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Carbon Stocks and Projections on Public Forestlands in the United States, 1952–2040

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ABSTRACT / Approximately 37% of forestlands in the conterminous United States are publicly owned; they represent a substantial area of potential carbon sequestration in US forests and in forest products. However, large areas of public forestlands traditionally have been less intensively inventoried than privately owned forests. Thus, less information is available about their role as carbon sinks. We present estimates of carbon budgets on public forestlands of the 48 conterminous states, along with a discussion of the assumptions necessary to make such estimates. The forest carbon budget simulation model, FORCARB2, makes estimates for US forests primarily based on inventory data. We discuss methods to develop consistent carbon budget estimates from inventory data at varying levels of detail. Total carbon stored on public forestlands in the conterminous US increased from 16.3 Gt in 1953 to the present total of 19.5 Gt, while area increased from 87.1 million hactares to 92.1 million hactares. At the same time the proportion of carbon on public forestlands relative to all forests increased from 35% to 37%. Projections for the next 40 years depend on scenarios of management influences on growth and harvest.

Forest ecosystems represent significant stocks of sequestered carbon in the United States. Estimates of current stocks as well as trends in carbon stock changes are basic information useful for developing greenhouse gas policy and management strategies. Estimates of carbon in US forestlands contribute to national greenhouse gas inventories as well as to planning national efforts to reduce or offset increasing concentration of atmospheric carbon dioxide (US EPA 2003). Over 40% of forestlands in the entire United States are publicly owned. Thus, they represent a substantial portion of the potential carbon sequestration in US forests and forest products. We present nationally consistent estimates of forest ecosystem carbon budgets on public forestlands of the conterminous United States together with a discussion of the assumptions necessary to make such estimates. Estimates of carbon in harvested wood are also presented.

National-scale forest carbon budgets that include the recent past as well as projected future carbon trends have focused primarily on privately owned timberlands (Birdsey and Heath 1995, Heath and Smith 2000). We extend this framework to publicly owned forestlands. The essential components of these carbon estimates were US forest inventory data, forest sector models to project likely forest growth for the future, and a forest inventory-to-carbon simulation model. Forest inventory statistics and databases developed as part of the USDA Forest Service Renewable Resources Planning Act (RPA) assessments (Smith and others 2001) provide aggregate summary values for past inventories and detailed plot-level information about the current status of US forests. Projections of future timber resources based on growth, management, and expected timber demand are developed by a system of models that include NAPAP (Ince 1994) and TAMM/ATLAS (Mills and Kincaid 1992, Haynes 2003). We used an updated version of the forest carbon budget simulation model FORCARB (Plantinga and Birdsey 1993, Birdsey and Heath 1995), called FORCARB2, which utilizes inventory data or forest sector model results such as age, volume, and area summaries produced by TAMM/ATLAS. Together, these methods estimate carbon for publicly owned forestlands over three time periods—past, present, and future.

Methods

The forest ecosystem carbon estimates provided here are based on the set of individual-pool carbon estimators used in FORCARB2. These estimators are applied to available sets of forest inventory data: RPA

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summaries of periodic inventories between 1953 and 1977, detailed plot-level RPA forest inventory databases compiled between 1987 and 2002, and timber projections from ATLAS for 2010 through 2040. Each of these three datasets provide slightly different inventory summaries as inputs for the FORCARB2 estimators. The datasets are described below. Methods for linking inventory to FORCARB2 differ for these three datasets and are discussed separately below. Estimates are limited to all publicly owned forestland in the conterminous United States. Public forestlands include national forests, forests owned by state or local governments, and federally owned forests not a part of the national forest system such as forests on national parks or Bureau of Land Management lands. We also discuss a method to produce estimates of carbon in harvested wood for public forestlands.

FORCARB2 for Estimating Forest Ecosystem Carbon Pools

Carbon stocks are estimated for live and standing dead trees (1 inch diameter at breast height or greater), understory vegetation, down dead wood, forest floor, and soils. Estimates are based on factors and empirical models with inputs from inventory such as area, volume, stand age, and a set of classification variables, including region, forest type, and ownership. Thus, an essential characteristic of FORCARB2 is the set of empirical relationships linking carbon mass with inventory data, which reflects management, growth, land-use changes, and other forest conditions. Carbon stock change, or net annual flux, is computed from the difference between two successive estimates of stock divided by the number of years in the interval.

Live tree carbon and standing dead tree carbon are estimated from stand-level volumes from the inventory data. Volume is a measure of total merchantable volume of wood of trees classified as growing stock; we use the plot-level summaries of growing stock volume (cubic meters per hectare) expressed as volume per area as inputs to a set of volume-to-biomass equations. Carbon mass is based on the volume-to-biomass coefficients as published in Smith and others (2003). Carbon in understory vegetation is estimated from forest inventory data and equations based on Birdsey (1996). Forest floor carbon is estimated from the forest inventory data using a basic simulation model (Smith and Heath 2002). Estimates of carbon in down dead wood are described in Annex O of the Inventory of US Greenhouse Gas Emissions and Sinks: 1990–2001 (US EPA 2003). Estimates of soil carbon are based solely on forest type and are from Johnson and Kern (2003). Future work will include effects of land use change on soil carbon. Examples of conversion coefficients used in the forest carbon modeling system are found in US EPA (2003; see Annex O).

The estimators of individual carbon pools in FORCARB2 are applied to inventory data to determine carbon density (carbon mass per area). Such estimates represent regional average values according to stand classification and inventory variables. They can be summed across areas to represent total carbon stock. Similar to precision of inventory data, precision of an estimator is proportional to area.

The tree carbon estimators (Smith and others 2003) were developed at the scale of a typical USDA Forest Service Forest Inventory and Analysis Program (FIA) inventory plot; 90% of the publicly owned inventory plots were representative of 2000–7000 acres, based on area expansion factors. The volume-to-biomass equations used to estimate tree carbon are nonlinear, and resulting estimates can be biased if volume is averaged over a significantly larger area (Smith and others 2003). This effect is under an assumption of heterogeneity of growing stock volume among plots. That is, summing volume before applying equations will give a different result than applying equations at plot-level before summing. Because our goal was to produce consistent estimates, we configured inventory data from each of the three datasets as growing stock volume over relatively small or homogenous plots classified according to forest type.

Forest Inventory Databases, 1987–2002

Relatively detailed plot-level forest inventory databases were compiled as part of the USDA Forest Service RPA assessments and summarized as statistics for US forests (Waddell and others 1989, Powell and others 1993, Smith and others 2001). Summary databases were created for 1987, 1992, 1997, and 2002. The database for 2002 can be accessed at: http://ncrs2.fs.fed.us/4801/fiadb/rpadb_dump/rpadb_dump.htm . The RPA data are generally compiled at the FIA plot level and are well suited as inputs for estimating all carbon pools. Thus, no modification of inventory data was necessary for FORCARB2 carbon estimates.

Plot-level RPA datasets were often most complete for forests that were classified as timberlands—that is, productive forests available for harvest of wood products. Two other classifications of forests were those reserved by law from harvest for wood products (called "reserved" forestlands in the following), and those with productivity lower than that of timberlands (called "other" forestlands) (see Smith and others 2001). These two forest classifications comprise almost 40% of total public forestland in the 48 states, yet they have not

been surveyed in the past as frequently or intensively as timberland. The West includes 85% of the reserved and other forests. As a consequence, plot-level data were often incomplete in the 1987 through 1997 databases. The 2002 database provided volume estimates for all reserved and other forestlands; these data enabled direct plot-level estimates of carbon density. We summarized average carbon density in the 2002 database according to carbon pool, region, forest type, and ownership. Summaries were then applied to areas of similarly classified (nontimberland) forestland in earlier RPA databases. Thus, any changes in nontimberland forest carbon over the period 1987–2002 reflect changes in area and forest type. Because field inventory data were generally unavailable for these forestlands, we identified inventory years for the reserved and other forestlands as the nominal years associated with the RPA data. We present values for 1987 and 2002.

We used the 1987 through 2002 RPA forest databases to define two distinct carbon stock estimates for each region. The databases include the most recent periodic forest inventories, which varied according to state and source of the inventory. They provide information on the actual year of the field inventory or source date. We used this information to estimate the average year associated with carbon stock according to region and ownership. From the four databases, we identified two inventories for each state, generally one in the 1980s and a second in the 1990s. We sought two distinct average dates for each state that were at least four years apart. A few states (specifically Pennsylvania, West Virginia, Minnesota, Iowa, Missouri, and Kentucky) had only one distinct survey identified in the RPA databases, generally conducted in the 1980s. Regional averages of annual net carbon changes according to forest type and ownership were calculated from forest inventory data for all other states. These average carbon changes were applied to the few states with only one inventory in order to generate a second carbon stock from inventory, and thus provide the two stock estimates per region.

Forest inventory statistics, 1953–1977

Aggregate forest statistics for 1953, 1963, and 1977 are presented in Smith and others (2001) as total area and merchantable timber volume according to state and ownership. These inventory data are not compatible with FORCARB2 carbon estimators. Thus, we disaggregated the summary statistics in two steps. We first allocated all area and volume totals according to region, ownership, and forest type. We then simulated plot-level inventory data by assuming a parametric frequency distribution for stand growing stock volumes.

Totals for area and timber volumes obtained from Smith and others (2001) were allocated to the forest types in FORCARB2 that describe volume-to-biomass relationships (Smith and others 2003). Detailed information about the distribution of volumes among forest types and regions was obtained from Birdsey and Lewis (2003), Waddell and others (1989), and USDA Forest Service forest resource publications (USDA Forest Service 1958, 1982). Volumes were allocated to forest types so that totals reflected values in current summary statistics, such as the 2002 RPA database.

Some assumptions and modifications of data were necessary to link these past summaries with the current RPA data. For example, volume and area records according to forest type were not available to distinguish the Westside and Eastside of the Pacific Northwest for 1963. However, we had total volume and area for the two regions from inventories of other years. To fill in specific forest types for this period, we assumed that the volume-to-area ratios by forest type and owner were relatively continuous with the periods before and after the missing values for 1963. Older forest statistics classified "tribally-owned Native American" forestlands as publicly owned. More recent statistics have reclassified these forests as "nonindustrial privately owned." We reclassified the older statistics as privately owned to match the current protocols and therefore did not include them in our estimates. Thus, total areas may not match areas published in some previous compilations of forest statistics. Some reclassification of forest type, productivity, or even ownership can occur within a series of periodic inventories. Trends in public lands areas and volumes in Rocky Mountain inventories between 1953 and 1987 suggest such reclassification may have occurred in that region. These changes can produce discontinuities in trends that cannot be eliminated without detailed information about changes in classifications between inventories.

Most summary combinations by region, type, and owner were still very large aggregate values relative to the scale most appropriate for the tree volume-to-biomass equations and other FORCARB2 estimators. Summing merchantable volume over tens to hundreds of thousands of hectares and applying the resulting average volume per area to estimate carbon will appreciably overestimate carbon stocks (Smith and others 2003). To avoid this error, we simulated a large number of roughly inventory-sized plots by modeling plot-level growing stock volume as parametric distributions (probability density functions). We examined the frequency distribution of growing stock volume (cubic meters per hectare) in current inventory data. The distributions showed some variability among regions

and forest types and were generally skewed to the right (few large values). Extreme values were overrepresented by lognormal distributions. Three-parameter Weibull distributions fit the data well for many forest types, but fit was often improved by subjectively changing the value of the location (or threshold) parameter. Because the Weibull shape parameter was very often equal to 1, the exponential distribution became a likely candidate.

We selected the exponential distribution because it fit the data well, and is simple to apply. The probability density function for the exponential distribution is as follows:

$$f(\text{vol}) = \exp(-\text{vol}/\beta)/\beta \qquad (1)$$

where exp is the exponential function, vol is a specific growing stock volume (cubic meters per hectare), and β is the aggregate mean growing stock volume (cubic meters per hectare). The resulting probability density was divided into equally probable intervals to represent a large number of equal-sized plots. The number of intervals ("plots") was determined by total area divided by 2428 hectares. (6000 acres, to approximate the same magnitude as areas in the original regressions). Area per plot was total area divided by the number of equally probable intervals.

Sets of simulated plots were created for timberlands and reserved forestlands according to region, forest type, and ownership. The FORCARB2 carbon estimators were applied to growing stock volume of these plots. Carbon stocks on other forestlands were based on carbon densities determined for the 2002 RPA data; thus any change in carbon stock reflects only area or forest type change.

Forest Timber Resource Projections, 2010–2040

Estimated carbon stocks for 2010–2040 are based on results from the forest simulation models TAMM and ATLAS that project inventory, growth, and harvest on timberlands (Mills and Kincaid 1992, Haynes 2003). ATLAS projections of forest inventories are specific to period, region, forest type, ownership, and age class. Inventory simulations also include effects of management on growth and harvest. Growth rates are from internal yield tables, and harvest rates are based on timber demand as projected by TAMM.

We developed ATLAS simulations for national forest and other public timberlands based on the 1997 RPA database. Growth rates were based on a modification of yield tables assigned to nonindustrial private timberlands by Haynes (2003). An informal examination of inventory data suggested that growth on

public lands in the South was not very different than that of the lowest-intensity management of private timberlands, as defined in ATLAS. Similar comparisons for the North and West suggested slight differences. Therefore, as a preliminary estimate, we applied the lowest management intensity yields to public timberlands with the slight reductions of 10% and 15% in the North and West, respectively. Harvest volumes were based on information developed by Haynes (2003). Mills and Zhou (2003) have very recently developed ATLAS simulations for National Forests; however, we continued to use our parameterization of ATLAS to maintain consistent application of the model to all public timberlands. The results of these two simulations are compared in the results and discussion.

Timber volume inventories developed by ATLAS are input to FORCARB2. ATLAS results are large aggregate values, but in this case, scale is considerably less likely to represent a source of error. Aggregate values are stratified according to age, which strongly reduces the variability in growing stock volume—the source of the scaling error (Smith and others 2003). FORCARB was developed initially to estimate carbon inventories directly from ATLAS results. Thus, the carbon pool estimators were directly applied to the projected inventories. We assumed no change in area for public timberlands. We did not simulate projections for reserved or other forestlands because we had little information on disturbance effects.

Carbon in Harvested Wood Products

Information on carbon in wood harvested and removed from public timberlands for a subset of the period is based on estimates in Skog and Nicholson (1998), which have been updated (K. Skog, personal communication). The estimates are based on models, starting with historical reconstruction starting in 1910 and continuing with modeled projections in 1990. The fate of carbon in harvested wood is reported in four pools: products in use, landfills, emitted by burning to produce energy, and emitted by decay or burning without energy production (Heath and others 1996). Data were not available by owner, so we approximated the amount by calculating the ratio of timber harvested from public timberlands for each year starting in 1990 using the projected harvest data from Haynes (2003). We multiplied the carbon transferred into the harvested wood pools each year by these ratios.

Table 1.   Projected total merchantable volume (millions of cubic meters) on public timberlands

Region	Year			
	2010	2020	2030	2040
National forest timberlands (million m³)				
NC	330	362	385	406
NE	144	154	162	170
SC	394	425	446	464
SE	317	354	376	390
PNWW	1762	1918	2066	2204
PNWE	758	807	846	880
PSW	1145	1260	1368	1470
RM	2988	3264	3503	3713
Other public timberlands (million m³)				
NC	492	530	571	617
NE	407	430	450	468
SC	237	262	284	301
SE	281	306	325	341
PNWW	835	947	1054	1156
PNWE	88	100	112	127
PSW	58	63	69	73
RM	327	359	390	420

Results and Discussion

The assumptions employed to link FORCARB2 with forest inventory data are essential to meet our goal of consistent estimates for 1953 through 2040. Different assumptions, and thus effects, apply for the three separate databases. Total areas and volumes for 1952–2002 (by region and ownership) matched the totals provided in Smith and others (2001) and the 2002 RPA database. Projections did not include any area change; thus, areas were constant after 2002. Projections for 2010 through 2040 were from our parameterization and input files created for ATLAS. Despite slight differences in starting inventory and modeled yields, totals of simulated volumes (Table 1) were not very different from simulations of Mills and Zhou (2003, Tables 18–19) and Haynes (2003, Tables 34–37).

The assumption of exponentially distributed stand volumes was a basic part of disaggregating the 1953–1977 data. While it is unlikely that all forests classified by region, owner, and type were distributed in this exact form, many in the 2002 database were very close. As a test of this assumption on a detailed database, the exponential model was applied to the 2002 RPA data. Aggregate volumes were modeled as described above. That is, volumes were summed according to region, ownership, and forest type categories to produce 147 aggregate volumes. From this, the exponential distribution model generated a total of 81,833 simulated plots. The estimate for total live tree carbon on all timber-
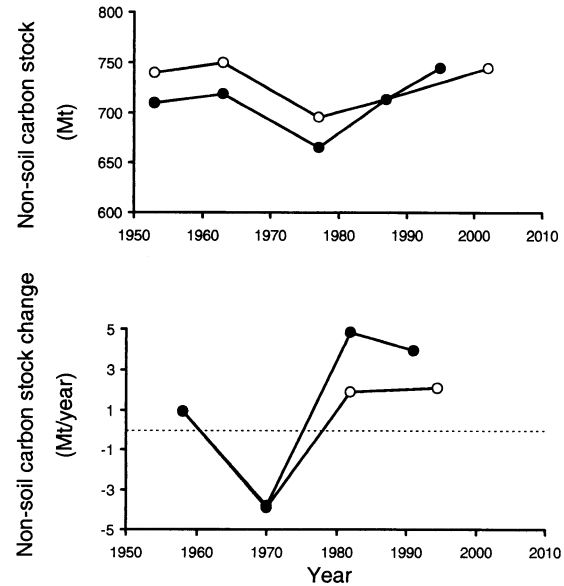

Figure 1. Examples of the effect of model assumptions on carbon stocks and stock change for PNWW national forest timberlands. Closed symbols represent stock and stock change modeled as described in this report. Open symbols represent carbon stock estimates made for regional aggregate values for 1953–1977 and RPA inventory years defined as 1987 and 2002 (that is, without simulating stand-level data or determining year of field data).

lands in the conterminous United States was 13,915 Mt carbon. The total when FORCARB2 estimators were applied directly at the plot-level data was 14,043 Mt carbon. Thus, the model underestimated the total by less than 1%. Estimates made directly from the 147 average volumes summed to 15,016 Mt carbon, an overestimate of about 7%. These results demonstrate the efficacy of our method for disaggregating historical inventory data.

Figure 1 provides an example of effects of some of our assumptions for national forest timberlands on the Westside of the Pacific Northwest. Effects of scale in estimating carbon stock for 1953–1977 are illustrated by the vertical displacement in the first three points of the upper panel. Employing the weighted average year of field data in the RPA databases resulted in average years identified as 1987 and 1995 for the nominal 1987 and 2002 data, respectively. The effect is evident in the lateral change in location of the fifth point of the upper panel. The lower panel of Figure 1 provides an example of the effect of these modeling assumptions on net stock change.

Carbon stocks for all nonsoil pools—tree, understory, down dead wood, and forest floor—for 1953–2040 are shown in Figure 2. Estimates for organic car-
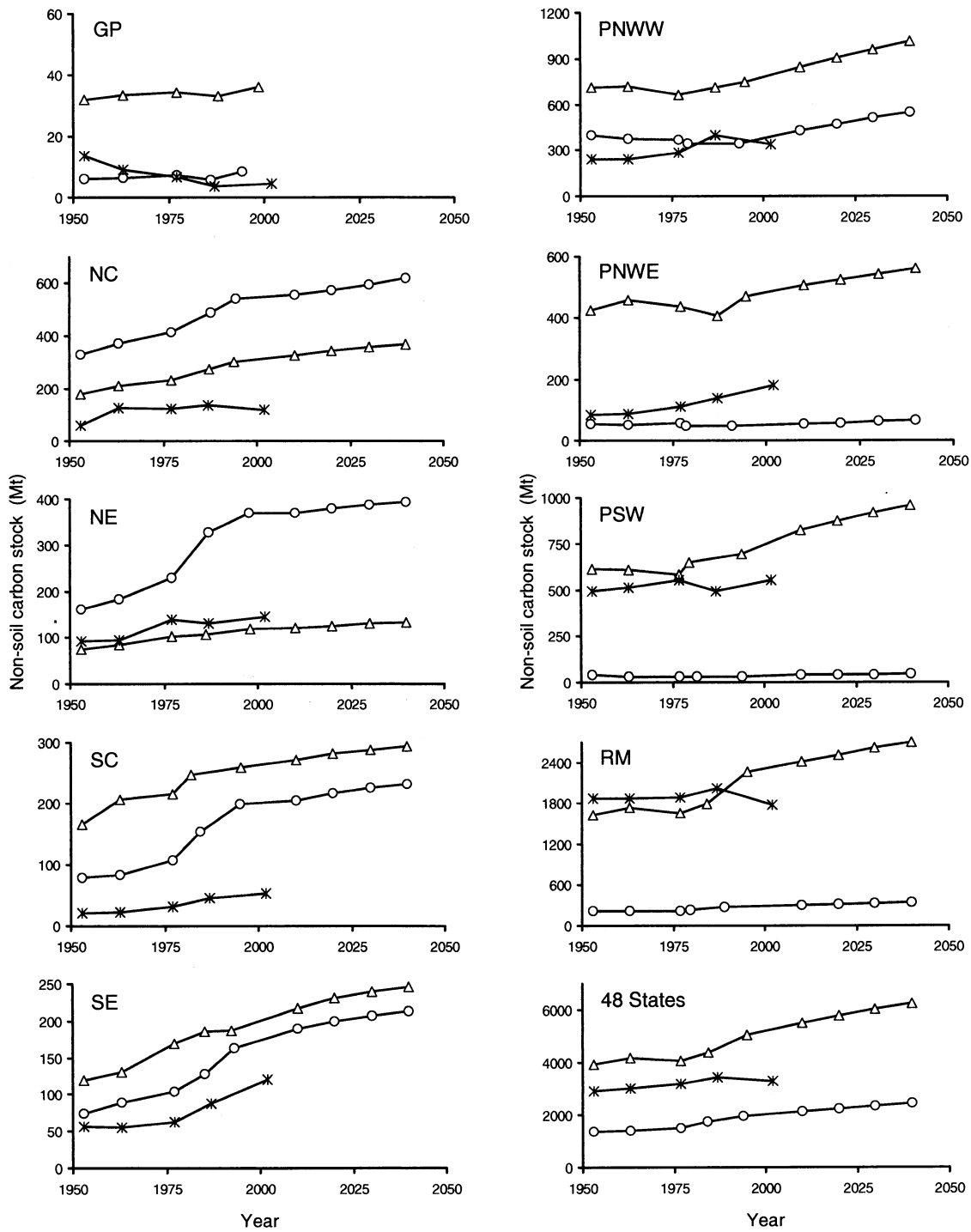
Figure 2. Nonsoil carbon stocks estimated for national forest (Δ) and other public (○) timberlands as well as publicly owned reserved and other forests (*) for 1953–2040.

bon in soil carbon are not well developed and simply reflect forest type; therefore, we emphasize nonsoil carbon stocks for most of the summaries we present. Stocks were summarized for national forest and other public timberlands as well as reserved and other forests. Estimates for 1953 through the present were determined according to regions in RPA forest resource summaries (Smith and others 2001) with the exception

of the Pacific Northwest, which is divided into the Eastside and Westside. The regions are as follows: Great Plains (GP), North Central (NC), Northeast (NE), South Central (SC), Southeast (SE), Pacific Northwest-Westside (PNWW), Pacific Northwest-Eastside (PNWE), Pacific Southwest (PSW), and Rocky Mountain (RM).

Timber projections produced by ATLAS differ slightly from the RPA regions (Haynes 2003). Specifically, GP is not included as a separate region. Most of the GP area is allocated to NC, with the exception of western South Dakota, which is placed with RM. This is because forests in the Black Hills of western South Dakota more closely match Western forest types. The proportion of GP forest carbon stocks in western South Dakota (and thus placed with RM by ATLAS) decreased from 92% to 91% for national forests and from 25% to 18% for other public timberlands between the 1987 and 2002 RPA databases. These were the proportions of GP carbon in NC and RM for 2010 through 2040.

Net average annual ecosystem nonsoil carbon stock change is shown in Figure 3 for the pooled regions North (NC, NE, and part of GP), South (SC and SE), Pacific Coast (PNWW, PNWE, and PSW), Rocky Mountain (RM and part of GP), and all regions. Stock changes are generally positive throughout the interval. In the West, stock changes are generally greater for national forests as compared with other public timberlands. No such trend is evident in the East. Estimated net ecosystem carbon accumulation on public timberlands for 2001 represented 33% of all such sequestration on forestlands on the conterminous 48 states—see Table 6-4 of US EPA (2003) for comparison with stock changes provided in Figure 3.

The large fluctuations in stock change for National Forests in the Rocky Mountains are an effect of the slight reductions in carbon stock in the third and fourth points of Figure 2 (RM, national forest). Values determined for these points are related to classification effects as discussed above. The interval between the 1987 and 1997 RPA summaries included large fluctuations in some forest types (Waddell and others 1989, Smith and others 2001). These changes included greater than 3%/yr increases in area of Douglas fir, fir–spruce, hardwood, and other Western forest types. These were accompanied by similar decreases in area in Western white pine and larch. The extreme carbon stock changes generated in the Rocky Mountains are carried to the summary net stock change for all national forest timberlands in the conterminous United States (bottom panel of Figure 3).

Net stock change as presented in Figure 3 is extremely sensitive to the stock estimates in Figure 2. The
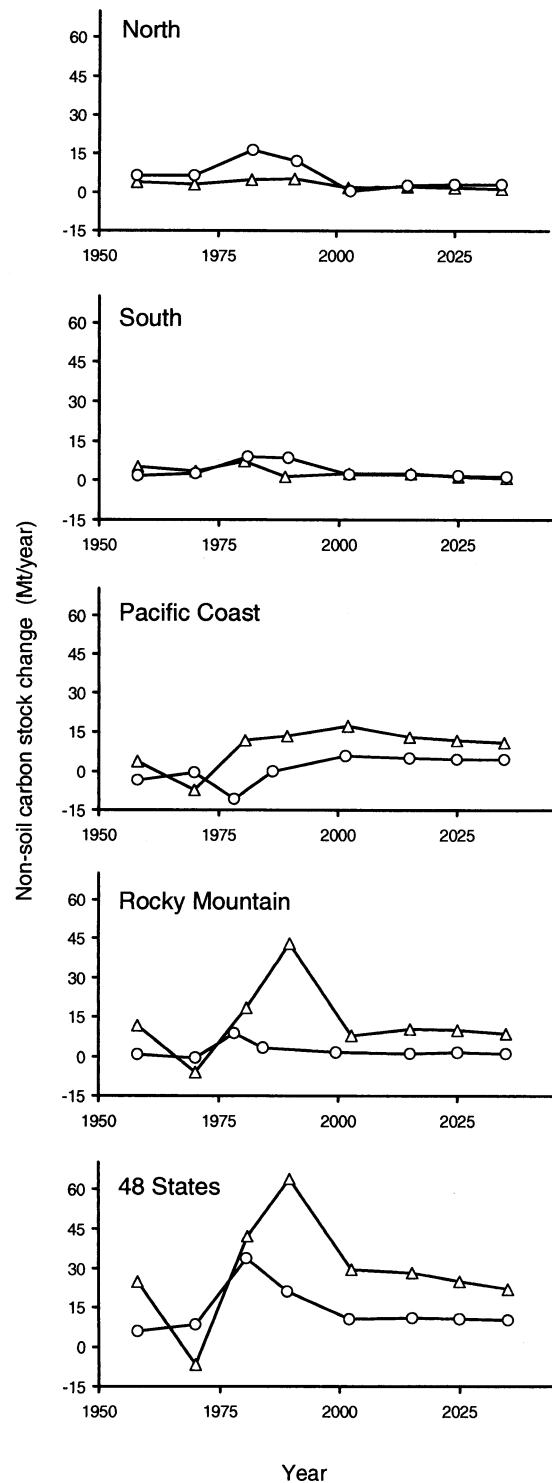

Figure 3. Net ecosystem nonsoil carbon stock change (flux) summarized for the North, South, Pacific Coast, Rocky Mountains, and all 48 states for national forest (Δ) and other public (O) timberlands.

Table 2. Estimated annual carbon flux, or net stock change, for forest ecosystem and harvested wood products of public timberlands[a]

Year	Carbon (Mt/yr)				
	Forest ecosystem	Products in use	Landfills	Emitted with energy capture	Emitted without energy capture
1990	83.1	2.0	7.6	8.0	5.2
1995	65.6	1.4	4.1	4.6	3.3
2000	48.2	1.3	3.5	4.0	2.8
2005	39.9	1.5	3.9	4.7	3.2

[a]Positive values indicate a net increase in carbon sequestration in the respective pool. Note that carbon emitted is returned to the atmosphere; these pools are included to show the relative amount that includes some concomitant energy capture.

large fluctuations in stock change for National Forests in the Rocky Mountains provide a good example of this effect. The apparent extremes in net carbon stock change for Rocky Mountain National Forest centered about 1970 and 1990 would be eliminated by a hypothetical 10% increase in carbon stock for the third and fourth points in Figure 2 (as discussed above). Under this scenario the 1970 value of −6 would become 6 Mt C/yr, and the 1990 value of 43 would become 26 Mt C/yr. This "what-if" effect would similarly affect the extreme net stock changes of the 48-state summary. A qualitatively similar effect could occur with the calculated year of field data for the RPA databases, as discussed for Figure 1. This discussion is simply a demonstration of sensitivity; the stock values provided in Figure 2 are our best estimates.

Wood products are harvested from US forests, and many products act as carbon sinks for varying lengths of time. Thus, comprehensive carbon budgets include sequestration by harvested wood products. We estimated carbon flux in products pools based on Skog and Nicholson (1998) and Haynes (2003). Results in Table 2 indicate that including pools of carbon in harvested wood products increases net sequestration by public timberlands by about 10% as compared with simply counting ecosystem totals (total for 2000 from Figure 2 is 48.3 Mt carbon and total of carbon going into products in use and landfills for 2000 from Table 2 is 4.8 Mt carbon). Additionally, an appreciable amount of energy capture is included in the total reemitted through burning or decay. Approximately 8% of the carbon sequestered in products and landfills for 2000 was from public timberlands [compare Table 2 with Table 6-4 of US EPA (2003)].

Carbon stocks for National Forest and Other Public timberlands were estimated by Birdsey and Heath (1995) for the same interval, 1953–2040 (Figure 4). The two efforts are ostensibly similar: both are based on FORCARB and RPA forest resource data. Birdsey and Heath (1995) relied on 1992 RPA data (Powell and
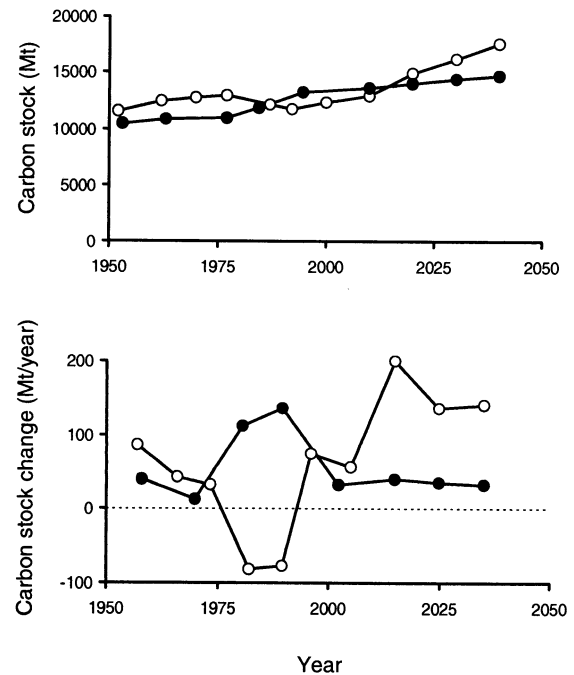

Figure 4. Forest ecosystem carbon stocks (including soil) and net annual stock change for publicly owned timberlands in the conterminous United States as estimated by this report (closed symbols) and Birdsey and Health (1995) (open symbols).

others 1993); earlier inventories remained as aggregate summaries and inventory projections were not based on ATLAS simulations. The earlier version of FORCARB had different specific carbon pool estimators (Birdsey 1992) than are currently used in FORCARB2. Nevertheless, overall magnitude of carbon stocks was generally similar (Figure 4). A separate estimate of carbon on public forestlands, using essentially the same carbon estimators, found values similar our projections for nonsoil carbon between 1990 and 2040 (Turner and others 1995).

Table 3.   Estimates of current regional average carbon density (metric tons carbon per hectare) and area (1000 hectares) for forest ecosystem carbon pools

Region[a]	Carbon pool/area	Carbon (t/ha)			
		National forest timberlands	Other public timberlands	Reserved forestlands	Other forestlands
GP	Biomass	55.7	52.6	58.5	15.0
	Nonliving plant mass	31.7	27.9	29.2	13.3
	Soil organic carbon	86.9	116.6	97.7	97.9
	Area (1000 ha)	413	104	27	77
NC	Biomass	66.2	60.1	63.3	26.3
	Nonliving plant mass	28.4	29.2	28.1	30.4
	Soil organic carbon	158.9	172.9	161.4	176.5
	Area (1000 ha)	3,106	5,984	1,109	344
NE	Biomass	100.3	85.6	43.8	40.1
	Nonliving plant mass	31.7	26.7	24.9	25.7
	Soil organic carbon	132.5	122.9	135.4	135.0
	Area (1000 ha)	876	3,205	1,987	129
SC	Biomass	79.0	79.0	80.9	28.2
	Nonliving plant mass	17.8	17.1	16.7	8.5
	Soil organic carbon	93.5	109.1	93.4	88.0
	Area (1000 ha)	2,645	2,057	530	28
SE	Biomass	81.1	67.0	78.4	31.5
	Nonliving plant mass	17.0	15.7	16.6	8.4
	Soil organic carbon	98.8	114.2	114.1	85.0
	Area (1000 ha)	1,906	1,983	1,274	2
PNWW	Biomass	188.8	133.0	180.8	36.0
	Nonliving plant mass	70.0	53.0	72.3	24.1
	Soil organic carbon	110.5	98.1	128.5	85.1
	Area (1000 ha)	2,878	1,859	1,326	76
PNWE	Biomass	63.8	73.8	91.5	30.5
	Nonliving plant mass	44.1	44.2	54.4	26.5
	Soil organic carbon	90.2	84.5	116.0	61.6
	Area (1000 ha)	4,370	405	1,031	533
PSW	Biomass	115.9	138.5	98.1	32.8
	Nonliving plant mass	56.5	65.8	50.4	28.4
	Soil organic carbon	90.1	79.0	85.1	68.9
	Area (1000 ha)	4,013	155	2,596	2,738
RM	Biomass	80.1	63.0	75.3	30.7
	Nonliving plant mass	50.2	46.4	46.4	26.5
	Soil organic carbon	94.6	91.6	88.3	61.4
	Area (1000 ha)	17,377	2,449	7,573	14,932

[a]The regions are: Great Plains (GP), North Central (NC), Northeast (NE), South Central (SC), Southeast (SE), Pacific Northwest-Westside (PNWW), Pacific Northwest-Eastside (PNWE), Pacific Southwest (PSW), and Rocky Mountain (RM).

Current carbon stocks on public forestlands for the nine regions and four classifications of forestland are summarized in Table 3. Listed are average carbon density for biomass (live trees and understory), nonliving plant mass (standing dead trees, down dead wood, and forest floor), and soil organic carbon. Also listed are total areas for each forest. Values are from FORCARB2 estimates made directly from the plot-level 2002 RPA forest database. Total carbon stocks are 8.9, 4.3, 4.0, 2.3 Gt for national forest timberlands, other public timberlands, reserved forestlands, and other forestlands, respectively. Of the total 19.5 Gt carbon stock in public forest ecosystems,

10.3 Gt is in nonsoil carbon pools. The total is approximately 43% percent of the total nonsoil carbon stock for all forestland in the conterminous United States as provided by Table 6-5 in US EPA (2003).

In conclusion, we have demonstrated the feasibility of estimating carbon sequestration on publicly owned forestlands where limitations with inventory data have previously limited our ability to adequately estimate net carbon change. In comparison with current forest carbon inventories (US EPA 2003), an estimated 33% of the net annual stock change for nonsoil forest ecosystem carbon was on publicly owned forestlands for

2001–2002. This same carbon pool represents about 43% of total carbon stock and is on about 37% of forestland in 2002. Current estimates of net annual flux over the 1953–2040 interval indicate slightly lower rates of net carbon sequestration as compared with previous estimates (Figure 4). Despite the apparent recent reduction in rate of sequestration (Table 2), total forest carbon stocks continue to increase (Figure 2). Net accumulation is projected to continue increasing in the near future (Figure 3).

Acknowledgements

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