140 |
| S | 14.3 | c | mx | pine - hardwood | NC | | 35 | 84 | 1.4 | 0.46 | | | 140 |
| S | 16.4 | c | mx | pine - hardwood | NC | | 35 | 84 | 1.4 | 0.41 | | | 140 |
| S | 12.6 | c | mx | pine - hardwood | NC | | 35 | 84 | 1.4 | 0.39 | | | 141 |
| S | 19.8 | c | mx | pine - hardwood | NC | | 35 | 84 | 1.4 | 0.46 | | | 141 |
| S | 10.6 | c | mx | pine - hardwood | NC | | 35 | 84 | 1.4 | 0.46 | | | 141 |
| S | 8.7 | c | mx | hickory | NC | | 35 | 84 | 1.4 | 0.46 | | | 138 |
| S | 3.3 | d | hw | oak | SC | | 34 | | 0.2 | | 1.9 | | 138 |
| S | 5.4 | d | hw | yellow poplar | SC | | 34 | | 0.2 | | 3.7 | | 138 |
| S | 5.0 | d | hw | mixed hardwood | SC | | 34 | | 0.2 | | 3.2 | | 139 |
| S | 3.3 | d | hw | *Nyssa - Acer* | VA | 78 | | | | | 1.4 | | 139 |
| S | 2.4 | d | hw | oak - hickory | VA | 52 | | | | | 1 | | 11 |
| S | 4.2 | d | hw | oak - hickory | NC | m | 35 | 84 | 0.9 | | | | 11 |
| S | 4.3 | d | hw | oaks | NC | m | 35 | 84 | 0.9 | | | | 16, 77 |
| S | 2.3 | o | hw | *Liriodendron* | TN | 75 | 36 | | | | | | 25 |
| S | 3.3 | o | hw | *Liriodendron*, hardwood | TN | 50 | 36 | | 0.2 | | 1.4 | o | 25 |
| S | 0.8 | o | hw | oak - hickory | TN | 30-80 | 36 | | 0.3 | | 0.4 | o | 25 |
| S | 14.9 | o | hw | chestnut oak | TN | 30-80 | 36 | | 0.3 | | 5.6 | o | 25 |
| S | 13.8 | o | hw | oak - hickory | TN | 30-80 | 36 | | 0.3 | | 5.6 | o | 25 |
| S | 5.2 | o | hw | *Liriodendron* | NC | 60-200 | 35 | | 0.8 | | 2.2 | o | 29, 139 |
| S | 8.7 | d | hw | maple - oak | TN | 55 | 36 | | 0.3 | | 6.3 | | 29, 139 |
| S | 3.5 | d | hw | mixed hardwood | NC | | 35 | | 0.9 | | 2.2 | | 41 |
| S | 6.6 | c | hw | mixed hardwood | TN | m | 36 | 84 | 0.3 | 0.21 | | | 41 |
| S | 24.8 | c | hw | chestnut oak | NC, TN | m | 36 | 84 | 1.0 | 0.34 | | | 77 |
| S | 5.2 | o | hw | oak - hickory | TN | | 36 | | 0.3 | | 5.4 | o | 77 |
| S | 5.6 | o | hw | oak - hickory | TN | | 36 | | 0.3 | | 4.6 | o | 77 |
| S | 2.6 | o | hw | oak - hickory | GA | 150 | 32 | | | | | | 77 |
| S | 3.7 | o | hw | oak | FL | 100 | 28 | | 0.0 | | | | 77 |
| S | 3.7 | o | hw | oak - hickory | NC | | 36 | | 0.8 | | 4.9 | o | 89 |
| S | 7.4 | o | hw | oak - hickory | NC | 4 | 35 | 83 | 1.0 | | | | 89 |
| S | 12.0 | o | hw | oak - hickory | NC | 7 | 35 | 83 | 0.9 | | | | 89 |
| S | 6.3 | o | hw | hardwood | NC | 50 | 35 | 83 | 0.9 | | | | 94, v |
| S | 4.6 | d | hw | oak - hickory | South | 12 | | | | | | | 94, 77 |
| S | 4.5 | o | hw | scrub oak | SC | 150 | 34 | | | | 1.9 | o | 103 |

**Continued**

**Table A1.—Continued**

| R | C | ff | T | D | L | A[a] | La[a] | Lo[a] | E[a] | c:dw | mrt | rf | cite[b] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (Mg/ha) | | | | | (years) | | | (km) | | (years) | | |
| S | 4.3 | d | hw | hardwood | GA | 22 | 32 | 84 | 0.2 | | | | 116 |
| S | 3.0 | d | hw | hardwood | NC | m | 31 | 87 | 0.9 | | | | 116 |
| S | 3.6 | d | hw | hardwood | NC | 0 | 31 | 87 | 0.9 | | | | 116 |
| S | 3.3 | d | hw | pin oak | NC | m | 31 | 87 | 0.8 | | | | 118, 77 |
| S | 2.6 | d | hw | upland hardwood | NC | m | 35 | | | | | | 127 |
| S | 7.0 | c | hw | oak | TN | | 36 | 84 | 0.3 | 0.36 | | | 133 |
| S | 3.4 | d | hw | red spruce | SC | | 35 | 83 | | | | | 41 |
| S | 53.8 | c | | conifer - hardwood | NC, TN | m | 36 | 84 | 1.7 | 0.36 | | | 41 |
| S | 2.4 | d | | *Chamaecyparis* | VA | 57 | | | | | 0.9 | | 139 |
| S | 2.5 | d | | *Taxodium* | VA | 86 | | | | | 1 | | 139 |
| P | 8.6 | d | df | Douglas-fir | WA | 40 | 47 | | | | 11.6 | | 139 |
| P | 5.0 | d | df | Douglas-fir | OR | | 44 | | 0.3 | | 5.6 | | 138 |
| P | 10.7 | d | df | Douglas-fir | OR | 70 | 44 | | 0.6 | | 14.5 | | 139 |
| P | 2.6 | d | df | Douglas-fir | OR | 43 | 44 | | | | 2.6 | | 139 |
| P | 12.4 | d | df | alder, Douglas-fir | BC | 23 | 50 | 124 | 0.5 | | | | 12 |
| P | 8.5 | d | df | alder, Douglas-fir | WA | 25 | 48 | 122 | 0.0 | | | | 12 |
| P | 2.6 | d | df | Douglas-fir | BC | 23 | 50 | 124 | 0.5 | | | | 12 |
| P | 7.8 | d | df | Douglas-fir | WA | 25 | 48 | 122 | 0.0 | | | | 12 |
| P | 8.6 | o | df | Douglas-fir | WA | 55 | 46 | 122 | 0.6 | | 3.6 | o | 15 |
| P | 16.1 | o | df | Douglas-fir, alder | WA | 55 | 46 | 122 | 0.6 | | 2.4 | o | 15 |
| P | 14.3 | o | df | Douglas-fir, conifer | OR | 55 | 45 | 124 | 0.2 | | 3.8 | o | 15 |
| P | 11.6 | o | df | Douglas-fir, conifer | OR | 55 | 45 | 124 | 0.2 | | 0.9 | o | 15 |
| P | 5.3 | d | df | Douglas-fir | WA | 26 | | | 0.3 | | | | 19 |
| P | 9.0 | d | df | Douglas-fir | WA | 30.5 | | | 0.3 | | | | 19 |
| P | 9.2 | d | df | Douglas-fir | WA | 33.3 | | | 0.3 | | | | 19 |
| P | 8.0 | d | df | Douglas-fir | WA | 38 | | | 0.3 | | | | 19 |
| P | 120.2 | o | df | Douglas-fir | OR | 450 | 44 | | 0.6 | | 35.6 | o | 25 |
| P | 165.6 | o | df | western hemlock | OR | 121 | 45 | | 0.2 | | 49 | o | 25 |
| P | 43.1 | c | df | Douglas-fir | OR | 150 | 44 | 124 | 0.1 | 0.47 | | | 26 |
| P | 9.2 | c | df | Douglas-fir | OR | 150 | 44 | 124 | 0.1 | 0.42 | | | 26 |
| P | 3.7 | c | df | Douglas-fir plantation | OR | 9 | 44 | 124 | 0.1 | 0.38 | | | 26 |
| P | 6.7 | c | df | Douglas-fir | WA | 38 | | | | | | | 32 |
| P | 9.7 | c | df | Douglas-fir | WA | 38 | | | | | | | 32 |
| P | 8.7 | c | df | Douglas-fir | WA | 38 | | | | | | | 32 |
| P | 6.5 | c | df | Douglas-fir | OR | 38 | | | | | | | 32 |
| P | 8.1 | c | df | Douglas-fir | OR | 38 | | | | | | | 32 |
| P | 8.2 | c | df | Douglas-fir | OR | 38 | | | | | | | 32 |
| P | 11.9 | c | df | western hemlock | WA | 32 | | | | | | | 32 |
| P | 13.7 | c | df | western hemlock | WA | 32 | | | | | | | 32 |
| P | 10.6 | c | df | western hemlock | OR | 32 | | | | | | | 32 |
| P | 5.8 | d | df | Douglas-fir | OR | 48 | 45 | 123 | 0.3 | | 6.1 | d | 39 |
| P | 5.5 | d | df | Douglas-fir | OR | 48 | 45 | 123 | 0.3 | | 4.8 | d | 39 |
| P | 5.5 | d | df | Douglas-fir | OR | 48 | 45 | 123 | 0.3 | | 4.3 | d | 39 |
| P | 6.0 | d | df | Douglas-fir | OR | 48 | 45 | 123 | 0.3 | | 4 | d | 39 |
| P | 9.8 | d | df | Douglas-fir | OR | 48 | 45 | 123 | 0.3 | | 10.4 | d | 39 |
| P | 5.3 | d | df | Douglas-fir, bigleaf maple | OR | 48 | 45 | 123 | 0.3 | | 2.9 | d | 39 |
| P | 6.8 | d | df | Douglas-fir, bigleaf maple | OR | 48 | 45 | 123 | 0.3 | | 4.3 | d | 39 |
| P | 4.5 | d | df | Douglas-fir, bigleaf maple | OR | 48 | 45 | 123 | 0.3 | | 3.1 | d | 39 |

**Continued**

**Table A1.—Continued**

| R | C | ff | T | D | L | A[a] | La[a] | Lo[a] | E[a] | c:dw | mrt | rf | cite[b] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (Mg/ha) | | | | | (years) | | | (km) | | (years) | | |
| P | 4.6 | d | df | Douglas-fir, bigleaf maple | OR | 48 | 45 | 123 | 0.3 | | 2.4 | d | 39 |
| P | 11.4 | d | df | Douglas-fir, bigleaf maple | OR | 48 | 45 | 123 | 0.3 | | 5.8 | d | 39 |
| P | 81.4 | d | df | western hemlock - fir | BC | m | 49 | 125 | 0.5 | | | | 40 |
| P | 44.4 | d | df | western hemlock - fir | BC | m | 49 | 125 | 0.5 | | | | 40 |
| P | 55.5 | d | df | western hemlock - fir | BC | m | 49 | 125 | 0.6 | | | | 40 |
| P | 92.5 | d | df | western hemlock - fir | BC | m | 49 | 125 | 0.5 | | | | 40 |
| P | 58.1 | d | df | Douglas-fir | OR, WA | m | | | | | | | 42, 33 |
| P | 11.3 | d | df | Douglas-fir | OR | | 44 | | 0.3 | | 8.6 | | 138 |
| P | 14.5 | d | df | Douglas-fir | OR | | 44 | | 0.9 | | 9.9 | | 138 |
| P | 12.6 | d | df | hemlock - spruce | OR | | 44 | | 0.2 | | 9.6 | | 138 |
| P | 78.7 | o | df | Douglas-fir | OR, WA | 40 | | | | | | | 48, v |
| P | 7.9 | o | df | Douglas-fir | OR, WA | 40 | | | | | | | 48, v |
| P | 8.1 | d | df | hemlock - spruce | OR | 26 | 45 | | 0.2 | | 3.1 | | 46, 139 |
| P | 26.3 | o | df | Douglas-fir | OR, WA | 23 | | | | | | | 49, v |
| P | 82.2 | o | df | Douglas-fir | OR, WA | 80 | | | | | | | 49, v |
| P | 31.4 | o | df | Douglas-fir | OR | 450 | 44 | 123 | 0.6 | | 13.4 | o | 47 |
| P | 27.1 | o | df | Douglas-fir | OR | 450 | 44 | 123 | 0.6 | | 10 | o | 47 |
| P | 15.1 | o | df | Douglas-fir | OR | 450 | 44 | 123 | 0.6 | | 7.3 | o | 47 |
| P | 31.3 | o | df | Douglas-fir | OR | 450 | 44 | 123 | 0.6 | | 12.9 | o | 47 |
| P | 25.1 | o | df | Douglas-fir | OR | 450 | 44 | 123 | 0.6 | | 10.8 | o | 47 |
| P | 14.8 | d | df | Douglas-fir | WA | | 47 | | 0.5 | | 19.5 | | 55, 138 |
| P | 8.3 | d | df | Douglas-fir | WA | | 47 | | 0.2 | | 18.3 | | 55, 138 |
| P | 13.2 | d | df | Douglas-fir | WA | | 47 | | 0.2 | | 16 | | 55, 138 |
| P | 8.8 | d | df | Douglas-fir | WA | | 47 | | 0.1 | | 12 | | 55, 138 |
| P | 28.3 | d | df | Douglas-fir | WA | | 47 | | 0.1 | | 48.1 | | 55, 138 |
| P | 2.9 | c | df | Douglas-fir | OR | <30 | 46 | 123 | | 0.38 | | | 59 |
| P | 8.2 | c | df | Douglas-fir | WA | | | | | | | | 63, 32 |
| P | 17.0 | c | df | western hemlock | OR | | | | | | | | 63, 32 |
| P | 33.0 | d | df | Douglas-fir, w. hemlock | OR | m | | | | | | | 80 |
| P | 25.7 | d | df | Douglas-fir, w. hemlock | OR | m | | | | | | | 80 |
| P | 31.2 | d | df | Douglas-fir, w. hemlock | OR | m | | | | | | | 80 |
| P | 36.2 | d | df | Douglas-fir, w. hemlock | OR | m | | | | | | | 80 |
| P | 44.3 | d | df | Douglas-fir, w. hemlock | OR | m | | | | | | | 80 |
| P | 45.4 | d | df | Douglas-fir, w. hemlock | OR | m | | | | | | | 80 |
| P | 45.3 | d | df | Douglas-fir, w. hemlock | OR | m | | | | | | | 80 |
| P | 59.8 | d | df | Douglas-fir, w. hemlock | WA | m | | | | | | | 80 |
| P | 71.3 | d | df | Douglas-fir, w. hemlock | WA | m | | | | | | | 80 |
| P | 55.2 | d | df | Douglas-fir, w. hemlock | WA | m | | | | | | | 80 |
| P | 91.1 | d | df | Douglas-fir, w. hemlock | WA | m | | | | | | | 80 |
| P | 31.4 | c | df | Douglas-fir | OR | m | 44 | 122 | 1.0 | | | | 93 |
| P | 18.1 | d | df | western hemlock | WA | | 48 | 124 | 0.1 | | | | 106 |
| P | 27.4 | d | df | western hemlock | WA | | 46 | 123 | 0.4 | | | | 106 |
| P | 17.8 | d | df | western hemlock | WA | | 48 | 124 | 0.2 | | | | 106 |
| P | 10.4 | d | df | western hemlock | WA | | 48 | 124 | 0.1 | | | | 106 |
| P | 14.1 | d | df | western hemlock | WA | | 47 | 124 | 0.2 | | | | 106 |
| P | 10.7 | d | df | western hemlock | WA | | 47 | 124 | 0.2 | | | | 106 |
| P | 14.8 | d | df | western hemlock | WA | | 48 | 125 | 0.1 | | | | 106 |
| P | 8.1 | d | df | western hemlock | WA | | 47 | 124 | 0.1 | | | | 106 |
| P | 17.8 | d | df | western hemlock | WA | | | | 0.9 | | | | 106 |

**Continued**

**Table A1.—Continued**

| R | C | ff | T | D | L | A[a] | La[a] | Lo[a] | E[a] | c:dw | mrt | rf | cite[b] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (Mg/ha) | | | | | (years) | | | (km) | | (years) | | |
| P | 30.3 | d | df | western hemlock | WA | | 49 | 122 | 0.7 | | | | 106 |
| P | 14.4 | d | df | western hemlock | WA | | | | 0.3 | | | | 106 |
| P | 16.3 | d | df | western hemlock | WA | | 47 | 122 | 0.5 | | | | 106 |
| P | 10.7 | d | df | western hemlock | WA | | 48 | 122 | 0.2 | | | | 106 |
| P | 11.8 | d | df | western hemlock | WA | | | | 0.1 | | | | 106 |
| P | 19.2 | d | df | western hemlock | WA | | | | 0.9 | | | | 106 |
| P | 11.5 | d | df | western hemlock | WA | | | | 0.3 | | | | 106 |
| P | 11.4 | d | df | Douglas-fir | OR, WA | 46 | | | | | | | 129, v |
| P | 1.4 | d | df | Douglas-fir | WA | 9 | 47 | | 0.2 | | 1.6 | | 128, 139 |
| P | 11.0 | o | df | Douglas-fir | WA | 22 | 47 | 121 | 0.2 | | 4.4 | o | 130 |
| P | 8.4 | o | df | Douglas-fir | WA | 30 | 47 | 121 | 0.2 | | 3.7 | o | 130 |
| P | 8.4 | o | df | Douglas-fir | WA | 30 | 47 | 121 | 0.2 | | 7.7 | o | 130 |
| P | 9.4 | o | df | Douglas-fir | WA | 42 | 47 | 121 | 0.2 | | 5.3 | o | 130 |
| P | 12.8 | o | df | Douglas-fir | WA | 42 | 47 | 121 | 0.2 | | 7.8 | o | 130 |
| P | 14.6 | o | df | Douglas-fir | WA | 49 | 47 | 121 | 0.2 | | 12.1 | o | 130 |
| P | 21.6 | o | df | Douglas-fir | WA | 73 | 47 | 121 | 0.2 | | 29.1 | o | 130 |
| P | 8.6 | c | df | coastal hemlock | OR | 120 | 45 | 124 | 0.2 | 0.41 | 3.4 | d | 136 |
| P | 4.6 | c | df | Douglas-fir | WA | 300 | 47 | 122 | 0.2 | 0.38 | 3.2 | d | 136 |
| P | 6.4 | c | df | Douglas-fir | WA | 45 | 47 | 122 | 0.2 | 0.36 | 5.5 | d | 136 |
| P | 7.4 | d | df | Douglas-fir | WA | 150 | 47 | | | | 12.6 | | 137, 139 |
| P | 10.4 | d | df | Douglas-fir | WA | 70 | 47 | | | | 31.1 | | 137, 139 |
| P | 3.7 | d | df | Douglas-fir | WA | 1 | 47 | | | | | | 137, 139 |
| P | 5.9 | d | df | Douglas-fir | WA | 10 | 47 | | | | 80 | | 137, 139 |
| P | 10.0 | d | df | Douglas-fir | WA | 40 | 47 | | | | 32.9 | | 137, 139 |
| P | 8.5 | d | df | Douglas-fir | WA | 40 | 47 | | | | 20 | | 137, 139 |
| P | 11.1 | d | df | Douglas-fir | WA | 150 | 47 | | | | 11.4 | | 137, 139 |
| P | 12.2 | d | df | Douglas-fir | WA | 1 | 47 | | | | | | 137, 139 |
| P | 6.7 | d | df | Douglas-fir | WA | 10 | 47 | | | | 39.1 | | 137, 139 |
| P | 8.5 | d | df | Douglas-fir | WA | 70 | 47 | | | | 22.8 | | 137, 139 |
| P | 14.3 | d | df | Douglas-fir | OR, WA | 100 | | | | | | | 149, v |
| P | 17.7 | d | fh | fir, hemlock | WA | 23 | 47 | | 1.2 | | 31.7 | | 139 |
| P | 55.3 | d | fh | fir, hemlock | WA | 180 | 47 | | 1.2 | | 68.6 | | 139 |
| P | 31.6 | d | fh | noble fir, Douglas-fir | OR | | 44 | | 1.2 | | 17.4 | | 138 |
| P | 35.1 | d | fh | fir - hemlock | OR | | 44 | | 1.5 | | 28.8 | | 138 |
| P | 21.7 | c | fh | mountain hemlock | OR | 215 | 44 | 122 | 1.8 | 0.28 | | | 87 |
| P | 17.7 | c | fh | mountain hemlock | OR | 18 | 44 | 122 | 1.8 | 0.3 | | | 87 |
| P | 16.8 | c | fh | mountain hemlock | OR | 35 | 44 | 122 | 1.8 | 0.25 | | | 87 |
| P | 18.3 | c | fh | mountain hemlock | OR | 74 | 44 | 122 | 1.8 | 0.3 | | | 87 |
| P | 19.8 | d | fh | fir, hemlock | WA | 175 | 47 | 121 | 1.2 | | 17.7 | d | 131 |
| P | 50.8 | c | fh | Pacific silver fir | WA | 200 | 47 | 121 | 1.2 | 0.35 | 66.5 | d | 136 |
| P | 23.5 | d | fh | fir, hemlock | OR, WA | m | | | | | | | 145 |
| P | 5.3 | d | hw | red alder | WA | 5.2 | | | 0.3 | | | | 19 |
| P | 7.6 | d | hw | red alder | WA | 10 | | | 0.3 | | | | 19 |
| P | 5.0 | d | hw | red alder | WA | 11.5 | | | 0.3 | | | | 19 |
| P | 4.8 | d | hw | red alder | WA | 13.7 | | | 0.3 | | | | 19 |
| P | 14.2 | d | hw | red alder | WA | 24.4 | | | 0.3 | | | | 19 |
| P | 13.1 | d | hw | red alder | WA | 28.7 | | | 0.3 | | | | 19 |
| P | 14.5 | d | hw | red alder | WA | 40.6 | | | 0.3 | | | | 19 |
| P | 36.5 | o | hw | red alder | WA | 30 | 47 | | 0.2 | | 4.2 | o | 25 |

**Continued**

**Table A1.—Continued**

| R | C | ff | T | D | L | A[a] | La[a] | Lo[a] | E[a] | c:dw | mrt | rf | cite[b] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (Mg/ha) | | | | | (years) | | | (km) | | (years) | | |
| P | 1.3 | d | hw | red alder | OR, WA | 14 | | | | | | | 84, v |
| P | 0.9 | d | hw | red alder | OR, WA | 24 | | | | | | | 84, v |
| P | 0.9 | d | hw | red alder | OR, WA | 65 | | | | | | | 84, v |
| P | 16.9 | d | hw | elm | WA | 36 | 47 | | 0.2 | | 2.9 | | 128, 139 |
| P | 5.0 | c | hw | alder | WA | 40 | 47 | 122 | 0.3 | 0.34 | 3.1 | d | 136 |
| P | 7.0 | d | hw | red alder | OR | | 44 | | | | 3.5 | | 150, 138 |
| W | 9.0 | c | p | lodgepole pine | OR | 100 | 44 | 121 | 1.7 | | | | 23 |
| W | 19.5 | o | p | lodgepole pine | WY | m | 43 | 110 | 2.9 | | | | 30 |
| W | 13.9 | o | p | lodgepole pine | WY | 105 | 41 | 106 | 2.8 | | 20.6 | o | 34 |
| W | 13.1 | o | p | lodgepole pine | WY | 105 | 41 | 106 | 2.8 | | 18.8 | o | 34 |
| W | 18.6 | o | p | lodgepole pine | WY | 105 | 41 | 106 | 2.8 | | 21.7 | o | 34 |
| W | 16.9 | o | p | lodgepole pine | WY | 105 | 41 | 106 | 2.9 | | 19.6 | o | 34 |
| W | 9.5 | o | p | lodgepole pine | WY | 70 | 41 | 106 | 3.1 | | 12 | o | 34 |
| W | 13.1 | o | p | lodgepole pine | WY | 240 | 41 | 106 | 3.0 | | 11.7 | o | 34 |
| W | 10.7 | o | p | lodgepole pine | WY | 15 | 41 | 106 | 2.8 | | 49.9 | o | 119 |
| W | 8.9 | o | p | lodgepole pine | WY | 30 | 41 | 106 | 2.8 | | 8.7 | o | 119 |
| W | 10.2 | o | p | lodgepole pine | WY | 50 | 41 | 106 | 2.8 | | 10.7 | o | 119 |
| W | 12.0 | o | p | lodgepole pine | WY | 100 | 41 | 106 | 2.8 | | 13.6 | o | 119 |
| W | 15.1 | o | p | lodgepole pine | WY | 260 | 41 | 106 | 2.8 | | 18.8 | o | 119 |
| W | 45.5 | d | p | lodgepole pine | CO | m | 40 | 106 | 2.8 | | | | 123 |
| W | 34.0 | d | p | lodgepole pine | CO | m | 40 | 106 | 2.8 | | | | 123 |
| W | 31.5 | d | p | lodgepole pine | CO | m | 40 | 106 | 2.8 | | | | 123 |
| W | 27.8 | d | p | lodgepole pine | CO | m | 40 | 106 | 2.8 | | | | 123 |
| W | 27.0 | d | p | lodgepole pine | CO | m | 40 | 106 | 2.9 | | | | 123 |
| W | 36.3 | d | p | lodgepole pine | CO | m | 40 | 106 | 3.0 | | | | 123 |
| W | 33.3 | d | p | lodgepole pine | CO | m | 41 | 107 | 3.0 | | | | 123 |
| W | 40.0 | d | p | lodgepole pine | CO | m | 41 | 107 | 2.9 | | | | 123 |
| W | 33.7 | d | p | lodgepole pine | CO | m | 41 | 106 | 3.2 | | | | 123 |
| W | 41.4 | d | p | lodgepole pine | CO | m | 41 | 106 | 2.9 | | | | 123 |
| W | 23.0 | d | p | lodgepole pine | CA | m | | | | | | | 135 |
| W | 15.6 | o | p | lodgepole pine | WY | 85 | 41 | 106 | 2.8 | | 20.3 | o | 147 |
| W | 69.7 | d | p | ponderosa pine | CA | | 38 | | 1.5 | | 60 | | 138 |
| W | 12.1 | d | p | ponderosa pine | AZ | | 35 | | 2.2 | | 15.5 | | 138 |
| W | 2.6 | d | p | ponderosa pine, conifer | CA | | 37 | 119 | 1.5 | | | | 1 |
| W | 10.0 | d | p | ponderosa pine | IM | 50 | | | | | | | 7, v |
| W | 12.0 | d | p | ponderosa pine | IM | 50 | | | | | | | 7, v |
| W | 8.5 | d | p | ponderosa pine | IM | 50 | | | | | | | 7, v |
| W | 5.8 | d | p | ponderosa pine | IM | | | | | | | | v |
| W | 7.7 | d | p | ponderosa pine | AZ | y | | | | | | | 37 |
| W | 3.3 | d | p | ponderosa pine | MT | m | | | | | | | 67 |
| W | 40.7 | d | p | ponderosa pine, conifer | CA | 70 | 39 | 121 | 1.3 | | | | 68 |
| W | 4.6 | d | p | ponderosa pine | IM | 49 | | | | | | | 70, v |
| W | 13.8 | d | p | ponderosa pine | IM | 50 | | | | | | | 71, v |
| W | 30.7 | d | p | ponderosa pine | IM | 50 | | | | | | | 71, v |
| W | 19.2 | d | p | ponderosa pine | West | | | | | | | | 73, 33 |
| W | 14.8 | c | p | ponderosa pine | AZ | m | 34 | 111 | 2.2 | 0.4 | | | 72 |
| W | 9.9 | c | p | ponderosa pine | AZ | m | 34 | 111 | 2.2 | 0.42 | | | 72 |
| W | 11.5 | d | p | ponderosa pine | AZ | | 35 | 112 | 2.1 | | | | 78 |

**Continued**

**Table A1.—Continued**

| R | C | ff | T | D | L | A[a] | La[a] | Lo[a] | E[a] | c:dw | mrt | rf | cite[b] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (Mg/ha) | | | | | (years) | | | (km) | | (years) | | |
| W | 24.4 | d | p | ponderosa pine | AZ | | 35 | 112 | 2.1 | | | | 78 |
| W | 46.0 | d | p | ponderosa pine | CA | m | | | | | | | 135 |
| W | 35.8 | c | p | ponderosa pine | NM | 200 | 36 | 106 | 2.7 | 0.32 | 48.7 | d | 136 |
| W | 18.1 | d | p | ponderosa pine | AZ | 56 | | | | | | | 142, 139 |
| W | 25.0 | d | p | Jeffrey pine, conifer | CA | m | 39 | 121 | 1.4 | | | | 68 |
| W | 34.6 | d | p | Jeffrey pine | CA | m | | | | | | | 135 |
| W | 9.9 | d | p | western white pine | CA | m | | | | | | | 135 |
| W | 3.3 | d | rs | white fir, giant sequoia | CA | | 37 | 119 | 1.8 | | | | 1 |
| W | 35.9 | o | rs | *Sequoia* | CA | | | | | | | | 100, v |
| W | 53.8 | d | rs | giant sequoia | CA | m | | | | | | | 135 |
| W | 96.9 | c | rs | giant sequoia | CA | m | | | 2.3 | | 15.2 | | 121 |
| W | 22.2 | d | pj | singleleaf pinyon | IM | m | | | 2.2 | | | | 33 |
| W | 20.0 | d | pj | pinyon - juniper | CA | m | | | | | | | 135 |
| W | 23.2 | o | mc | Douglas-fir, spruce, fir | NM | 50 | 35 | 107 | 2.9 | | 13.4 | o | 44 |
| W | 23.3 | d | mc | Douglas-fir | MT | m | | | | | | | 67 |
| W | 47.0 | d | mc | Douglas-fir, incense-cedar | CA | 110 | 39 | 121 | 1.0 | | | | 68 |
| W | 23.6 | d | mc | Douglas-fir | CA | m | | | | | | | 135 |
| W | 25.2 | d | mc | spruce - fir | CO | 350 | 40 | 106 | 3.6 | | 40 | d | 9 |
| W | 26.3 | d | mc | cedar - hemlock | ID | m | | | | | | | 67 |
| W | 37.4 | d | mc | cedar - hemlock | MT | m | | | | | | | 67 |
| W | 26.6 | d | mc | subalpine fir | MT | m | | | | | | | 67 |
| W | 43.7 | d | mc | spruce - fir | CO | m | 40 | 106 | 3.1 | | | | 123 |
| W | 37.0 | d | mc | spruce - fir | CO | m | 40 | 106 | 3.0 | | | | 123 |
| W | 34.8 | d | mc | spruce - fir | CO | m | 40 | 106 | 3.2 | | | | 123 |
| W | 43.3 | d | mc | spruce - fir | CO | m | 40 | 106 | 2.8 | | | | 123 |
| W | 36.3 | d | mc | spruce - fir | CO | m | 40 | 106 | 3.0 | | | | 123 |
| W | 38.5 | d | mc | spruce - fir | CO | m | 41 | 107 | 3.0 | | | | 123 |
| W | 44.4 | d | mc | spruce - fir | CO | m | 40 | 106 | 3.4 | | | | 123 |
| W | 54.8 | d | mc | spruce - fir | CO | m | 41 | 106 | 3.3 | | | | 123 |
| W | 38.1 | d | mc | spruce - fir | CO | m | 41 | 106 | 3.0 | | | | 123 |
| W | 45.5 | d | mc | spruce - fir | CO | m | 41 | 106 | 2.8 | | | | 123 |
| W | 31.9 | d | mc | incense-cedar | CA | m | | | | | | | 135 |
| W | 41.9 | d | mc | mountain hemlock | CA | m | | | | | | | 135 |
| W | 31.6 | d | mc | red and white fir | CA | m | | | | | | | 135 |
| W | 24.1 | c | mc | spruce - fir | NM | 300 | 36 | 106 | 3.4 | 0.37 | 58.9 | d | 136 |
| W | 19.3 | d | mc | mixed conifer | IM | | | | | | | | v |
| W | 29.1 | o | mc | fir, cedar, pine | CA | m | 39 | 121 | 1.3 | | 13.3 | o | 54 |
| W | 73.9 | c | mc | fir - pine | CA | m | | | 2.1 | | 17 | | 121 |
| W | 34.6 | c | mc | mixed conifer | NM | 200 | 36 | 106 | 2.7 | 0.42 | 21 | d | 136 |
| W | 34.0 | d | hw | aspen | CO | m | 40 | 106 | 2.8 | | | | 123 |
| W | 34.4 | d | hw | aspen | CO | m | 40 | 106 | 2.8 | | | | 123 |
| W | 51.1 | d | hw | aspen | CO | m | 40 | 106 | 2.8 | | | | 123 |
| W | 37.4 | d | hw | aspen | CO | m | 40 | 106 | 2.8 | | | | 123 |
| W | 49.2 | d | hw | aspen | CO | m | 40 | 106 | 2.8 | | | | 123 |
| W | 17.8 | d | hw | aspen | CO | m | 41 | 107 | 2.8 | | | | 123 |
| W | 25.2 | d | hw | aspen | CO | m | 41 | 107 | 2.8 | | | | 123 |
| W | 33.3 | d | hw | aspen | CO | m | 41 | 107 | 2.8 | | | | 123 |
| W | 18.5 | d | hw | aspen | CO | m | 41 | 107 | 2.7 | | | | 123 |
| W | 43.3 | d | hw | aspen | CO | m | 41 | 106 | 2.7 | | | | 123 |

**Continued**

**Table A1.—Continued**

| R | C (Mg/ha) | ff | T | D | L | A[a] (years) | La[a] | Lo[a] | E[a] (km) | c:dw | mrt (years) | rf | cite[b] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W | 10.0 | c | hw | aspen | NM | 60 | 36 | 106 | 3.1 | 0.35 | 11.4 | d | 136 |
| W | 16.2 | d | hw | black oak | CA | | 38 | | 1.5 | | 28.3 | | 138 |
| W | 13.8 | d | hw | gambel oak | West | | | | | | | | 24, 33 |
| W | 20.7 | d | hw | gambel oak | AZ | | 35 | 112 | 2.1 | | | | 78 |
| W | 4.7 | d | hw | oak, chaparral | AZ | m | 34 | 111 | 1.6 | | | | 101 |
| | | | | | | | | | | | | | |
| A | 30.2 | o | sw | black spruce | AK | 130 | 65 | 148 | 0.3 | | | | 31 |
| A | 20.6 | o | sw | white spruce | AK | 160 | 65 | 148 | 0.2 | | | | 31 |
| A | 73.3 | o | sw | black spruce | AK | 55 | 65 | | 0.5 | | 460 | o | 25 |
| A | 48.8 | o | sw | black spruce (muskeg) | AK | 51 | 65 | | 0.2 | | 620 | o | 25 |
| A | 65.6 | o | sw | black spruce | AK | 130 | 64 | | | | 220 | o | 25 |
| A | 14.2 | d | hw | aspen | AK | | 64 | | 0.1 | | 20.5 | | 138 |
| A | 21.9 | d | hw | aspen | AK | | 64 | | 0.1 | | 33.2 | | 138 |
| A | 16.2 | d | hw | birch | AK | | 64 | | 0.1 | | 19.7 | | 138 |
| A | 18.2 | d | hw | birch | AK | | 64 | | 0.1 | | 23 | | 138 |
| A | 19.1 | o | hw | aspen | AK | 70 | 65 | 148 | 0.3 | | | | 31 |
| A | 27.2 | o | hw | paper birch | AK | 110 | 65 | 148 | 0.3 | | | | 31 |
| A | 25.5 | d | hw | birch | AK | 50 | 64 | | | | 26 | | 139 |
| A | 37.8 | o | hw | paper birch | AK | 50 | 64 | | | | 26 | o | 25 |

[a]Some papers did not explicitly provide age, latitude, longitude, or elevation. However, a number of these also provided enough information to include an approximate value; these columns include these values as well as values directly from site descriptions.

[b]Observations with two citations are those where the primary reference was identified (the first citation) but the value was obtained from another source (the second citation). Citations "v" are from an unpublished report by K. A. Vogt, 1996; on file at the USDA Forest Service Northeastern Research Station, Durham, NH.

**Table A2. —Forest types used for summarizing data.**

| Region | Forest type | Type description |
|---|---|---|
| North | p | pine |
| | sf | spruce, fir, hemlock |
| | mx | mixed conifer-hardwood |
| | ab | aspen-birch |
| | mb | maple-beech-birch, northern hardwood |
| | oh | mixed hardwood, oak, hickory |
| South | p | pine |
| | mx | mixed conifer-hardwood |
| | hw | mixed hardwood, oak, hickory |
| Pacific Northwest | df | Douglas-fir, Western hemlock, Sitka spruce |
| | sfh | fir-hemlock, higher elevation |
| | hw | hardwood |
| West | p | pine |
| | rs | redwood/sequoia |
| | pj | pinyon/juniper |
| | mc | mixed conifer |
| | hw | hardwood |
| Alaska | sw | softwood |
| | hw | hardwood |

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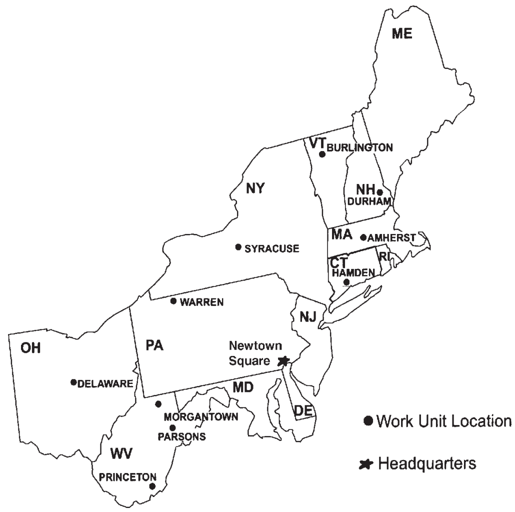
Includes a large set of published values of forest floor mass and develop large-scale estimates of carbon mass according to region and forest type. Estimates of average forest floor carbon mass per hectare of forest applied to a 1997 summary forest inventory, sum to 4.5 Gt carbon stored in forests of the 48 contiguous United States.

**Keywords**: forest carbon budget; carbon sequestration; afforestation

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