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Revised

U.S. Forest Carbon Calculation Tool: Forest-Land Carbon Stocks and Net Annual Stock Change

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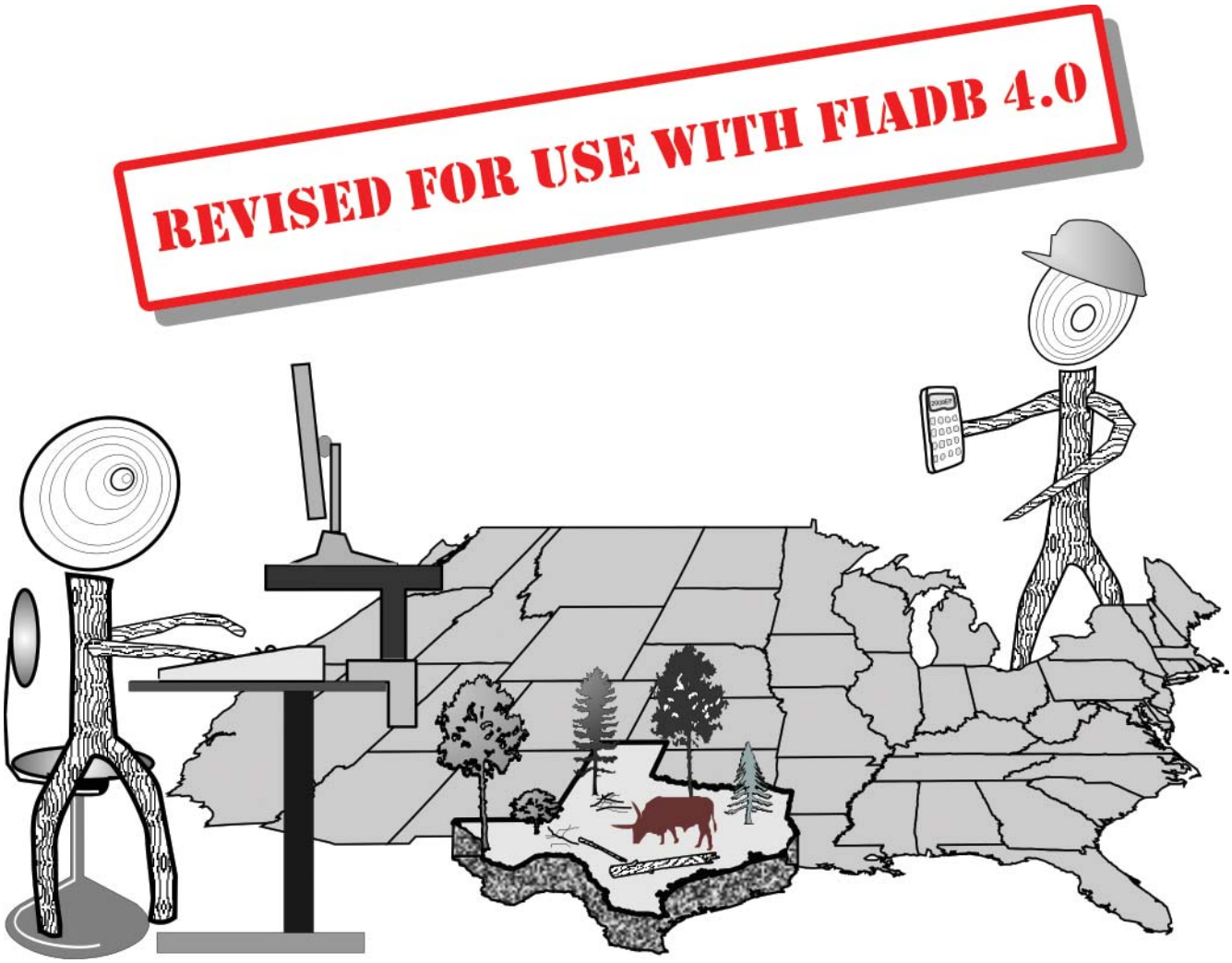

Abstract

The Carbon Calculation Tool 4.0, *CCTv40.exe*, is a computer application that reads publicly available forest inventory data collected by the U.S. Forest Service's Forest Inventory and Analysis Program (FIA) and generates state-level annualized estimates of carbon stocks on forest land based on FORCARB2 estimators. Estimates can be recalculated as new inventory data become available. The input set of FIA data files available on the Internet (as well as some older inventory files used to fill in gaps) are summarized by the application, converted to carbon stocks, and saved as part of a state or substate level "survey summary" file. This is used to produce state-level and national tables with annualized carbon stocks and flux (or net stock change) beginning with the year 1990. This user's guide includes instructions for use, example data sets, and a discussion of methods and assumptions.

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The computer program described in this publication was created using funding from the U.S. Environmental Protection Agency (EPA) and the USDA Forest Service for the purpose of estimating annual carbon stock change estimates for U.S. forests beginning in 1990 through current year for the EPA's National Greenhouse Gas Inventory.

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QUICK START GUIDE

The Carbon Calculation Tool 4.0, *CCTv40.exe*, is a computer application that reads publicly available forest inventory data collected by the U.S. Forest Service's Forest Inventory and Analysis Program (FIA) and generates state-level annualized estimates of carbon stocks on forest land based on FORCARB2 estimators. Estimates can be recalculated as new inventory data become available. The input set of FIA data files available on the Internet (as well as some older inventory files used to fill in gaps) are summarized by the application, converted to carbon stocks, and saved as part of a state or substate level "survey summary" file. This is used to produce state-level and national tables with annualized carbon stocks and flux (or net stock change) beginning with the year 1990.

The entire application is oriented around the survey summary file. Operations are designed for: 1) updating the survey summary file based on new FIA inventory data; or 2) generating annualized estimates from the summaries. On startup of *CCTv40.exe*, a window with three buttons appears. The choices are to: obtain data from FIA, update the survey summary, or produce annualized estimates (Fig. 1). Note that CCT modifies the original survey summary file or a more recent version of the same file format.

Obtain Data from FIA

This button opens a web browser to the FIA site for downloading the FIADB 4.0 inventory data files, which are organized and identified by state. The four files needed for each state are POP_EVAL_GRP, PLOTSNAP, COND, and TREE, which are available in *.zip* (or compressed) or *.csv* (comma separated) formats. All downloaded and unzipped inventory data must be saved together in a single location, for example, all sets are placed together in the "DataFiles" folder.

Update Survey Summary File

This button opens a window for modifying the current survey summary file (initially, *survey_summary_04Dec09.csv* in the "SurveySummaryFiles" folder). Specify the current survey summary file and the directory containing the inventory data files, and then click the "Start" button. The current survey summary list appears in the lower right box, and a list of potential survey updates appears in the lower left box. List items are selected or unselected by clicking and highlighting. Surveys are moved from left to right by the two update buttons if an update is needed (as evaluated by CCT) or forced (overwrite). Execution of the update buttons may take some time. "Save + Clear" opens a save dialogue box for saving the modified survey summary file.

Produce Annualized Estimates

This button opens a window to produce tabular annualized stock and flux estimates. Specify the survey summary file, the output directory, the summary sets of carbon pools, and the method for developing the annualized values. Then select the desired tables and click "Generate the Selected Tables" to produce them. File names are based on the survey summary.

Changes in the Carbon Calculator Tool

The Carbon Calculation Tool has been revised to make it compatible with the current format of FIA inventory data—FIADB 4.0 (USDA For. Serv. 2009c, b). The resulting changes principally affect three general aspects of the calculator: 1) downloading inventory data; 2) processing and summarizing surveys; and 3) determination of annualized stock and change values. The Internet download page has a different appearance, and the organization of data tables has changed. Surveys from all years are combined into single tables. Four data tables are required for each state, these are: POP_EVAL_GRP, PLOTSNAP, COND, and TREE.

Within each state, inventory data are associated with evaluation groups and expanded to population totals according to methods described in the FIADB 4.0 User's Guide (USDA For. Serv. 2009a). Each evaluation group is associated with a nominal reporting year. The expansion methods represent a slight change in data processing. The older non-FIADB data were also reprocessed to be consistent with these methods. As in the previous version of CCT, all state-level population summaries match separately published FIA data summaries.

An important change associated with the "Produce Annualized Estimates" window affects the development of the annualized stock and stock-change values for 1990 to present. The interpretation and use of the FIA annual inventory data has the potential to affect trends in annualized estimates for some states. CCT 4.0 now offers our preferred default method as well as alternate methods for compiling these annual data. Details are provided in the text.

INTRODUCTION

The Carbon Calculation Tool 4.0, CCT, is an interactive executable program that reads publicly available forest inventory data collected by the U.S. Forest Service's Forest Inventory and Analysis Program (FIA) and generates state-level annualized estimates of forest carbon stocks based on FORCARB2 estimators (Heath and others 2003, Smith and others 2004a). Specifically, these inventory data are in the Forest Inventory and Analysis Database (FIADB) available on the Internet (USDA For. Serv. 2009b). Values for average net annual carbon stock change on forest lands[1] are based on annualized differences between successive stocks. These calculated stock changes also are referred to as flux hereafter, which is consistent with the use of the term in reporting forest carbon (for example, U.S. EPA 2009). These inventory-based methods for developing estimates of forest carbon for the United States are consistent with standard methodologies such as those in "Good Practice Guidance for Land Use, Land Use Change, and Forestry" (Penman and others 2003) developed by the Intergovernmental Panel on Climate Change (IPCC). Calculations replicate the process that we use to develop estimates of forest carbon supplied to the U.S. Environmental Protection Agency (EPA) for the annual "Inventory of U.S. Greenhouse Gas Emissions and Sinks" (U.S. EPA 2009).

The calculation tool:

- Estimates state-level forest ecosystem carbon stocks and provides annualized stock and flux estimates for 1990 to the present
- Provides a means of updating estimates to reflect changes in or additions to forest inventory data as new data become available on the Internet[2]
- Produces tabular summaries by state or national total (49 states)[3] for forest ecosystem pools identified as "good practice" by the IPCC (Penman and others 2003) and reported in EPA's annual inventory of greenhouse gas emissions and sinks (for example, see U.S. EPA 2009)

The use of CCT can be described as two sequential, separate, steps. First, FIA data are used to develop estimates of forest carbon stocks at state or substate levels. These carbon stocks are defined for each state according to reporting year, or evaluation group, in the FIADB. In the second step, the stock-change method is applied to all or a subset of reporting years to produce annualized stock and flux. "Annualized" values are essentially

[1]Forest land in the United States includes land that is at least 10-percent stocked with trees of any size. Timberland is defined as unreserved productive forest land producing or capable of producing crops of industrial wood. Productivity is at a minimum rate of 20 cubic feet of industrial wood per acre per year. The remaining portion of forest land is classified as "reserved forest land," which is forest withdrawn from timber use by statute or regulation, or "other forest land," which includes forests that are incapable of growing timber at a rate of less than 20 or more cubic feet per acre per year (Smith and others 2009).

[2]CCT is released with a survey summary file that reflects the full set of FIA inventory data available at a particular date. The current version includes data posted to the Internet on December 4, 2009, as reflected in the filename: *survey_summary_04Dec09.csv*. Thus, the set of annualized estimates generated from this survey summary are based on the FIA datasets included on the CD. Any changes in the annualized estimates depend on postings of new or revised FIA data after the aforementioned date.

[3]Hawaii and portions of Alaska are omitted because inventory data are currently unavailable.

the interpolated values (between successive reporting years) that correspond to the integer years 1990 through the current year. A survey summary file, which is modified by information obtained in the first step and is the starting point of the second step, is the core data file underlying CCT.

Factors used to convert FIA inventory variables to carbon are consistent among inventories and states. However, in the past, the timing, coverage, and survey methods of forest inventories were sometimes inconsistent—over time or among states. Because the stock-change method requires consistent sequential sets of inventory data, some state-specific methods for adapting and augmenting FIA data are applied by CCT. In some cases, inventories are subdivided to substate classifications; in other cases, older FIA inventory data[4] are used to supplement those currently available on the Internet. These modifications are reflected in the organization of the survey summary file.

Annualized outputs of stock and flux are organized according to year (1990 to present), state, and carbon pool. The forest ecosystem carbon pools identified for EPA and IPCC reporting are above- and belowground biomass, dead wood, litter, and soil organic carbon. However, CCT output allows for allocating biomass to live trees or understory vegetation. Similarly, dead wood can be allocated to standing dead trees or down dead wood (also known as coarse woody debris). Operational and then methodological details follow, in that order.

CCT PARTS AND BASIC OPERATION

The application is structured around a fundamental list of carbon stocks associated with each available inventory. This list, called the survey summary file (the initial version is *survey_summary_04Dec09.csv*), is located in the ”SurveySummaryFiles” folder. Thus, CCT focuses on: 1) updating the survey summary file from FIA data; or 2) using the survey summary file to generate annualized stock and flux estimates. Note that CCT uses only one survey summary file at any one time, but multiple versions of survey summary files are also possible because the survey summary represents a composite of a specific set of FIA inventory data. Alternate survey summary files can represent subsets of these data, such as data available for download as of a specified date, for example. When the data change, it is possible to save a new summary under a different name. Once CCT is started (by double clicking on the shortcut to *CCTv40.exe*), a window with three buttons appears. The choices are obtaining data from FIA, updating the survey summary file, or producing annualized estimates (Fig. 1). Each button opens a new window. The first-time use of CCT and use of windows opened by the three buttons are described in the sections that follow.

First-Time Use

The CCT package contains three folders: “CCT”, “ArchiveRPAData” and “FIA_zipped.” The CCT folder includes the program executable and all necessary program files. The two remaining folders contain data used to develop the current survey summary file;

[4]Older FIA data also are publicly available but not necessarily for download from the Internet. See Appendix B or methods discussed in the text.

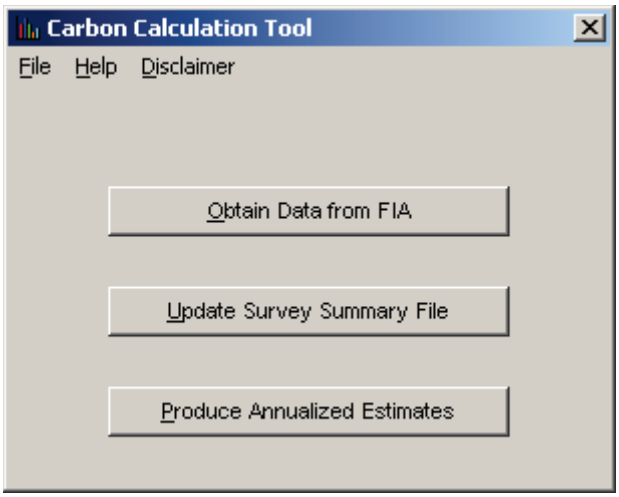

Figure 1A.

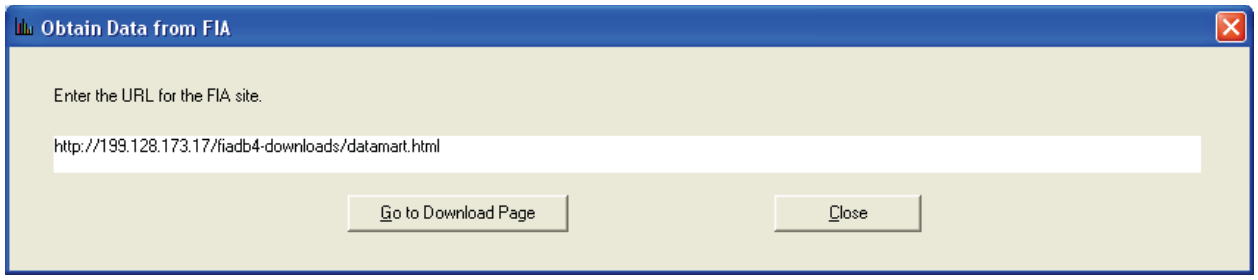

Figure 1B.

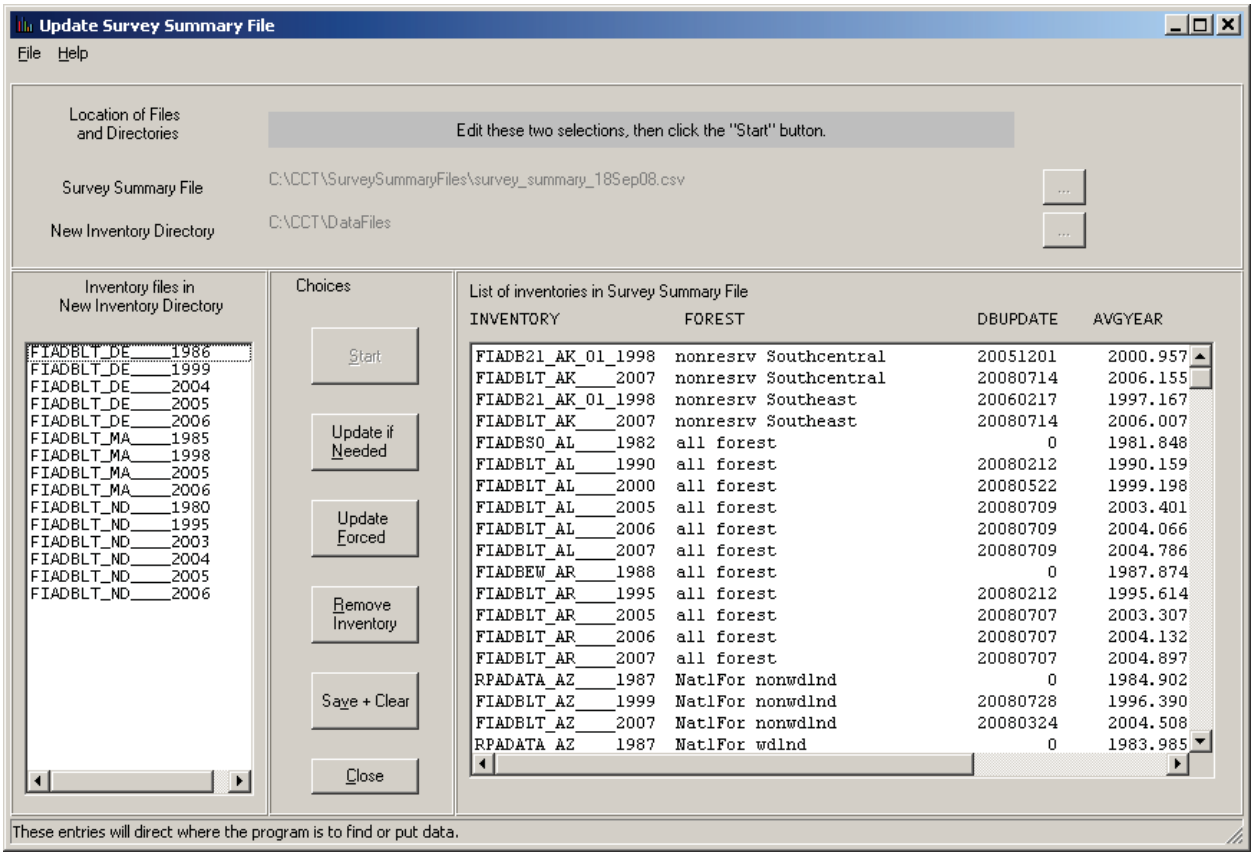

Figure 1C.

Figure 1.—Carbon Calculation Tool 4.0 interface windows: (A) Startup window, (B) Obtain Data from FIA window, (C) Update Survey Summary File window, and (D) Produce Annualized Estimates window.

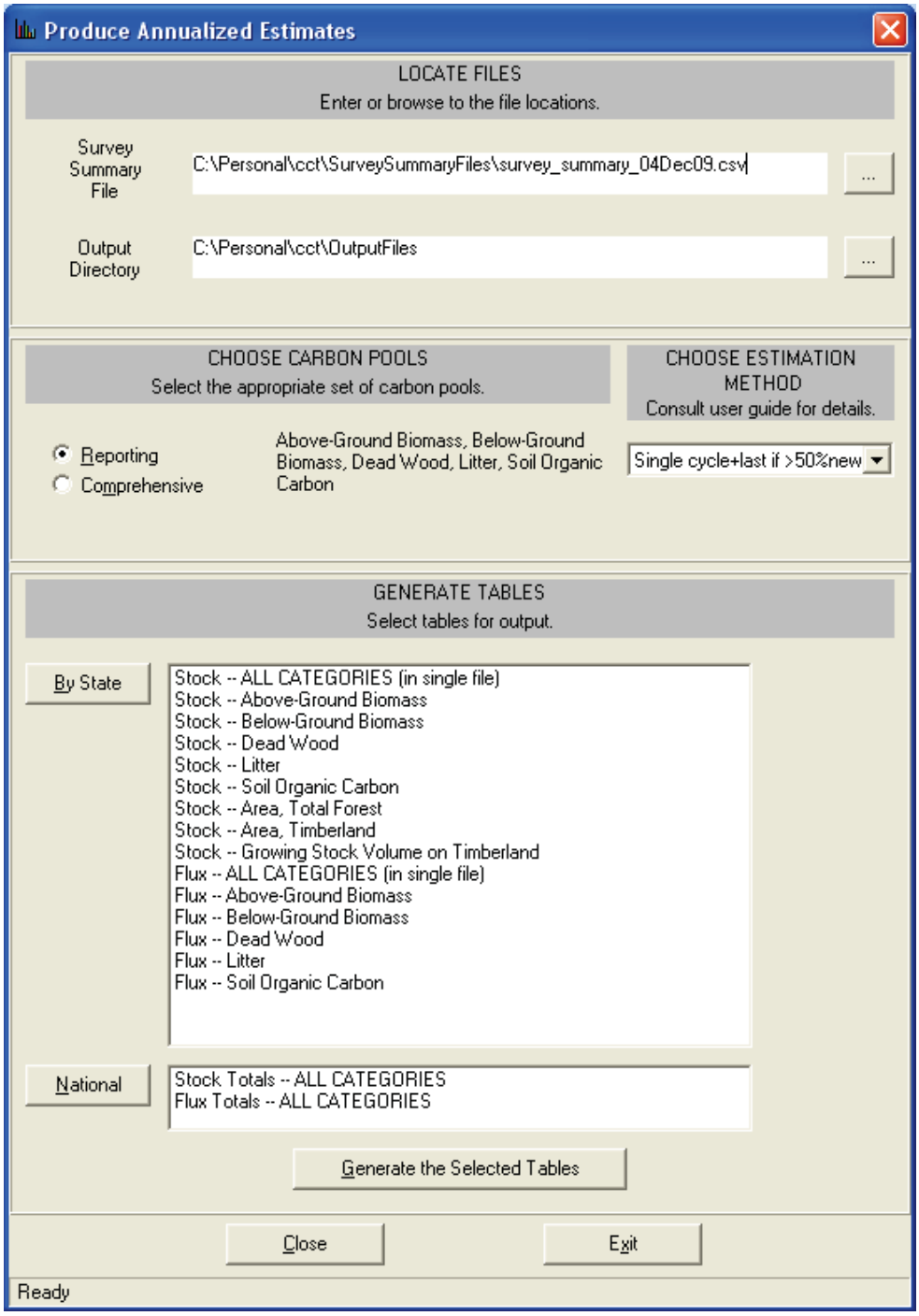

Figure 1D.

these may be useful only as background or example data. See Appendix A for details on the contents of the CCT electronic media. CCT cannot be run directly from the CD/DVD because the tool needs to write files to a drive. The first step is to copy the CCT folder to any location on your hard drive. Then reset the properties from read-only (this is often the case when copied from a CD/DVD) by right-clicking on the newly copied version of the CCT folder, selecting "Properties" from the list, unchecking the read-only attribute, and applying changes to the folder, subfolder, and files.

Within the CCT folder, the "CCTFiles" folder includes the executable (*CCTv40.exe*) and other necessary files for execution (for example, *.dll's*). We suggest making a shortcut to *CCTv40.exe* to start CCT and leave the contents of CCTFiles undisturbed once they are copied onto your PC. To make the shortcut, open the CCTFiles folder, right-click on *CCTv40.exe*, and select "Create Shortcut." Drag the newly created shortcut to a location outside of the CCTFiles folder and use it to launch the application. "UserGuideandExamples" includes the CCT user's guide, example tables in spreadsheet format, and text files with additional information on the current version of CCT. The "SurveySummaryFiles" folder includes our initial and recommended version of the comma-delimited survey summary file (*survey_summary_04Dec09.csv*).

The three folders—"DataFiles,"[5] "SurveySummaryFiles", and "OutputFiles"—are provided as locations for input FIA data, intermediate results, and output tables, respectively. You can rename or relocate these folders as desired because names and locations are specified from within CCT when accessing or saving data. These can be relocated to any directory. The DataFiles folder is the only one likely to require significant storage space because it contains the potentially large FIA inventory data files.

Start the application by double-clicking on the shortcut to *CCTv40.exe*.

Obtain Data from FIA

This button facilitates downloading inventory data directly from the FIA Internet site. Clicking on the button opens a dialog box in which a web address can be specified. Clicking on "Go to Download Page" opens a web browser to the indicated web address. It is initially set to http://199.128.173.17/fiadb4-downloads/datamart.html,[6] which is currently the address for the FIADB DataMart, the site for downloading FIA data files (USDA For. Serv. 2009b). The application currently processes version 4.0 files; when FIA changes the format of the files, the current version of the application may not be able to process them correctly. Thus, we expect to update this program as needed and will post these updates at the Northern Research Station website (http://nrs.fs.fed.us/carbon/tools).

FIADB files are available for download in .zip (compressed) format. Only 4 tables are used by CCT: POP_EVAL_GRP, PLOTSNAP, COND, and TREE. The link to "Recent load history" near the top of the page gives the dates when each of the states' inventories was loaded. It is necessary to download only files that have been loaded since the last comprehensive download. There are multiple methods of obtaining the files needed by CCT. You may click on a state on the leftmost U.S. map near the top of the web page. This will enable you to download one *.zip* file per state which contains all

[5]The CD includes several example sets of FIADB 4.0 files in the DataFiles folder.

[6]Should this link fail, try again later as the web server might be down or there may be network problems, or FIA may have changed the web address. To locate the new address, open a web browser and navigate to the FIA home page: http://www.fia.fs.fed.us/, then, follow links to "Data" until a link appears for download of "FIADB 4.0" files. Once the download page is located, copy the new web address (highlight and Ctrl+C) and paste (Ctrl+V) into the text box on the "Download Data from FIA" window, replacing the former address. Upon exiting normally from CCT, the new web address is saved for future use.

of that state's data. Repeat these steps for additional states you want. Another method would be to scroll down the web page until you find the state(s) you want. Here, you can either download a state's complete file (as above), or you can download only the four individual files needed by CCT. Each state's *.zip* file contains up to 47 files in *.csv*, or comma separated, format. After downloading, the files need to be extracted (unzipped). All downloaded and unzipped files must be saved together in a single location. For example, all sets of four files can be placed together in the DataFiles folder.

Update the Survey Summary File

This button opens a window used for modifying and renaming the survey summary file (initially, *survey_summary_04Dec09.csv* in the SurveySummaryFiles folder). The upper portion of the window allows you to specify the directory and name of the current survey summary file and the directory containing the input FIA data files. Fill in the boxes by typing, pasting, or browsing. File and directory names are retained and become the default values in these boxes the next time the window is opened. Once selections are made, click the "Start" button.

After files and directories are selected successfully, lists of text should appear in the two large lower boxes. Information about records in the current survey summary file is listed in the lower right box. A list of names identifying FIA inventory files appears in the lower left box. The list includes only FIA inventories that are in the designated input directory, contain a complete set of files, and represent potential updates to the survey summary list on the right. To choose list items for processing, click on each item to highlight (Ctrl+Click for multiple selections and Shift+Click to select a block of items).

Information from the survey summary file displayed in the box to the right identifies the survey (first two columns: INVENTORY and FOREST) and specifies two dates associated with the data (the two remaining columns: UPDATED and AVGYEAR). The first value (INVENTORY) generally is taken from FIA filenames and includes the state, and reporting year of the survey.[7] This label distinguishes the current downloadable FIADB files from the older FIA data sources (see the methods section and Appendix B). The second column (FOREST) identifies specific substate divisions used by CCT. For example, four states (Oklahoma, Oregon, Texas and Washington) are subdivided into east and west, and many states have summaries for National Forests, reserved lands, or woodlands separate from all other forest land within the state. These first two columns (INVENTORY and FOREST) uniquely identify each survey and thus each record in the survey summary file. Annualized stock and flux estimates are based on successive sets of surveys uniquely identified by state and FOREST (see methods section). The third column (UPDATED) displays the date of the most recent update of that set of inventory data. This column is set to zero for records based on non-FIADB surveys. The last column (AVGYEAR) is the average year of field-data collection for the entire set of data associated with each survey. See Table 1 for an explanation of the variables included in the survey summary file.

[7]For non-FIADB inventory formats, this reporting year is *inventory year*, which is a year selected by FIA that best represents the inventory, presumably when the majority of data were collected. For RPA datasets, the year given is the year associated with the published assessment.

Table 1.—Variables in the output tables or the survey summary file

Variable	Value represented
INVENTORY	Identifies the source of the inventory data as FIADBLT (FIADB 4.0 – Lite), FIADBEW (Eastwide), FIADBWW (Westwide), FIADBSO (Southern FIA), or RPA data. The variable also includes information to identify the state and reporting year (that is, nominal year associated with an inventory) of each inventory.
FOREST	A classification for subdividing surveys in some states. If no subdivisions are made in a state, this is listed as "All forest". When National Forests are treated as a group, they are identified as "NatlFor" with remaining forest being identified as "nonNatlFor." When National Forests are considered individually, they are identified by name, with remaining National Forests in that state labeled as "Other NatlFor." Reserved lands are identified as "Resrv" with remaining land being "Nonresrv." Woodlands are identified as "Wdlnd" with other forest in that state identified as "Nonwdlnd." Substate portions of Oklahoma, Oregon, Texas, and Washington are also identified by "East," "West," or "Central."
AVGYEAR	The average year for field collection of the plot-level inventory data assigned to the survey. For example, the midpoint of 1992 is represented as 1992.5.
UPDATED	The date of last update or change in the files used to develop the summary, in the form YYYYMMDD (FIADB 4.0 only).
STATECD	A 2-digit code (FIPS) to identify the state (an FIA variable).
AVGCYCLE	The average inventory cycle number for that state (FIADB 4.0 only).Records based on data other than FIADB 4.0 are set to zero.
AREA_kha	Area of forest land in 1,000 hectares (kilohectares).
TMLDAREA_kha	Area of timberland in 1,000 hectares (kilohectares).
TREE_AG_Tg	Total carbon stock in above-ground portions of live trees (teragrams). Units in flux tables are teragrams per year (TREE_AG_Tgpy).
TREE_BG_Tg	Total carbon stock in below-ground (coarse root) portions of live trees (teragrams). Units in flux tables are teragrams per year (TREE_BG_Tgpy).
UNDERSTORY_Tg	Total carbon stock in understory (teragrams). Units in flux tables are teragrams per year (UNDERSTORY_Tgpy).
LIVE_AG_Tg	Total carbon stock in live above-ground biomass (teragrams). Units in flux tables are teragrams per year (LIVE_AG_Tgpy). This value is not in the survey summary file but is calculated from output for live tree and understory.
LIVE_BG_Tg	Total carbon stock in live below-ground biomass (teragrams). Units in flux tables are teragrams per year (LIVE_BG_Tgpy). This value is not in the survey summary file but is calculated from output for live tree and understory.
STANDINGDEAD_Tg	Total carbon stock in standing dead trees (teragrams). Units in flux tables are teragrams per year (SD_Tgpy).
DOWNDEAD_Tg	Total carbon stock in down dead wood (also known as coarse woody debris; teragrams). Units in flux tables are teragrams per year (DD_Tgpy).
DW_Tg	Total carbon stock in dead wood (teragrams). Units in flux tables are teragrams per year (DW_Tgpy). This value is not in the survey summary file but is calculated from output for standing dead tree and down dead wood.
FF_Tg	Total carbon stock in litter (also known as forest floor; teragrams). Units in flux tables are teragrams per year (FF_Tgpy).
SOC_Tg	Total stock of soil organic carbon (teragrams). Units in flux tables are teragrams per year (SOC_Tgpy).
TMLDGSVOL_Mm3	Total of live growing-stock volume on timberlands in million cubic meters (Mm^3).
STATE	The state name is included as a convenience for users who want to construct tables from the survey summary file or output datasets.

Updates to the specified survey summary file are achieved by creating new summaries from the selected data on the left (input FIA data files) and adding them to the right. Depending on the data, the newly calculated summaries can replace existing records on the survey summary list or add new records. Buttons allow some flexibility when specifying updates to the survey summary file. An "Update if Needed" button allows you to add new files (takes files listed on the left and adds to the right box) if the data in those files represent an update. The need for the updates is determined by CCT according to classification (INVENTORY and FOREST) and date of last modification (UPDATED). Alternatively, selecting one or more inventories on the left and clicking the "Update Forced" button allows you to force the application to accept the input data to overwrite existing summary data, regardless of the most recent date of the inventory data. The "Remove Inventory" button deletes the selected records from the survey summary list (on the right).

Once all modifications or updates are complete, you can save the revised survey summary under the same or different name by clicking the "Save + Clear" button, which opens a save dialogue box. To leave the window without saving changes, click on the "Close" button.

A "log" file is created to document changes to the survey summary file, which correspond to changes in the summary information appearing in the lower right box. The log is located in the same directory as the survey summary file, and its name is based on the survey summary file. Thus, as the survey summary file is modified and saved in CCT these changes are documented in a readily viewed text file. Existing log files are appended as the corresponding survey summary file is changed; if the file is renamed, a new log is created. This log file is created for the convenience of users interested in this documentation.

All FIADB inventories placed in the specified DataFiles folder that include the set of four necessary files can be processed by CCT. However, some FIADB inventory data are excluded from updating the surveys listed in the lower right box. This includes some older datasets that do not cover all forest land within a state. The list in the lower left box will include these inventories but only apply the usable portion to the survey summary list in the lower right box. CCT processing detects and excludes these data from the survey summary. For example, the 1985 data for Arizona are complete only for non-National Forest land. Therefore, the 1985 inventory for Arizona is listed in the lower left box, but only the non-National Forest portion of the data are processed and listed in the lower right box. Surveys included and excluded by CCT are listed in Tables 2 and 3, respectively; see the methods section for further explanation.

The execution time required after clicking an update button varies according to the number and size of the inventories selected.[8] Execution time of calculations for a single

[8]Ninety percent of the individual-state calculations took less than 2 minutes each on a PC with a Pentium 4, 3 Ghz processor (1.048 GB RAM). The maximum time was just over 14 minutes (based on the September 8, 2006 datasets).

survey usually is less than a minute; recalculation of all FIADB files currently posted to the Internet may exceed two hours. This variable length of time required after clicking either update button is the only discernable time required for any CCT operation. Should you wish to halt execution during an update, type Ctrl+Alt+Delete and select the Task List; next, select Carbon Calculation Tool on the Applications tab of the Windows Task Manager. Finally, click "End Task" and then exit the Task Manager. Updates for each survey are added to the list as they are calculated so that halting a long list of updates may result in a survey summary list that is difficult to evaluate. If it is necessary to halt an update, the simplest path to recovery may be to start over with the last good version of the survey summary file (a good reason to periodically change the name or save older versions).

Produce Tables of Annualized Estimates

This button opens a window used to produce arrays of annualized stock and flux estimates that are generated from a specified survey summary file and then saved as output files. If necessary, fill in the location and name of a survey summary file and an output directory. Filenames for the output tables are constructed automatically by appending a specific table identifier to the name of the survey summary file. All output tables are comma-delimited text files.

The annualized estimates are based on the survey summary file, which resolves each state's inventory (or survey) to a population total carbon stock for all forestland at a specific time (i.e., a precise carbon stock at a precise time). Linear interpolation between successive inventory summaries provides annualized carbon stocks for the intervening years, and extrapolation beyond the most recent inventory provide annualized stocks up to the current year. Specifically, annualized values are the interpolated or extrapolated carbon stocks corresponding to integer years. Typically, the average years (AVGYEAR) of the summaries are not whole numbers. Annualized stock change is based on the difference between successive year's annualized stocks.

Annualized totals for stock and stock change can be subdivided according to state or carbon pool classifications. Two suites of carbon pools are possible: 1) Reporting: above- and below-ground biomass, dead wood, litter, and soil organic carbon; or 2) Comprehensive: above- and belowground live trees, understory, standing dead trees, down dead wood, forest floor, and soil organic carbon. The "reporting" set of pools are the forest ecosystem pools identified as "good practice" by the IPCC (Penman and others 2003) and reported in the annual inventory of greenhouse gas emissions and sinks (U.S. EPA 2009). The "comprehensive" set of pools corresponds to the set of inventory-to-carbon conversion factors. The set of ecosystem carbon pools included in the available output tables depends on the selected setting. If you change the set of pools selected, the list of available output tables also changes.

The full set of forest inventories available for making the carbon stock-change calculations are compiled and summarized in the survey summary file. The net list is also the result of some filtering of incomplete summaries from the FIADB and the

Table 2.—Summary of average year, area, and volume for the separate surveys identified for use by CCT from currently available FIADB 4.0 and other datasets

State	Inventory	Forest[a]	Average year	Average cycle	Forest area	Timberland Area
					thousand ha	*thousand ha*
Alabama	SOFIA, 1982	All forest	1981.85	--	8,774	8,765
Alabama	FIADB 4.0, 1990	All forest	1990.16	6	8,889	8,876
Alabama	FIADB 4.0, 2000	All forest	1999.20	7	9,303	9,277
Alabama	FIADB 4.0, 2005	All forest	2003.40	8	9,184	9,138
Alabama	FIADB 4.0, 2006	All forest	2004.07	8.14	9,132	9,089
Alabama	FIADB 4.0, 2007	All forest	2004.79	8.30	9,153	9,118
Alabama	FIADB 4.0, 2008	All forest	2005.56	8.44	9,219	9,186
Alaska	FIADB 4.0, 2008	Nonresrv Southcentral	2006.69	2	1,075	762
Alaska	FIADB 4.0, 2008	Nonresrv Southeast	2006.56	2	2,916	1,736
Alaska	FIADB 4.0, 2008	Resrv Southcentral	2006.21	2	679	0
Alaska	FIADB 4.0, 2008	Resrv Southeast	2005.74	2	1,521	0
Arizona	RPA, 1987	NatlFor nonwdlnd	1984.90	--	1,504	1,000
Arizona	FIADB 4.0, 1999	NatlFor nonwdlnd	1996.20	2	1,322	973
Arizona	FIADB 4.0, 2008	NatlFor nonwdlnd	2005.01	3	1,220	969
Arizona	RPA, 1987	NatlFor wdlnd	1983.99	--	2,001	0
Arizona	FIADB 4.0, 1999	NatlFor wdlnd	1996.42	2	2,005	0
Arizona	FIADB 4.0, 2008	NatlFor wdlnd	2004.86	3	1,875	0
Arizona	FIADB 4.0, 1985	NonNatlFor nonwdlnd	1985.77	1	701	502
Arizona	FIADB 4.0, 1999	NonNatlFor nonwdlnd	1995.84	2	723	454
Arizona	FIADB 4.0, 2008	NonNatlFor nonwdlnd	2005.90	3	916	401
Arizona	FIADB 4.0, 1985	NonNatlFor wdlnd	1987.05	1	3,552	0
Arizona	FIADB 4.0, 1999	NonNatlFor wdlnd	1989.53	2	3,811	0
Arizona	FIADB 4.0, 2008	NonNatlFor wdlnd	2005.19	3	3,547	0
Arkansas	Eastwide, 1988	All forest	1987.88	--	7,158	6,979
Arkansas	FIADB 4.0, 1995	All forest	1995.62	7	7,604	7,443
Arkansas	FIADB 4.0, 2005	All forest	2003.31	8	7,396	7,265
Arkansas	FIADB 4.0, 2006	All forest	2004.13	8.21	7,448	7,317
Arkansas	FIADB 4.0, 2007	All forest	2004.90	8.41	7,495	7,367
California	RPA, 1997	NatlFor	1991.06	--	5,748	4,082
California	FIADB 4.0, 2007	NatlFor	2004.94	5	6,443	3,963
California	Westwide, 1994	NonNatlFor	1993.78	--	7,023	3,183
California	FIADB 4.0, 2007	NonNatlFor	2004.71	5	7,068	3,862
Colorado	RPA, 1997	NatlFor nonwdlnd	1981.21	--	4,020	2,786
Colorado	FIADB 4.0, 2008	NatlFor nonwdlnd	2005.57	2	4,081	3,166
Colorado	RPA, 1997	NatlFor wdlnd	1975.18	--	82	0
Colorado	FIADB 4.0, 1984	NatlFor wdlnd	1997.37	1	174	0
Colorado	FIADB 4.0, 2008	NatlFor wdlnd	2005.82	2	391	0
Colorado	Westwide, 1983	NonNatlFor nonwdlnd	1980.48	--	1,975	1,890
Colorado	FIADB 4.0, 2008	NonNatlFor nonwdlnd	2005.68	2	1,933	1,446
Colorado	Westwide, 1983	NonNatlFor wdlnd	1983.26	--	2,351	0
Colorado	FIADB 4.0, 2008	NonNatlFor wdlnd	2005.77	2	2,838	0
Connecticut	FIADB 4.0, 1985	All forest	1984.58	3	754	735
Connecticut	FIADB 4.0, 1998	All forest	1998.39	4	752	686
Connecticut	FIADB 4.0, 2005	All forest	2004.52	5	726	707
Connecticut	FIADB 4.0, 2006	All forest	2005.23	5	707	687
Delaware	FIADB 4.0, 1986	All forest	1985.61	3	158	152
Delaware	FIADB 4.0, 1999	All forest	1999.33	4	155	152
Delaware	FIADB 4.0, 2004	All forest	2004.84	5	163	156
Delaware	FIADB 4.0, 2005	All forest	2005.23	5	172	168
Delaware	FIADB 4.0, 2006	All forest	2005.62	5	148	146
Florida	FIADB 4.0, 1987	All forest	1987.31	6	6,697	6,064
Florida	FIADB 4.0, 1995	All forest	1994.58	7	6,565	5,930
Florida	FIADB 4.0, 2005	All forest	2003.66	8	6,534	6,294

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Table 2.—continued.

State	Inventory	Forest[a]	Average year	Average cycle	Forest area	Timberland Area
					thousand ha	*thousand*
Florida	FIADB 4.0, 2007	All forest	2005.01	8	6,838	6,439
Georgia	FIADB 4.0, 1989	All forest	1988.63	6	9,768	9,565
Georgia	FIADB 4.0, 1997	All forest	1996.94	7	9,880	9,630
Georgia	FIADB 4.0, 2004	All forest	2001.47	8	10,030	9,812
Georgia	FIADB 4.0, 2005	All forest	2002.31	8.18	10,024	9,810
Georgia	FIADB 4.0, 2006	All forest	2003.70	8.41	10,092	9,883
Georgia	FIADB 4.0, 2007	All forest	2004.78	8.62	10,075	9,882
Georgia	FIADB 4.0, 2008	All forest	2005.91	8.81	10,046	9,884
Idaho	Westwide, 1991	Caribou-Targhee NatlFor	1992.22	--	691	642
Idaho	FIADB 4.0, 2008	Caribou-Targhee NatlFor	2006.71	2	746	664
Idaho	RPA, 1987	Kootenai NatlFor	1987.50	--	23	17
Idaho	FIADB 4.0, 1991	Kootenai NatlFor	1994.62	1	20	20
Idaho	FIADB 4.0, 2008	Kootenai NatlFor	2006.81	2	19	19
Idaho	FIADB 4.0, 1991	NonNatlFor nonwdlnd	1990.35	1	2,038	1,900
Idaho	FIADB 4.0, 2008	NonNatlFor nonwdlnd	2006.53	2	1,946	1,778
Idaho	FIADB 4.0, 1991	NonNatlFor wdlnd	1981.58	1	153	0
Idaho	FIADB 4.0, 2008	NonNatlFor wdlnd	2006.10	2	128	0
Idaho	Westwide, 1991	Other NatlFor	1987.77	--	2,978	2,800
Idaho	FIADB 4.0, 1991	Other NatlFor	1999.94	1	3,396	2,707
Idaho	FIADB 4.0, 2008	Other NatlFor	2006.55	2	3,343	2,700
Idaho	RPA, 1987	Payette NatlFor	1981.66	--	832	411
Idaho	FIADB 4.0, 2008	Payette NatlFor	2006.56	2	747	489
Idaho	RPA, 1987	Salmon-Challis NatlFor	1978.08	--	1,225	502
Idaho	FIADB 4.0, 2008	Salmon-Challis NatlFor	2006.61	2	1,250	699
Idaho	Westwide, 1991	Sawtooth NatlFor	1982.72	--	408	363
Idaho	FIADB 4.0, 1991	Sawtooth NatlFor	1996.06	1	424	374
Idaho	FIADB 4.0, 2008	Sawtooth NatlFor	2006.39	2	443	365
Illinois	FIADB 4.0, 1985	All forest	1985.06	3	1,726	1,631
Illinois	FIADB 4.0, 1998	All forest	1997.81	4	1,752	1,654
Illinois	FIADB 4.0, 2003	All forest	2002.89	5	1,754	1,671
Illinois	FIADB 4.0, 2004	All forest	2003.36	5	1,790	1,719
Illinois	FIADB 4.0, 2005	All forest	2003.76	5	1,831	1,766
Illinois	FIADB 4.0, 2006	All forest	2004.58	5.20	1,938	1,870
Illinois	FIADB 4.0, 2007	All forest	2005.42	5.39	1,960	1,900
Indiana	FIADB 4.0, 1986	All forest	1986.29	3	1,797	1,739
Indiana	FIADB 4.0, 1998	All forest	1997.68	4	1,822	1,758
Indiana	FIADB 4.0, 2003	All forest	2001.28	5	1,842	1,785
Indiana	FIADB 4.0, 2004	All forest	2002.29	5.21	1,865	1,807
Indiana	FIADB 4.0, 2005	All forest	2003.36	5.43	1,913	1,860
Indiana	FIADB 4.0, 2006	All forest	2004.35	5.63	1,884	1,832
Indiana	FIADB 4.0, 2007	All forest	2005.65	5.85	1,952	1,900
Indiana	FIADB 4.0, 2008	All forest	2006.70	6	1,920	1,874
Iowa	FIADB 4.0, 1990	All forest	1989.70	3	831	788
Iowa	FIADB 4.0, 2003	All forest	2001.87	4	1,079	1,044
Iowa	FIADB 4.0, 2004	All forest	2002.76	4.20	1,112	1,087
Iowa	FIADB 4.0, 2005	All forest	2003.65	4.44	1,165	1,143
Iowa	FIADB 4.0, 2006	All forest	2004.48	4.63	1,217	1,190
Iowa	FIADB 4.0, 2007	All forest	2005.28	4.81	1,236	1,213
Iowa	FIADB 4.0, 2008	All forest	2006.14	5	1,227	1,202
Kansas	FIADB 4.0, 1981	All forest	1981.24	3	551	490
Kansas	FIADB 4.0, 1994	All forest	1994.21	4	625	603
Kansas	FIADB 4.0, 2003	All forest	2002.64	5	901	862
Kansas	FIADB 4.0, 2004	All forest	2002.99	5	860	829
Kansas	FIADB 4.0, 2005	All forest	2003.39	5	852	821

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Table 2.—continued.

State	Inventory	Forest[a]	Average year	Average cycle	Forest area	Timberland Area
					thousand ha	*thousand*
Kansas	FIADB 4.0, 2006	All forest	2004.43	5.23	851	817
Kansas	FIADB 4.0, 2007	All forest	2005.46	5.45	866	834
Kansas	FIADB 4.0, 2008	All forest	2006.62	5.69	902	853
Kentucky	FIADB 4.0, 1988	All forest	1987.27	4	5,129	4,997
Kentucky	FIADB 4.0, 2004	All forest	2002.33	5	4,860	4,729
Kentucky	FIADB 4.0, 2005	All forest	2003.04	5.20	4,891	4,764
Kentucky	FIADB 4.0, 2006	All forest	2004.01	5.41	4,909	4,782
Louisiana	SOFIA, 1984	All forest	1984.14	--	5,614	5,614
Louisiana	FIADB 4.0, 1991	All forest	1991.37	6	5,581	5,578
Louisiana	FIADB 4.0, 2005	All forest	2003.54	7	5,722	5,680
Maine	Eastwide, 1982	All forest	1982.50	--	7,225	6,955
Maine	FIADB 4.0, 1995	All forest	1995.34	4	7,163	6,860
Maine	FIADB 4.0, 2003	All forest	2001.55	5	7,165	6,962
Maine	FIADB 4.0, 2005	All forest	2003.54	5.40	7,152	6,946
Maine	FIADB 4.0, 2006	All forest	2004.54	5.61	7,161	6,939
Maryland	FIADB 4.0, 1986	All forest	1985.64	4	1,093	981
Maryland	FIADB 4.0, 1999	All forest	1999.62	5	1,038	960
Maryland	FIADB 4.0, 2004	All forest	2004.76	6	972	888
Maryland	FIADB 4.0, 2005	All forest	2005.25	6	1,072	1,022
Maryland	FIADB 4.0, 2006	All forest	2005.88	6	987	929
Massachusetts	FIADB 4.0, 1985	All forest	1984.57	3	1,321	1,200
Massachusetts	FIADB 4.0, 1998	All forest	1997.75	4	1,265	1,065
Massachusetts	FIADB 4.0, 2005	All forest	2004.69	5	1,283	1,197
Massachusetts	FIADB 4.0, 2006	All forest	2005.37	5	1,236	1,172
Michigan	FIADB 4.0, 1980	All forest	1979.79	4	7,433	7,079
Michigan	FIADB 4.0, 1993	All forest	1992.79	5	7,805	7,536
Michigan	FIADB 4.0, 2003	All forest	2002.48	6	7,792	7,554
Michigan	FIADB 4.0, 2004	All forest	2002.83	6	7,815	7,576
Michigan	FIADB 4.0, 2005	All forest	2003.39	6.08	7,826	7,596
Michigan	FIADB 4.0, 2006	All forest	2003.97	6.19	7,909	7,672
Michigan	FIADB 4.0, 2007	All forest	2004.86	6.46	7,976	7,737
Minnesota	FIADB 4.0, 1977	All forest	1977.05	4	6,692	5,518
Minnesota	FIADB 4.0, 1990	All forest	1989.18	5	6,751	5,958
Minnesota	FIADB 4.0, 2003	All forest	2001.41	12	6,568	5,963
Minnesota	FIADB 4.0, 2004	All forest	2002.19	12.20	6,554	5,976
Minnesota	FIADB 4.0, 2005	All forest	2003.20	12.40	6,597	6,048
Minnesota	FIADB 4.0, 2006	All forest	2004.14	12.60	6,633	6,096
Minnesota	FIADB 4.0, 2007	All forest	2005.19	12.80	6,768	6,215
Minnesota	FIADB 4.0, 2008	All forest	2006.20	13	6,876	6,311
Mississippi	Eastwide, 1987	All forest	1986.74	--	6,876	6,872
Mississippi	FIADB 4.0, 1994	All forest	1993.69	7	7,525	7,522
Mississippi	FIADB 4.0, 2006	All forest	2006.77	8	7,941	7,906
Missouri	FIADB 4.0, 1989	All forest	1988.21	4	5,666	5,412
Missouri	FIADB 4.0, 2003	All forest	2001.74	5	5,899	5,692
Missouri	FIADB 4.0, 2004	All forest	2002.66	5.19	5,933	5,734
Missouri	FIADB 4.0, 2005	All forest	2003.57	5.37	5,927	5,749
Missouri	FIADB 4.0, 2006	All forest	2004.42	5.56	6,102	5,935
Missouri	FIADB 4.0, 2007	All forest	2005.29	5.76	6,189	6,032
Missouri	FIADB 4.0, 2008	All forest	2006.27	6	6,231	6,090
Montana	RPA, 1987	NatlFor	1987.50	--	5,598	3,359
Montana	FIADB 4.0, 1989	NatlFor	1996.02	1	5,910	4,707
Montana	FIADB 4.0, 2008	NatlFor	2006.11	2	6,175	4,900
Montana	FIADB 4.0, 1989	NonNatlFor nonresrv	1989.01	1	3,090	3,035
Montana	FIADB 4.0, 2008	NonNatlFor nonresrv	2006.04	2	3,628	3,155

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Table 2.—continued.

State	Inventory	Forest[a]	Average year	Average cycle	Forest area	Timberland Area
					thousand ha	*thousand*
Montana	RPA, 1997	NonNatlFor resrv	1989.50	--	398	0
Montana	FIADB 4.0, 2008	NonNatlFor resrv	2006.26	2	557	0
Nebraska	FIADB 4.0, 1983	All forest	1982.81	2	291	218
Nebraska	FIADB 4.0, 1994	All forest	1994.58	3	382	362
Nebraska	FIADB 4.0, 2003	All forest	2002.67	4	516	471
Nebraska	FIADB 4.0, 2004	All forest	2003.12	4	507	470
Nebraska	FIADB 4.0, 2005	All forest	2003.51	4	504	475
Nebraska	FIADB 4.0, 2006	All forest	2004.46	4.22	533	510
Nebraska	FIADB 4.0, 2007	All forest	2005.54	4.45	535	513
Nevada	RPA, 1987	NatlFor nonwdlnd	1973.60	--	264	40
Nevada	FIADB 4.0, 1989	NatlFor nonwdlnd	1996.58	1	250	95
Nevada	FIADB 4.0, 2005	NatlFor nonwdlnd	2005.07	2	257	102
Nevada	RPA, 1987	NatlFor wdlnd	1978.44	--	701	0
Nevada	FIADB 4.0, 1989	NatlFor wdlnd	1996.61	1	1,039	0
Nevada	FIADB 4.0, 2005	NatlFor wdlnd	2005.14	2	1,101	0
Nevada	RPA, 1997	NonNatlFor nonwdlnd	1985.38	--	212	45
Nevada	FIADB 4.0, 2005	NonNatlFor nonwdlnd	2005.17	2	373	66
Nevada	FIADB 4.0, 1989	NonNatlFor wdlnd	1980.49	1	2,638	11
Nevada	FIADB 4.0, 2005	NonNatlFor wdlnd	2005.20	2	2,757	0
New Hampshire	FIADB 4.0, 1983	All forest	1983.22	4	1,970	1,948
New Hampshire	FIADB 4.0, 1997	All forest	1997.10	5	1,952	1,825
New Hampshire	FIADB 4.0, 2005	All forest	2004.12	6	1,963	1,898
New Hampshire	FIADB 4.0, 2006	All forest	2004.71	6	1,914	1,837
New Jersey	FIADB 4.0, 1987	All forest	1986.83	3	764	751
New Jersey	FIADB 4.0, 1999	All forest	1998.80	4	863	759
New Jersey	FIADB 4.0, 2004	All forest	2005.05	5	787	771
New Jersey	FIADB 4.0, 2005	All forest	2005.53	5	879	841
New Jersey	FIADB 4.0, 2006	All forest	2006.15	5	843	787
New Mexico	RPA, 1987	NatlFor nonwdlnd	1985.79	--	1,684	1,159
New Mexico	FIADB 4.0, 1999	NatlFor nonwdlnd	1997.21	2	1,504	1,134
New Mexico	RPA, 1987	NatlFor wdlnd	1985.80	--	1,276	0
New Mexico	FIADB 4.0, 1999	NatlFor wdlnd	1996.55	2	1,772	0
New Mexico	FIADB 4.0, 1987	NonNatlFor nonwdlnd	1987.18	1	852	850
New Mexico	FIADB 4.0, 1999	NonNatlFor nonwdlnd	1999.26	2	751	630
New Mexico	FIADB 4.0, 1999	NonNatlFor wdlnd	1988.94	2	2,726	0
New York	Eastwide, 1980	Nonresrv	1980.50	--	6,362	6,299
New York	FIADB 4.0, 1993	Nonresrv	1992.93	4	6,283	6,233
New York	FIADB 4.0, 2005	Nonresrv	2004.02	5	6,465	6,404
New York	FIADB 4.0, 2006	Nonresrv	2004.58	5	6,499	6,448
New York	RPA, 1987	Resrv	1987.50	--	1,108	0
New York	FIADB 4.0, 2005	Resrv	2003.91	5	1,110	0
New York	FIADB 4.0, 2006	Resrv	2004.59	5	1,146	0
North Carolina	FIADB 4.0, 1984	All forest	1983.90	5	7,669	7,466
North Carolina	FIADB 4.0, 1990	All forest	1990.04	6	7,801	7,572
North Carolina	FIADB 4.0, 2002	All forest	2000.71	7	7,411	7,155
North Carolina	FIADB 4.0, 2005	All forest	2004.65	8	7,518	7,300
North Carolina	FIADB 4.0, 2006	All forest	2005.17	8	7,525	7,303
North Dakota	FIADB 4.0, 1980	All forest	1979.25	2	230	140
North Dakota	FIADB 4.0, 1995	All forest	1994.68	3	272	179
North Dakota	FIADB 4.0, 2003	All forest	2002.47	4	301	213
North Dakota	FIADB 4.0, 2004	All forest	2002.98	4	297	221
North Dakota	FIADB 4.0, 2005	All forest	2003.38	4	293	216
North Dakota	FIADB 4.0, 2006	All forest	2004.68	4.26	284	206
North Dakota	FIADB 4.0, 2007	All forest	2005.56	4.43	283	202

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Table 2.—continued.

State	Inventory	Forest[a]	Average year	Average cycle	Forest area	Timberland Area
					thousand ha	*thousand*
North Dakota	FIADB 4.0, 2008	All forest	2006.52	4.63	289	207
Ohio	FIADB 4.0, 1991	All forest	1991.33	4	3,179	3,063
Ohio	FIADB 4.0, 2004	All forest	2003.34	5	3,288	3,187
Ohio	FIADB 4.0, 2005	All forest	2003.79	5	3,195	3,093
Ohio	FIADB 4.0, 2006	All forest	2004.59	5	3,205	3,112
Oklahoma	FIADB 4.0, 1989	Central & West	1988.88	51	909	540
Oklahoma	SOFIA, 1986	East	1986.17	--	1,946	1,919
Oklahoma	FIADB 4.0, 1993	East	1992.81	6	2,193	1,981
Oregon	Westwide, 1992	NatlFor East	1994.97	--	3,558	2,979
Oregon	FIADB 4.0, 2008	NatlFor East	2004.99	5	3,437	2,846
Oregon	Westwide, 1992	NatlFor West	1995.42	--	2,225	1,867
Oregon	FIADB 4.0, 2008	NatlFor West	2005.04	5	2,235	1,836
Oregon	Westwide, 1992	NonNatlFor East	1990.53	--	2,352	1,212
Oregon	FIADB 4.0, 2008	NonNatlFor East	2004.94	5	2,597	1,426
Oregon	Westwide, 1992	NonNatlFor West	1988.50	--	3,867	3,589
Oregon	FIADB 4.0, 2008	NonNatlFor West	2005.10	5	3,908	3,775
Pennsylvania	FIADB 4.0, 1989	All forest	1989.74	4	6,842	6,417
Pennsylvania	FIADB 4.0, 2004	All forest	2002.52	5	6,707	6,490
Pennsylvania	FIADB 4.0, 2005	All forest	2003.52	5.20	6,709	6,483
Pennsylvania	FIADB 4.0, 2006	All forest	2004.53	5.40	6,718	6,509
Rhode Island	FIADB 4.0, 1985	All forest	1984.53	3	165	144
Rhode Island	FIADB 4.0, 1998	All forest	1998.58	4	159	138
Rhode Island	FIADB 4.0, 2005	All forest	2004.55	5	144	142
Rhode Island	FIADB 4.0, 2006	All forest	2005.17	5	148	146
South Carolina	FIADB 4.0, 1986	All forest	1986.26	6	4,961	4,931
South Carolina	FIADB 4.0, 1993	All forest	1992.73	7	5,116	5,040
South Carolina	FIADB 4.0, 2001	All forest	2000.57	8	5,025	4,949
South Carolina	FIADB 4.0, 2006	All forest	2004.64	9	5,218	5,180
South Carolina	FIADB 4.0, 2007	All forest	2005.63	9.21	5,239	5,198
South Dakota	RPA, 1997	NatlFor	1985.72	--	402	380
South Dakota	FIADB 4.0, 1995	NatlFor	1999.27	4	406	399
South Dakota	FIADB 4.0, 2003	NatlFor	2002.55	5	421	405
South Dakota	FIADB 4.0, 2004	NatlFor	2003.05	5	421	398
South Dakota	FIADB 4.0, 2005	NatlFor	2003.57	5	418	398
South Dakota	FIADB 4.0, 2006	NatlFor	2004.41	5.17	407	388
South Dakota	FIADB 4.0, 2007	NatlFor	2005.41	5.37	406	390
South Dakota	FIADB 4.0, 2008	NatlFor	2006.49	5.59	414	400
South Dakota	RPA, 1987	NonNatlFor	1985.61	--	290	216
South Dakota	FIADB 4.0, 1995	NonNatlFor	1995.38	4	259	223
South Dakota	FIADB 4.0, 2003	NonNatlFor	2002.43	5	240	190
South Dakota	FIADB 4.0, 2004	NonNatlFor	2002.91	5	242	200
South Dakota	FIADB 4.0, 2005	NonNatlFor	2003.59	5	263	226
South Dakota	FIADB 4.0, 2006	NonNatlFor	2004.80	5.26	295	257
South Dakota	FIADB 4.0, 2007	NonNatlFor	2005.96	5.50	318	283
South Dakota	FIADB 4.0, 2008	NonNatlFor	2006.69	5.66	339	302
Tennessee	FIADB 4.0, 1989	All forest	1988.98	5	5,495	5,368
Tennessee	FIADB 4.0, 1999	All forest	1998.19	6	5,829	5,652
Tennessee	FIADB 4.0, 2004	All forest	2002.69	7	5,578	5,356
Tennessee	FIADB 4.0, 2005	All forest	2003.81	7.21	5,618	5,395
Tennessee	FIADB 4.0, 2006	All forest	2004.86	7.41	5,646	5,417
Tennessee	FIADB 4.0, 2007	All forest	2005.79	7.61	5,659	5,443
Texas	FIADB 4.0, 2007	Central & West	2006.05	51	19,455	1,062
Texas	SOFIA, 1986	East	1985.64	--	4,683	4,617
Texas	FIADB 4.0, 1992	East	1992.22	6	4,838	4,764

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Table 2.—continued.

State	Inventory	Forest[a]	Average year	Average cycle	Forest area	Timberland Area
					thousand ha	*thousand*
Texas	FIADB 4.0, 2003	East	2002.66	7	4,909	4,810
Texas	FIADB 4.0, 2006	East	2004.09	7.59	4,909	4,838
Texas	FIADB 4.0, 2007	East	2005.07	7.81	4,896	4,831
Texas	FIADB 4.0, 2008	East	2006.01	8	4,908	4,842
Utah	FIADB 4.0, 1993	Nonwdlnd	1993.45	1	2,182	1,903
Utah	FIADB 4.0, 2008	Nonwdlnd	2004.64	2	2,309	1,658
Utah	FIADB 4.0, 1993	Wdlnd	1993.80	1	4,177	0
Utah	FIADB 4.0, 2008	Wdlnd	2004.52	2	5,065	0
Vermont	FIADB 4.0, 1983	All forest	1982.91	4	1,795	1,789
Vermont	FIADB 4.0, 1997	All forest	1997.29	5	1,869	1,814
Vermont	FIADB 4.0, 2005	All forest	2004.76	6	1,854	1,818
Vermont	FIADB 4.0, 2006	All forest	2005.54	6	1,850	1,813
Virginia	FIADB 4.0, 1984	All forest	1985.36	5	6,461	6,247
Virginia	FIADB 4.0, 1992	All forest	1991.49	6	6,485	6,252
Virginia	FIADB 4.0, 2001	All forest	1999.68	7	6,415	6,263
Virginia	FIADB 4.0, 2005	All forest	2001.88	7.53	6,380	6,190
Virginia	FIADB 4.0, 2006	All forest	2003.69	7.83	6,378	6,185
Virginia	FIADB 4.0, 2007	All forest	2004.97	8	6,364	6,169
Virginia	FIADB 4.0, 2008	All forest	2005.77	8.19	6,400	6,207
Washington	Westwide, 1991	NatlFor East	1995.24	--	1,831	1,391
Washington	FIADB 4.0, 2008	NatlFor East	2005.63	5	2,022	1,428
Washington	Westwide, 1991	NatlFor West	1995.43	--	1,372	1,011
Washington	FIADB 4.0, 2008	NatlFor West	2005.45	5	1,381	981
Washington	Westwide, 1991	NonNatlFor East	1991.87	--	2,026	1,623
Washington	FIADB 4.0, 2008	NonNatlFor East	2005.62	5	2,119	1,995
Washington	Westwide, 1991	NonNatlFor West	1991.15	--	3,588	2,996
Washington	FIADB 4.0, 2008	NonNatlFor West	2005.59	5	3,538	2,987
West Virginia	FIADB 4.0, 1989	All forest	1988.20	4	4,900	4,816
West Virginia	FIADB 4.0, 2000	All forest	2000.86	5	4,859	4,774
West Virginia	FIADB 4.0, 2004	All forest	2005.05	6	4,746	4,666
West Virginia	FIADB 4.0, 2005	All forest	2005.50	6	4,856	4,780
West Virginia	FIADB 4.0, 2006	All forest	2006.13	6	4,857	4,747
Wisconsin	FIADB 4.0, 1983	All forest	1982.44	4	6,213	5,975
Wisconsin	FIADB 4.0, 1996	All forest	1995.11	5	6,460	6,354
Wisconsin	FIADB 4.0, 2003	All forest	2001.97	6	6,428	6,324
Wisconsin	FIADB 4.0, 2004	All forest	2002.38	6	6,490	6,376
Wisconsin	FIADB 4.0, 2005	All forest	2003.24	6.18	6,523	6,426
Wisconsin	FIADB 4.0, 2006	All forest	2004.11	6.37	6,586	6,489
Wisconsin	FIADB 4.0, 2007	All forest	2005.06	6.56	6,640	6,545
Wisconsin	FIADB 4.0, 2008	All forest	2006.19	6.80	6,757	6,653
Wyoming	RPA, 1997	NatlFor	1981.52	--	2,354	1,199
Wyoming	FIADB 4.0, 2000	NatlFor	1999.95	2	2,430	1,562
Wyoming	FIADB 4.0, 1984	NonNatlFor nonresrv nonwdlnd	1983.53	1	990	858
Wyoming	FIADB 4.0, 2000	NonNatlFor nonresrv nonwdlnd	2001.82	2	1,104	867
Wyoming	FIADB 4.0, 1984	NonNatlFor nonresrv wdlnd	1983.60	1	290	0
Wyoming	FIADB 4.0, 2000	NonNatlFor nonresrv wdlnd	2002.05	2	352	0
Wyoming	RPA, 1997	NonNatlFor resrv	1984.50	--	793	0
Wyoming	FIADB 4.0, 2000	NonNatlFor resrv	1999.90	2	747	0

[a] Corresponds to the FOREST variable in the survey summary file; see Table 1 for description.

Table 3.—Summary of FIADB 4.0 datasets which were considered and not used because they were found to be incomplete.[a]

State	Reporting Year	Forest[b]
Arizona	1985	NatlFor nonwdlnd
Arizona	1985	NatlFor wdlnd
Colorado	1984	NatlFor nonwdlnd
Colorado	1984	NonNatlFor nonwdlnd
Colorado	1984	NonNatlFor wdlnd
Idaho	1991	Caribou-Targhee NatlFor
Idaho	1991	Payette NatlFor
Idaho	1991	Salmon-Challis NatlFor
Montana	1989	NonNatlFor resrv
Nevada	1989	NonNatlFor nonwdlnd
New Mexico	1987	NatlFor wdlnd
New Mexico	1987	NonNatlFor wdlnd
New York	1993	Resrv
South Dakota	1980	NonNatlFor
Wyoming	1984	NatlFor
Oregon	1999	NonNatlFor West
South Dakota	1980	NonNatlFor
Wyoming	1984	NatlFor

[a] As of December 4, 2009.
[b] Corresponds to the FOREST variable in the survey summary file; see Table 1 for description.

addition of supplemental older FIA data. The CCT 4.0 user also has the option of editing the survey summary file to include only specific data of interest before developing the annualized estimates. This editing can be through directly modifying the comma delimited survey summary file or through CCT 4.0 by selecting a set of assumptions to extract a subset of survey summary records (as presented in the next couple paragraphs).

The interpretation and use of the FIA's annual inventory data can affect trends in annualized stock and stock change for some states. In general, these annual inventory data are those collected since 1999 where a defined portion, or panel, of a state is surveyed each year so that once all panels are measured the process continues with the first panel in the next inventory cycle (USDA For. Serv. 2009a). These annual panels are typically 10 or 20 percent of the state; they are then combined in series from successive years to form whole-state inventory estimates in the FIADB (USDA For. Serv. 2009a). The sequence of whole-state estimates where a new panel replaces the oldest in the previous series are labeled "moving window" averages, which are identified by reporting year or evaluation (Bechtold and Patterson 2005, USDA For. Serv. 2009c).

The moving window evaluations may include panels from a single survey cycle, but more often a moving window evaluation includes panels taken from two successive survey cycles. Successive moving windows may differ by only one panel, or 20 percent of inventory plots. This potential for redundancy in data can affect the interpretation and use of the moving window averages when compiling the annualized stock-change estimates.[9] The survey cycles included in an evaluation are indicated by the average cycle

[9]Additional information on file as: Smith, J.E.; Heath, L.S. in prep. Approach for calculating forest carbon stock-change estimates in the United States using annualized inventory data.

Table 4.—An example of the surveys summarized as carbon stocks, using the five surveys for Maine (values are rounded)

Attribute	EASTWIDE 1982	FIADB 1995	FIADB 2003	FIADB 2005	FIADB 2006
Average year	1982.50	1995.34	2001.55	2003.54	2004.53
Average cycle	--	4	5	5.40	5.61
Live above ground (Tg C)	407	398	401	401	404
Live below ground (Tg C)	83	80	81	81	82
Dead wood (Tg C)	80	81	81	81	81
Litter (Tg C)	197	178	166	167	169
Soil organic carbon (Tg C)	621	597	591	588	588
Forest area (kha)	7,225	7,163	7,165	7,152	7,161
Timberland area (kha)	6,955	6,860	6,962	6,946	6,939
Live growing-stock volume (Mm^3)	609	592	634	634	638

variable (AVGCYCLE) in the survey summary file. Whole numbers indicate single-cycle evaluations, and decimal values indicate two-cycle evaluations such as 5.40 for the 2005 evaluation for Maine (Table 4), which indicates that the evaluation is a combination of cycles 5 and 6, for example. The default CCT 4.0 selection of moving window evaluations is to include only the most recent version of each single-cycle evaluation as well as the most recent two-cycle evaluation if it is predominantly composed of panels from the newer cycle. The user has the option (by selecting buttons) of selecting one of two alternate options rather than the default subset of annual evaluations. Additional details of the three options are listed below with examples from two states as listed in Table 2; the example states are Kansas and Virginia with the reporting years for the earliest annual evaluation of 2003 and 2001, respectively.

Single-cycle plus majority new-cycle last evaluation (default). Includes only the most recent version of each single-cycle evaluation as well as the most recent two-cycle evaluation if it is predominantly composed of panels from the newer cycle. This approach is recommended because it makes the most use of available inventories while reducing the influence of redundant data. Example reporting years are 2005 and 2008 for Kansas, and 2001 and 2007 for Virginia.

All annual evaluations included in the FIADB. Includes all evaluations provided in the data. This approach is included because it makes unselected use of all evaluations provided in FIADB 4.0. Example reporting years are 2003-2008 for Kansas, and 2001, 2005-2008 forVirginia.

Single-cycle evaluations. Includes only the most recent version of each single-cycle evaluation. This approach is included because it eliminates all redundancy in consecutive inventories used, effectively using the data as though they were

from a periodic inventory. Example reporting years are 2005 for Kansas, and 2001 and 2007 for Virginia.

Output tables are listed in two boxes in the lower portion of the window. The upper box contains available output tables for stock and flux for each of the carbon pools and estimates for forest area, timberland area, and timberland growing-stock volume. These are given by state and year from 1990 to the current year. The first stock table and the first flux table in the list writes out all categories within one file. The lower box contains available national (49 states) stock and flux tables. Individual tables can be created by clicking on each item to highlight (Ctrl+Click for multiple selections and Shift+Click to select a block of items) and then clicking "Generate the Selected Tables."

Annualized stocks estimated for each state are assumed to represent a value for January 1 of each year; flux is the difference between two successive stocks. For example, flux for 2003 is the difference between the annualized stocks for January 1, 2003 and January 1, 2004, with the sign convention that negative flux represents net carbon sequestration by the forest, that is, net gain in ecosystem carbon. Annualized stocks are produced for each year from 1990 to the current year as determined by the system year on your PC. Annualized flux is calculated as the difference between estimated stock for each successive year between 1990 and the current year. Units in the output tables are the same as in the survey summary file: Tg (teragrams, which equals 1 million metric tons) for carbon mass, kha (thousand hectares) for area, and Mm^3 (million cubic meters) for volume.

Additional Considerations for Use

The following are considerations for facilitating the use of this application.

- CCT is designed to update or modify existing survey summary files rather than to create a new survey summary file solely from FIA datasets. (However, an update can include replacing all existing summaries previously processed by CCT if you so designate.)
- The use of the download feature (from first button of first window) is optional. Any method of obtaining or downloading the FIADB 4.0 data is acceptable so long as the POP_EVAL_GRP, PLOTSNAP, COND, and TREE files for each survey are saved together in a single directory.
- Saving the modified survey summary file under a new name is useful, particularly if errors are made in specifying changes; then, it is usually easiest to quit and start over with the last good survey summary.
- Execution time for a single state's survey can be several minutes. Even determining if an update is necessary requires some time because each record of each file is read to verify dates. To minimize execution time, avoid running the application on FIADB files known not to have changed since the last update of the survey summary file.
- At least two survey summary points are necessary to calculate a net annualized flux. A single state by FOREST combination in the survey summary file results in a constant annualized stock and an annualized flux of zero.

- The survey summary file can be edited as text or within a spreadsheet. The most common reason for doing this would be to select a subset of the survey summary records before developing the annualized estimates.
- If the survey summary file is in an incorrect format, for example, missing variables in some records, CCT provides a message to that effect and then closes.
- CCT does not evaluate newly downloaded FIA files as to completeness or how representative they are for each state. However, you can compare survey summary values for total forest area, area of timberland, and growing-stock volume of live trees on timberland with published statistics such as those provided by Smith et al. (2009) based on FIA data. Note that comparisons with published values should be made with values provided in the survey summary file, not the areas and volumes in the output tables (since these are interpolated values).

METHODS AND ASSUMPTIONS PROGRAMMED INTO CCT

The carbon calculations are developed in three separate but related steps: 1) identifying appropriate forest inventories and classification of forest land for each state; 2) estimating carbon on inventory plots and aggregating carbon stocks; and 3) estimating annualized carbon stock and flux from survey summaries. The first two steps are parts of the process for updating the survey summary file from FIA data. The unique surveys, identified by INVENTORY and FOREST in the survey summary file, are separate state or substate inventories classified to form consistent sequences of inventories for each state. Classifications are based on preliminary analysis of all available inventory data and are built in. Estimation of carbon on inventory plots and aggregation to the state or substate survey summary level is the most time-consuming part of CCT processing. The final step uses information in the survey summary file to generate annualized stocks and fluxes in tabular form for individual states or for national totals; this eliminates the need for extensive recalculation on all data with each use. Each step is discussed in greater detail in this section.

Inventory Data

The annualized stock and flux calculations are based on the stock-change method, which entails interpolation between, and can involve extrapolation beyond, discrete estimates of carbon stock. The reliability of this approach is strongly dependent on reasonably consistent sequences of inventories. Thus, if a discontinuity is apparent within a series of successive inventories for a state, we subdivide the data for purposes of determining stock and stock change (for example, see the discussion below on inventories of some National Forests). Discontinuities include a significantly different date of inventory for a portion of a state or the omission of an identified part of a state's forest lands. The INVENTORY and FOREST classifications are used to organize consistent sequences of inventories. In this user's guide, and in the CCT application, the term survey refers to inventory data classifications appropriate for calculating stock change, that is, a defined portion of forest that was inventoried within an identified interval of time. In this section we describe the sources and types of available forest inventory data, the assumptions and logic used in the survey classifications in CCT, and the methods in CCT for resolving data updates and survey dates.

The availability of forest inventory data ultimately determined the classifications used in the survey summary file. Data goals were inventories for all 48 conterminous states plus Alaska beginning with the latest pre-1990 data and all inventories in subsequent years. This is because these data were available through the principal source of inventory data, the USDA Forest Service FIADB 4.0 dataset (USDA For. Serv. 2009b). These data include all inventories using the current annual inventory design as well as many of the older periodic inventories. Datasets are organized according to state (see USDA For. Serv. 2009a and Miles 2008 for details on the datasets and variables).

Some earlier FIA periodic inventories within the pre-1990-to-present interval have not been converted to the current downloadable database format. We identified, obtained, and included those data to fill in gaps where possible. Earlier FIA inventory data formats with plot and individual-tree data, as in the FIADB 4.0 data, are the Eastwide (Hansen and others 1992), Westwide (Woudenberg and Farrenkopf 1995), and FIA-Southern Region (SOFIA).[10] Where gaps remained, we considered plot-level inventory datasets that were produced as a part of forest-resource statistics developed for the Forest and Rangeland Renewable Resources Planning Act Assessment (RPA). (USDA For. Serv. 2009c). RPA datasets of interest were those compiled for 1987, 1997, and 2002, which correspond to published summary statistics by Waddell and others (1989) and Smith and others (2001, 2004b).[11] Many of these older inventories already were represented by FIADB 4.0 data, but others, if identified as separate datasets, were considered when identifying appropriate surveys for calculations of stock change.

Classification of surveys (for the survey summary file) was based primarily on resolving the dates of field-data collection or comparing forest area within inventories to forest statistics from other sources. The current annual FIA inventory design includes sampling a portion of each state each year. Past periodic inventories were on an irregular schedule (about once every 5 to 14 years). CCT resolves each inventory to represent stock at a specific time. However, if identifiable portions of a state's forest land were inventoried at intervals out of phase with other forest land, dividing the total inventory into a distinct series of surveys provides more accurate resolution of stock change. Examples of separate series of forest inventories within states include some National Forests, particularly in western states, which sometimes were inventoried at different times from other ownerships in the state. Additional survey classifications resulted from identifying and accounting for all forest land within a state for each inventory. Occasionally, specific portions of a state's forest land were absent from an inventory. For example, reserved forest land might be missing or significantly underrepresented in an inventory. This resulted in surveys classified to separately

[10]Data used for CCT annualized estimates are included on the CD. Eastwide and Westwide data were downloaded from the Internet when they were available (date unknown). The Southern Region (SOFIA) data were obtained from Linda Heatherly, U.S. Forest Service, Southern Research Station, Forest Inventory and Analysis, Knoxville, TN.

[11]Data used for CCT annualized estimates are included on the CD. The unpublished national Forest and Rangeland Renewable Resources Planning Act Assessment (RPA) forest inventory databases for 1987, 1997, and 2002 were provided by K.L. Waddell, W.B. Smith, and P.D. Miles, of the U.S. Forest Service, Forest Inventory and Analysis Program.

estimate the two parts, with fewer surveys in the state's reserved forest land sequence than the nonreserved forest land, for example.

Most states were not subdivided into multiple surveys. Separate substate classifications were established for a number of states based on National Forests or reserved forest land. In Idaho, individual National Forests were treated as separate groups due to apparently distinct inventories. In the past, surveys for the eastern and western portions of Oregon and Washington (as determined by the crest of the Cascade Mountains) were conducted at different times. Similarly, Oklahoma and Texas were divided according to area because only one survey of the central and western portions of those States is available. Additional survey classifications were based on forest type. For example, woodland[12] forest types form a substate classification where woodlands are a large part of forest land within a state (more than 5 percent of total forest area). This additional classification was included so that CCT users can evaluate the influence of woodlands on estimates of total carbon. In California, chaparral communities have been omitted from the most recent survey but were included in earlier inventories. To remain consistent with current survey practice, chaparral was identified and removed from the survey summary file representation of older inventory data.

The specific inventory data and survey classifications used by CCT are included in Table 2. Surveys are identified according to the State, Inventory, and Forest column headings, which identify spatial and temporal separation of the surveys. This same information is included in the survey summary file variables INVENTORY, which includes state, and FOREST (Table 1). Final selection of these classifications was based on identifying separate inventory datasets and verifying complete coverage of forest land. This process included comparisons of date of field-data collection, forest areas, and timber volumes among inventories and with published statistics, such as Smith and others (2009). The part of the FIADB 4.0 not compatible with the CCT FOREST classification is described in Table 3. If multiple versions of surveys were available for a particular FOREST classification, FIADB 4.0 data were used preferentially because there was overall consistency with current data. Eastwide, Westwide, or SOFIA data were the secondary choice if needed because they also included individual-tree data rather than plot-level data. Finally, RPA datasets that were considered complete were used as needed.

All inventory data underlying the initial survey summary file provided with CCT are included in the CCT package in the FIA_zipped and ArchiveRPAData folders. The FIADB 4.0, Eastwide, Westwide, and SOFIA data specified in Table 2 are in the FIA_zipped folder. The RPA data are in the folder ArchiveRPAData as spreadsheets with the pertinent data extracted from the larger RPA datasets.

Two date identifiers are important in defining and maintaining the survey summary file. One identifies the date of most recent updates for the FIADB files. Each of the FIADB

[12]Woodland currently refers to stands dominated by certain western U.S. species (particularly pinyon and juniper) for which stocking guides are not available. For a complete list of applicable forest type groups, see USDA For. Serv. (2009a).

4.0 files read by CCT includes two variables (created and modified dates) in each record that are scanned to identify the last update to the datasets. From these values, the date of last data update is retained in the survey summary file as UPDATED, which contains the date in the form YYYYMMDD. This variable (in the survey summary file) is read when an FIADB dataset with corresponding state and reporting year identifiers is specified as an input file. The date of the last update is compared with dates in the input FIADB data to determine whether the new file is more recent than the data summarized in the survey summary file. Annual inventories posted to the Internet are revised as each annual survey is added to the existing data; this provides an example of an update (to the survey summary) that might be necessary from a previously read set of FIADB files. The UPDATED information is relevant only to the FIADB data.

A second date identifier is AVGYEAR, which is calculated from the dataset variables identifying the dates of plot data collection. These dates are used to determine an average date for the overall survey. The variables generally are found in the plot file and specify the year, month, and day when the plot was surveyed. Assignment of year for a plot is defined as the date of field data as a decimal fraction of the year. The fractional portion of the year ranges from 0.003 for January 1 to 0.997 for December 31. The determination depends on year, month, and day or which of these is available. For example, if year is available but month and day are missing, the fractional part is set to 0.5. If year and month are available but day is missing, AVGYEAR = year+(month-0.5)/12; for example, the fractional part specified for March is 0.208. If all three variables are available, AVGYEAR = year+((Julian date of day-0.5)/(Julian date of Dec 31)), where Julian date is a number between 1 and 366 inclusive. Subtracting 0.5 in the numerator of the calculations is to place the fractional value at the midpoint of the category. Plots missing such date information are not included in the calculation of AVGYEAR. Note that this approach to establishing a fractional value for AVGYEAR does not imply precision about the hour when the plot was measured, but it does provide a systematic approach for determining a midpoint of the available date information.

Estimating Carbon on Inventory Plots

Carbon estimates derived from FIA or RPA data are based on the current coefficients of the forest carbon simulation model FORCARB2 and applied at the plot level (Birdsey and Heath 1995, 2001; Heath and others 2003; Smith and others 2004a). The carbon conversion coefficients of the model are applied to the survey data at the scale of the FIA inventory plots. The results are estimates of carbon density (Mg C/ha, megagrams or metric tons carbon per hectare) for each carbon pool. Carbon density is converted to carbon mass based on expansion factors (USDA For. Serv. 2009a, Miles 2008) and then summed to determine total carbon stock for a survey.

Classifications of forest carbon in CCT output can be pooled according to: 1) plot-level FORCARB2 calculations ("Comprehensive" in CCT, Smith and others 2004a), or 2) IPCC specifications, which are used in the EPA greenhouse gas reporting ("Reporting" in CCT, Penman and others 2003, U.S. EPA 2009). FORCARB2 estimates carbon density for live trees, standing dead trees, understory vegetation, down dead wood, forest floor, and soil organic matter, which is the comprehensive set in CCT:

- Live trees, which includes all live woody vegetation at least 1 inch (2.54 cm) in diameter at breast height (d.b.h., 1.3 m). Separate estimates are made for both aboveground and whole-tree biomass, which includes all living biomass of coarse living roots more than 2 mm in diameter. Belowground live-tree carbon is based on the difference between whole trees and above ground only
- Understory, which includes all live herbaceous vegetation and woody vegetation up to 1 inch (2.54 cm) d.b.h.
- Standing dead trees, which are nonliving but otherwise follow the same definition as live trees, including coarse nonliving roots more than 2 mm in diameter
- Down dead wood, also known as coarse woody debris, includes all nonliving woody biomass with a diameter of at least 7.5 cm at transect intersection lying on the ground. This pool also includes stumps and coarse roots more than 2 mm in diameter. Nonliving vegetation that otherwise would fall under the definition of understory is included in this pool
- Forest floor, which includes the litter, fumic, and humic layers and all nonliving biomass with a diameter less than 7.5 cm at transect intersection lying on the ground above the mineral soil
- Soil organic carbon, including all organic material in soil to a depth of 1 m but excluding the coarse roots of the pools mentioned earlier

These are the bases for the carbon-stock information summarized and saved in the survey summary file. However, carbon stocks also are reallocated to the following five pools (Penman and others 2003) if required for formatting results, which is the reporting set in CCT:

- Aboveground biomass, which includes aboveground portions of live trees and understory. In CCT, we assume that 90 percent of the understory is above ground.
- Belowground biomass, which includes belowground portions of live trees and understory. In CCT, we assume that 10 percent of the understory is below ground.
- Dead wood, which includes standing dead trees and down dead wood.
- Litter, which is identical to the previous definition for forest floor.
- Soil organic carbon, which is identical to the previous definition.

Tree carbon is based on individual-tree data or the plot-level value calculated for merchantable volume of wood in live trees. Most inventory data included in the CCT estimates include measured values for individual trees; in such cases, tree biomass and thus carbon mass are calculated according to Jenkins and others (2003). Carbon mass of wood is approximately 50 percent of dry weight (IPCC 1997). However, the few estimates of tree carbon based on the RPA plot-level data are from modified versions of the stand-level volume-to-biomass equations presented in Smith and others (2003). All estimates for carbon in standing dead trees also are based on modified versions of the equations in Smith and others (2003) because individual-tree data for standing dead trees currently are inconsistent among the available datasets.[13]

[13]See U.S. EPA 2009, particularly Annex 3.12, for additional details as well as the specific volume-based equations and coefficients.

Estimates of understory and down dead wood are functions of region and forest type as well as plot-level estimates of live-tree carbon density. Understory carbon density is based on Birdsey (1996) and was estimated at the inventory plot level (U.S. EPA 2009). Here we assume that 10 percent of understory carbon mass is below ground. This general root-shoot ratio (0.11) is near the lower range of temperate forest values provided in Penman and others (2003) and was selected on the basis of two general assumptions: ratios likely will be lower for light-limited understory vegetation compared with larger trees, and a greater proportion of all root mass is less than 2 mm in diameter. The ratio of down dead wood to live-tree estimates were developed by FORCARB2 simulations and applied at the plot level (Smith and others 2004a, U.S. EPA 2009).

Estimates of forest-floor and soil organic carbon are not based on the carbon density of trees. Forest-floor carbon is based on region, forest type, and stand age and determined by equations of Smith and Heath (2002), which are applied at the plot level. Estimates of soil organic carbon (U.S. EPA 2009) are based on the national STATSGO spatial database (USDA Soil Conserv. Serv. 1991) and the general approach described by Amichev and Galbraith (2004). They represent average soil organic carbon according to region and forest-type group in the current FIADB. These values for soil carbon stock and the stock-change calculated flux do not include expected effects of past land use change.

Not all inventory data used by CCT are amenable for making the carbon estimates from plot-level data. An historical focus of the FIA program was to provide information on timber resources of the United States. For this reason, some forest land that was less productive or where harvesting was prohibited by law was surveyed less intensively. This generally means that forest type and area were identified by aerial photography but trees were not measured in the field. However, all annualized surveys initiated since 1998 have followed a new national plot design for all forest land (USDA For. Serv. 2009a). The practical effect on estimating forest carbon stocks from 1990 through the present is that some older surveys of lands do not include the individual-tree or stand-level measurements, which are necessary inputs to FORCARB2 for predicting tree carbon. A preliminary analysis identified the surveys with such data gaps on forest land; these were filled by assigning average carbon densities calculated from the more complete, later inventories from the respective states. These forests are classified as reserved (harvesting is prohibited by law) or other (low productivity and not timberland or reserved).

Annualized Estimates from Survey Summaries

The overall approach for estimating annualized forest-carbon stocks and flux (net annual stock change) is to first interpolate stocks between successive survey summaries as defined by the survey summary file and then extrapolate up to the current calendar year. Carbon stocks, classified according to FOREST, are interpolated or extrapolated to January 1 of each year. For example, interpolating between successive stock summaries in Table 4 produces the annualized stock estimates provided in Table 5. This process is repeated for each carbon pool and the area and volume totals. Net annual stock change, or flux, is estimated for each carbon pool in each state as the difference between the

Table 5.—Annualized stock and flux based on five surveys in Maine as summarized in Table 4; note that values are rounded and the convention for a net annual increase in ecosystem carbon stock is a negative flux

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Stock																				
Live above ground (Tg C)	402	401	400	399	399	398	398	398	399	399	400	400	401	402	404	405	406	407	408	410
Live below ground (Tg C)	81	81	81	81	80	80	80	80	81	81	81	81	81	82	82	82	82	83	83	83
Dead wood (Tg C)	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	80
Litter (Tg C)	186	185	183	182	180	179	177	175	173	171	169	167	166	167	168	169	170	171	172	172
Soil organic carbon (Tg C)	607	605	603	602	600	598	597	596	595	593	592	591	590	590	589	588	587	586	586	585
Flux																				
Live above ground (Tg C /yr)	0.75	0.75	0.75	0.75	0.75	-0.05	-0.46	-0.46	-0.46	-0.46	-0.46	-0.80	-1.22	-1.22	-1.22	-1.22	-1.22	-1.22	-1.22	
Live below ground (Tg C /yr)	0.20	0.20	0.20	0.20	0.20	-0.04	-0.16	-0.16	-0.16	-0.16	-0.16	-0.22	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	
Dead wood (Tg C /yr)	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	0.02	0.13	0.13	0.13	0.13	0.13	0.13	0.13	
Litter (Tg C /yr)	1.48	1.48	1.48	1.48	1.48	1.80	1.97	1.97	1.97	1.97	1.97	0.69	-0.88	-0.88	-0.88	-0.88	-0.88	-0.88	-0.88	
Soil organic carbon (Tg C /yr)	1.83	1.83	1.83	1.83	1.83	1.34	1.08	1.08	1.08	1.08	1.08	0.95	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Forest area (kha)	7,189	7,184	7,179	7,174	7,169	7,164	7,163	7,163	7,164	7,164	7,165	7,165	7,165	7,163	7,162	7,160	7,159	7,158	7,156	7,155
Timberland area (kha)	6,900	6,892	6,885	6,878	6,870	6,863	6,871	6,888	6,904	6,920	6,937	6,953	6,959	6,951	6,943	6,935	6,927	6,919	6,911	6,903
Live growing-stock volume (Mm^3)	599	598	596	595	593	592	596	603	610	617	623	630	635	636	637	639	640	642	643	645

succeeding year and the current year's carbon stock, for example, flux for 2002 equals stock for 2002 minus stock for 2003. Note that this calculation of net annual flux sets the sign convention that net sequestration of carbon by forests is a negative flux. The moving window averages used to define the annual inventory evaluations in the FIADB can affect the annualized estimates for some states. The means for selecting subsets of available evaluations are described above in the "Produce Tables of Annualized Estimates" section.

CONCLUSIONS

The basic results of the carbon calculator are the survey summary file and the tabular summaries of stocks and fluxes. Carbon stock and flux estimates as processed by this revised version of CCT are the basis for the forest ecosystem carbon change values reported to the U.S. EPA by the U.S. Forest Service for inclusion in the annual inventory of greenhouse gas emissions and sinks.

Two influences on national-scale forest carbon budgets and overall carbon sequestration are not explicitly included in the CCT calculations: carbon in harvested wood products, and effects of land use change on soil. Long-lived wood products and sealed landfills represent significant pools of sequestered forest carbon. Similarly, current carbon estimates do not include explicit calculation of effects of land use change. For example, estimates of soil organic carbon are broad regional averages according to forest type and do not include the expected long-term accumulation of soil carbon following afforestation. In a broader sense, net annual carbon flux is the difference between total carbon on forest land at one time and total carbon flux on forest land the following year. This means that change in specific carbon density (Mg C/ha) or total forest land (hectares) can affect flux. A needed improvement, as an add-on or through further subdivision of the survey summary file, is the ability to distinguish net annual flux for the following three categories of forest land according to Penman and others (2003): forest remaining forest, forest becoming nonforest, and nonforest becoming forest.

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APPENDIX A

Contents of Electronic Media

Three main folders:

- CCT
- ArchiveRPAData
- FIA_zipped

CCT folder has five subfolders:

- CCTFiles
- DataFiles
- OutputFiles
- SurveySummaryFiles
- UserGuideandExamples

CCTFiles folder:

CCT.chm - The compiled help file accessed in CCT by clicking on "Help."
CCTv40.exe - The CCT executable; it is recommended that you create a shortcut to run this file.
CCT.ini - This text file is used as a storage area for the most recently used file and folder locations, as well as the current FIA download web address.
Copy of CCT.ini - This text file stores the original text for file and folder locations and the initial FIA download web address; if CCT.ini becomes corrupted, this file may be copied into its place.
GINO.CON and various *.dll's* (dynamic link libraries) - These files are needed by CCT to produce the graphical user interface. Do NOT delete, move, or edit these files in any way! For CCT to function properly, these files must be in the same directory as CCTv40.exe. If they are accidentally deleted or corrupted, the initial set should be retrieved from the electronic media.

DataFiles folder:

This folder can be used to place data files for use by CCT, though it is not necessary, that is, you may specify any folder location in CCT. It initially contains several example unzipped data (FIADB 4.0) files. Note that four files are included for each inventory. When the FIADB state files are unzipped, numerous files are extracted. However, CCT only requires these four; the others can be deleted or retained at your discretion. All files resulting from unzipping of the EASTWIDE, WESTWIDE, and SOFIA files are needed by CCT.

OutputFiles folder:
This folder is initially empty. It can be used as the location for output files from CCT; however, you may specify any folder location in CCT. Output files from CCT are named as follows: (survey summary file name)_(carbon pool abbreviation)_(table name).csv; for example, the initial output file containing below-ground biomass stocks (one of the reporting pools) would have the filename *survey_summary_04Dec09_Rpt_BGBiomassStock.csv*.

SurveySummaryFiles folder:
survey_summary_04Dec09.csv - This is the initial survey summary file for use in this version of CCT. The date in the filename indicates the date the FIADB files were last updated from the FIA download website. Additional survey summary files can be created manually or by saving to a new file name within CCT. The files can be placed in this folder location but any location can be specified in CCT.

UserGuideandExamples folder:
A copy of this user's guide.
Stock&Flux_ReportingPools_04Dec09.xls - A spreadsheet version of the CCT output tables for the reporting set of carbon pools generated by using the initial survey summary file (*survey_summary_04Dec09.csv*). The first worksheet in the file lists the tables with the names of their corresponding source files.
Stock&Flux_ComprehensivePools_04Dec09.xls - A spreadsheet version of the CCT output tables for the comprehensive set of carbon pools generated by using the initial survey summary file (*survey_summary_04Dec09.csv*). The first worksheet in the file lists the tables with the names of their corresponding source files.
ReadMe files (if any) - Text files with information on updates or use of CCT on specific operating systems; this is information not included in this user's guide.

ArchiveRPAData folder:
RPAinputs2CCT_22DEC09.zip - This is a .zip file containing a single .xls file by the same name. This spreadsheet contains the RPA data which were used to fill gaps which could not be covered through the use of available FIA inventory data. The file includes plot-level data from the 1987, 1997 and 2002 RPA assessments with corresponding carbon values based on FORCARB2 estimators.

FIA_zipped folder:
This folder contains all FIA inventory data used in creating the initial survey summary file (*survey_summary_04Dec09.csv*) and thereby used to generate the initial set of CCT output tables. The bulk of the folder consists of zipped files containing the FIADB 4.0 data files used by CCT. These represent the most recent set of available FIA inventories as of December 4, 2009. In addition, there are zipped files for each of the older-format inventories which were used to cover gaps in the data record (see Appendix B). These are identified by the prefixes EASTWIDE, WESTWIDE, and SOFIA. Data files must be extracted from these zipped files before they can be processed by CCT (see DataFiles folder for additional information).

APPENDIX B

Alternative Inventory File Formats

The primary data source for CCT is the FIA database (FIADB 4.0). Future changes to the FIADB format will require updates to CCT; these updates will be posted at http://nrs.fs.fed.us/carbon/tools or http://www.nrs.fs.fed.us/pubs/2394. As discussed in the text, data gaps were filled through the use of other inventories available in earlier formats. These included inventories in Eastwide format (Hansen and others 1992), Westwide format (Woudenberg and Farrenkopf 1995), and an unpublished format available from the FIA's Southern Region (SOFIA). Thus, CCT can process files in these formats. This section provides some additional information regarding these files.

During CCT development, numerous datasets were obtained in the three formats, but only 13 inventories were retained to supplement the FIADB data for the 49 states over the pre-1990-to-present interval. These included four Eastwide, five Westwide, and four SOFIA (Table 2). Zipped files representing each of these 13 inventories are included in the "FIA_zipped" folder. The file prefixes are EASTWIDE, WESTWIDE, and SOFIA, respectively. Each zipped file contains the files CCT needs to process these older inventories. Upon unzipping the files, the extracted files are immediately available for use in CCT. Each of the file formats includes several comma-delimited input files which are read by CCT. They are county(*cty*), plot(*plt*) and tree(*tre*) files for the Eastwide and Westwide data. The SOFIA data files have the designations *STOCK, DESN*, and *TR*. CCT identifies the database format and file type according to the filenames.

The data structure of these earlier inventories differed from the FIADB 4.0 structure. Many of the currently recorded fields were absent or present in a distinctly different format. Where possible, data were "translated" from the older format to the current; where this was not possible, the data were considered "missing." For example, the FIADB 4.0 database structure has the plot-level field RESERVCD, which indicates whether a plot is reserved forest. This field is not present in the Eastwide database structure; however, it can be gleaned from the field GLUCUR (current land use class). Likewise, the FIADB 4.0 field FORTYPCD (or forest type) was derived from the Westwide field TYPCUR; the Westwide codes were matched as closely as possible to the current codes. This "translation" procedure is done by the CCT application; should additional files be obtained in these earlier formats, preprocessing would not be necessary other than to ensure that the filenames and database structure follow the same conventions as those included in the CCT package.

An additional adjustment was made to these early inventory files by the authors; to conform to current federal privacy regulations, all location and detailed ownership information were removed from the files prior to writing to the available electronic media.

Smith, James E.; Heath, Linda S.; Nichols, Michael C. 2007. **U.S. forest carbon calculation tool: forest-land carbon stocks and net annual stock change.** Revised. Gen. Tech. Rep. NRS-13. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 34 p. [DVD-ROM].

The Carbon Calculation Tool 4.0, *CCTv40.exe*, is a computer application that reads publicly available forest inventory data collected by the U.S. Forest Service's Forest Inventory and Analysis Program (FIA) and generates state-level annualized estimates of carbon stocks on forest land based on FORCARB2 estimators. Estimates can be recalculated as new inventory data become available. The input set of FIA data files available on the Internet (as well as some older inventory files used to fill in gaps) are summarized by the application, converted to carbon stocks, and saved as part of a state or substate level "survey summary" file. This is used to produce state-level and national tables with annualized carbon stocks and flux (or net stock change) beginning with the year 1990. This user's guide includes instructions for use, example data sets, and a discussion of methods and assumptions.

KEY WORDS: greenhouse gas inventory, carbon sequestration, forest inventory, FIA

www.nrs.fs.fed.us