State Inventory Tool

# User Guide for Estimating Emissions and Sinks from Land Use, Land-Use Change, and Forestry

SEPTEMBER 2026

## ACKNOWLEDGEMENTS

The SIT was originally developed in conjunction with EPA's state and local programs to automate the steps states would need to take in developing their own emission estimates in a manner that was consistent with prevailing national and state guidelines. The result was a user-friendly set of eleven modules that help users estimate greenhouse gas emissions and removals at the state level. CGS is supporting updates to the tool to facilitate continuity in state inventory development and improvement work at the state level.

Modules and User Guides updates prepared by:

ICF

Prepared for:

Center for Global Sustainability, University of Maryland

This section of the User Guide provides instruction on using the Land Use, Land-Use Change, and Forestry Module (LULUCF) module of the State Inventory Tool (SIT), and describes the methodology used for estimating greenhouse gas emissions (GHG) emissions and sinks from land use, land-use change, and forestry at the state level.

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# 1.1 Module Overview

This User Guide accompanies and explains the LULUCF module of the SIT.

Because most state inventories developed today rely heavily on the SIT, User Guides have been developed for each of the SIT modules. These modules contain largely updated methodologies that are, for the most part, consistent with the Inventory of U.S. Greenhouse Gas Emissions and Sinks (EPA 2025a) and related disaggregated data by state. Users can refer to the chapters and annexes of the U.S. Inventory to obtain additional information not found in the SIT or in the companion User Guide. Future updates will be consistent with the Center for Global Sustainability at University of Maryland's Greenhouse Gas Inventory and Analysis for the United States (GHGIA) (Desai et al. 2026).

In recent years, EPA also published an annual Inventory of U.S. Greenhouse Gas Emissions and Sinks by State (EPA 2024a) to make available consistent state-level GHG data for all states for use by states, researchers, and the general public. There will be differences between the latest EPA developed state-level estimates and inventory estimates developed by states using the SIT or other tools. Inventories compiled by states may differ for several reasons, and differences do not necessarily mean that one set of estimates is more accurate, or "correct". The CGS plans to continue EPA's initiative to publish an updated annual crosswalk guide to facilitate understanding methodological differences between methods in the current GHGIA, its disaggregation by state and SIT source categories, methods, and data.

The LULUCF module calculates $CH_4$ and $N_2O$ emissions from fertilization of settlement soils, and forest fires, as well as carbon stock changes from forest management, urban trees, landfilled yard trimmings and food scraps, and agricultural soils.

The module provides default data for most inputs; however, if you have access to a more comprehensive or state-specific data source, it should be used in place of the default data. If using outside data sources, or for a more thorough understanding of the tool, please refer to the following discussion for data requirements and methodology.

## 1.1.1 Data Requirements

To calculate GHG emissions from land use, land-use change, and forestry, the data listed in Table 1 are required inputs (again, note that defaults are available for most of these data).

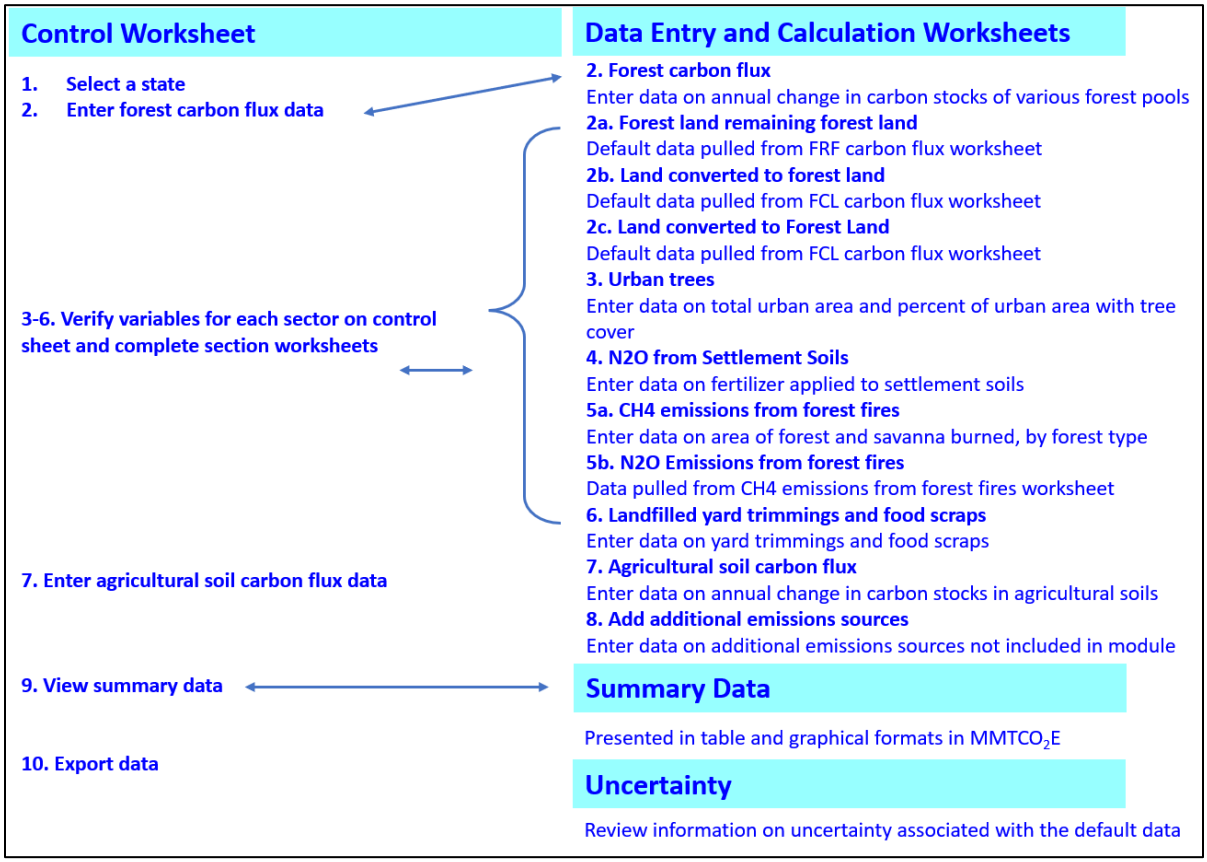
**Table 1. Required data inputs for the LULUCF module.**

| Forestry Worksheets | Input Data Required |
|---|---|
| Forest Carbon Stock Change (Forest Land Remaining Forest Land, Land Converted to Forest Land, and Forest Land Converted to Land) | Carbon emitted from or sequestered in aboveground biomass, belowground biomass, dead wood, litter, mineral and organic soils, drained organic soils, wood products and landfills (million metric tons) |
| Urban Trees Carbon Stock Change | Carbon sequestration factor for urban trees (metric ton C/hectare/year)<br>Total urban area (square kilometers)<br>Urban area tree cover (percent) |
| $N_2O$ from Settlement Soils | Direct $N_2O$ emission factor for managed soils (percent)<br>Total synthetic fertilizer applied to settlements (metric tons nitrogen) |
| Non-$CO_2$ Emissions from Forest Fires | Emission factors for $CH_4$ and $N_2O$ emitted from burning forest and savanna (grams of gas/kilogram of dry matter combusted)<br>Combustion efficiency of different vegetation types (percent)<br>Average biomass density (kilograms dry matter per hectare)<br>Area burned (hectares) |
| Landfilled Yard Trimmings and Food Scraps Carbon Stock Change | Grass, leaves, and branches constituting yard trimmings (percent)<br>Yard trimmings and foods scraps landfilled, 1960-present (tons)<br>Initial carbon content of yard trimmings and food scraps (percent)<br>Dry weight/wet weight ratio of yard trimmings and foods scraps (percent)<br>Proportion of carbon stored permanently for yard trimmings and foods scraps (percent)<br>Half-life of degradable carbon for yard trimmings and foods scraps (years) |
| Agricultural Soil Carbon Stock Change | Carbon emitted from or sequestered in aboveground biomass, belowground biomass, dead wood, litter, and mineral and organic soils on cropland and grassland (million metric tons) |

### 1.1.2 Tool Layout

Because there are multiple steps to complete within the LULUCF module, it is important to understand of the module's overall design. The layout of the LULUCF module and the purpose of its worksheets are presented in Figure 1.

**Figure 1: Flow of Information in the LULUCF Module***




* These worksheets are the primary worksheets used in the LULUCF module; subsequent worksheets are used to populate the default data and are provided for informational purposes only.

# 1.2 METHODOLOGY

This section provides a guide to using the LULUCF module of the SIT to estimate GHG emissions and sequestration from land use, land-use change, and forestry. Within the LULUCF module, there are six sections: forest carbon flux (carbon stock change); urban trees; $N_2O$ from settlement soils; non-$CO_2$ emissions from forest fires; carbon storage in landfilled yard trimmings and food scraps; and agricultural soil carbon flux. Because the methodology varies considerably among these sources/sinks, the details of each will be discussed in its respective step, following this general methodology discussion.

The LULUCF module follows the general methodology from the National Inventory Report (NIR) GHG Inventory by U.S. State. However, SIT aggregates changes in aboveground biomass, belowground biomass, deadwood, litter, and mineral and organic soil carbon stocks from Cropland Remaining Cropland, Land Converted to Cropland, Grassland Remaining Grassland, and Land Remaining Grassland under Ag Soil Carbon Flux in SIT. Default data is also not available for carbon flux from Wetlands Remaining Wetlands or from non-$CO_2$ emissions from Forest Fires; for these estimates, see the NIR GHG Inventory by U.S. State.

The LULUCF module will automatically calculate emissions after you enter the factors on the control worksheet and the required activity data on the individual sector worksheets. The tool provides default sector data for most sectors. The exception is forest fires where you will have to use an outside data source for area of forest burned per year (see Box 1 for suggested data sources).

**Box 1: Forest Fire Data Sources**

- Data are available from the National Interagency Coordination Center, which compiles fire records from Situation and Incident Status Summary (ICS-209) Reports. These records provide the number of acres burned by forest fire by state, and can be found in Table 12.4-2 of the EIIP Guidance or online at https://www.nifc.gov/fireInfo/fireInfo_statistics.html
- To obtain the most accurate emission estimates, it is necessary to have information on the type of forests that have burned, as different types of forests contain differing amounts of combustible biomass. To further refine the analysis, information on specific burns and forest types can be found in the U.S. Federal Wildland Fire Management's website: http://www.fs.fed.us/fire/.
- To obtain accurate emissions for both wildfires and prescribed burning, users may directly consult FOFEM, which is available for download at https://www.firelab.org/project/fofem. Additional instructions for using the model are provided on the website.
- Land management agencies (e.g., the U.S. Forest Service, Bureau of Land Management, State Natural Resource Divisions) in each state maintain statistics on the areas and types of forests within their jurisdiction that have burned.
- State-level estimates of non-CO2 emissions from forest fires are available for certain states from the U.S. Forest Service's publication, "Greenhouse gas emissions and removals from forest land, woodlands, and urban trees in the United States, 1990-2023" (see Appendix 1 of the publication). This information is also available in the 2025 NIR GHG Inventory by U.S. State released via Freedom of Information Act request (U.S. EPA 2025b).

There are nine general steps involved in estimating emissions using the LULUCF module: (1) select a state; (2) select an option for forest carbon flux; (3) enter emission factors and activity data for urban trees; (4) enter emission factors and activity data for $N_2O$ from settlement soils; (5) enter emission factors and activity data for non-$CO_2$ emissions from forest fires; (6) enter emission factors and activity data for landfilled yard trimmings and food scraps; (7) select an option for agricultural soil carbon flux; (8) add any additional emissions sources that are not included in the module; and (9) review summary information. The general equations used to calculate GHG emissions from land use, land-use change, and forestry are provided below.

## Step (1) Select a State

To begin, select the state you are interested in evaluating. By selecting a state, the rest of the tool will automatically reset to reflect the appropriate state default data and assumptions for use in subsequent steps of the tool.

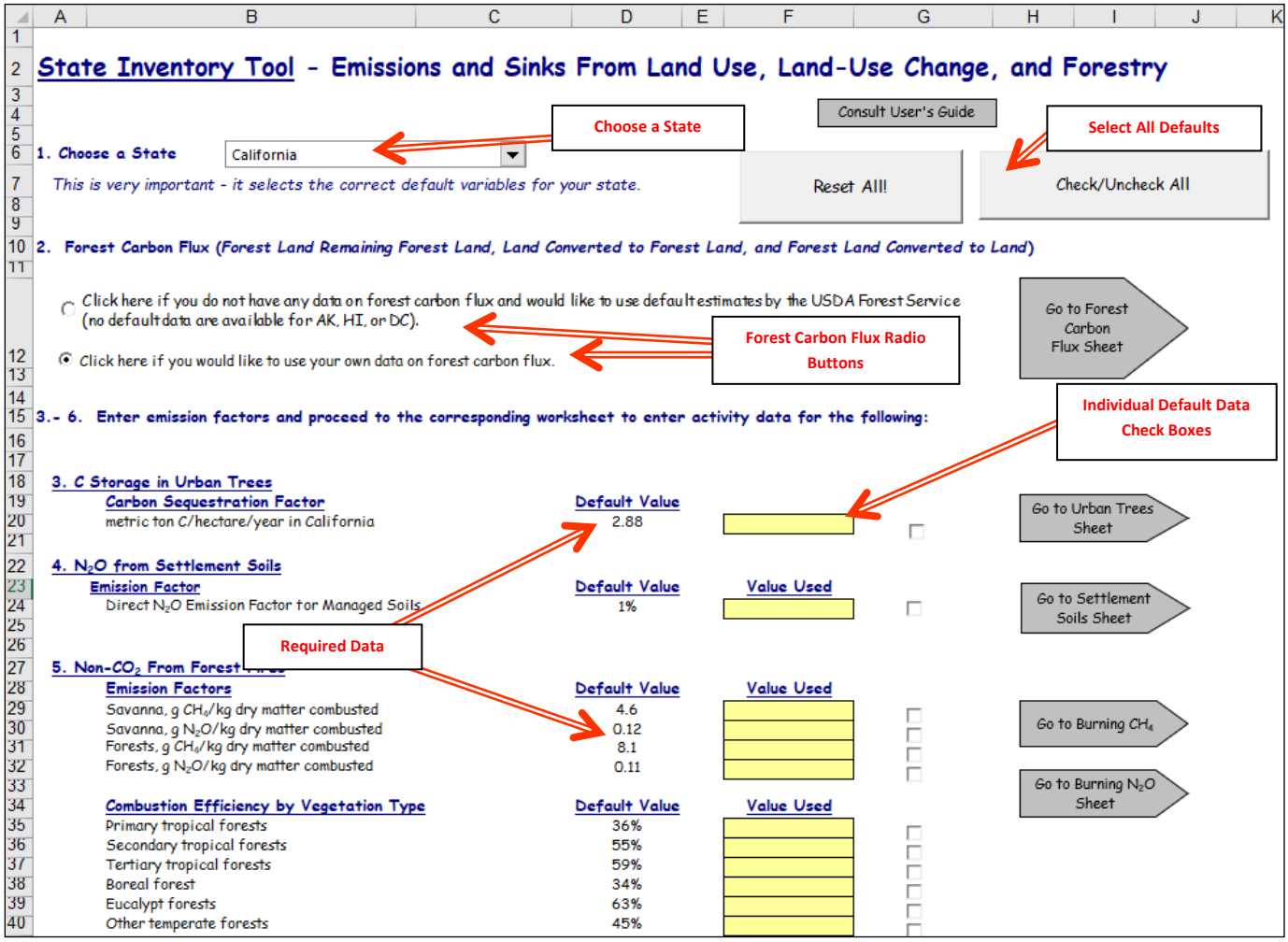
## Step (2) Select an Option for Forest Carbon Flux

### Control Worksheet

The control worksheet allows you to either select the default data provided or to enter user-specified data to be used throughout the tool. To proceed with the default data, select the first radio button

under step 2 on the control worksheet. Default data are available for three land-use categories: *Forest Land Remaining Forest Land, Land Converted to Forest Land,* and *Forest Land Converted to Land*. These three categories are summed together on the Summary tab to calculate Net Forest Carbon Flux. Please note that a complete series of default data is not available for all states. If you would like to use your own state-specific data, select the second radio button under step 2 of the control worksheet. See Figure 2 for an example of the radio buttons in step 2.

**Figure 2. Control Worksheet for the LULUCF Module**




As a result of biological processes (e.g., growth and mortality) and anthropogenic activities (e.g., harvesting, thinning, and other removals), carbon is continuously cycled through ecosystem components, as well as between the forest ecosystem and the atmosphere. For example, the growth of trees results in the uptake of carbon from the atmosphere and storage in living trees. As these trees age, they continue to accumulate carbon until they reach maturity, at which point their carbon storage remains relatively constant. As trees die or drop branches and leaves on the forest floor, decay processes will release carbon to the atmosphere and also increase soil carbon. Some carbon from forests is also stored in wood products, such as lumber and furniture; and also in landfills, because when wood products are disposed of, they do not decay completely, and a portion of the carbon gets stored

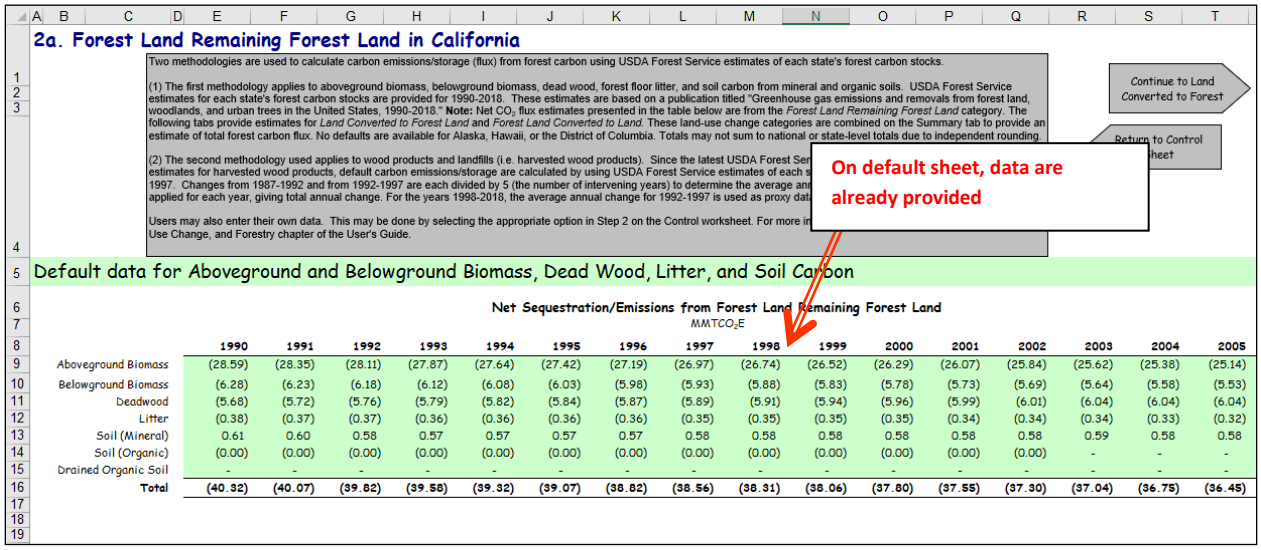
indefinitely, as with landfilled yard trimmings and food scraps. The net change in forest carbon is the change in the amount of carbon stored in each of these pools (i.e., in each ecosystem component) over time. This section presents the methodology for calculating forest carbon flux/carbon stock change.

After completing the control worksheet for this sector, use the gray arrows to navigate to the *Forest Land Remaining Forest Land* worksheet.

## Forest Land Remaining Forest Land Worksheet

If you are using the default data for forest carbon flux estimates, there is no further information to enter. Figure 3 shows the default worksheet for *Forest Land Remaining Forest Land*.

**Figure 3. Example of Forest Land Remaining Forest Land Worksheet Using Default Data**



2a. Forest Land Remaining Forest Land in California

Two methodologies are used to calculate carbon emissions/storage (flux) from forest carbon using USDA Forest Service estimates of each state's forest carbon stocks.

(1) The first methodology applies to aboveground biomass, belowground biomass, dead wood, forest floor litter, and soil carbon from mineral and organic soils. USDA Forest Service estimates for each state's forest carbon stocks are provided for 1990-2018. These estimates are based on a publication titled "Greenhouse gas emissions and removals from forest land, woodlands, and urban trees in the United States, 1990-2018." **Note:** Net $CO_2$ flux estimates presented in the table below are from the *Forest Land Remaining Forest Land* category. The following tabs provide estimates for *Land Converted to Forest Land* and *Forest Land Converted to Land*. These land-use change categories are combined on the Summary tab to provide an estimate of total forest carbon flux. No defaults are available for Alaska, Hawaii, or the District of Columbia. Totals may not sum to national or state-level totals due to independent rounding.

(2) The second methodology used applies to wood products and landfills (i.e. harvested wood products). Since the latest USDA Forest Ser estimates for harvested wood products, default carbon emissions/storage are calculated by using USDA Forest Service estimates of each s 1997. Changes from 1987-1992 and from 1992-1997 are each divided by 5 (the number of intervening years) to determine the average ann applied for each year, giving total annual change. For the years 1998-2018, the average annual change for 1992-1997 is used as proxy dat

Users may also enter their own data. This may be done by selecting the appropriate option in Step 2 on the Control worksheet. For more in Use Change, and Forestry chapter of the User's Guide.

Continue to Land Converted to Forest

Return to Control heet

On default sheet, data are already provided

Default data for Aboveground and Belowground Biomass, Dead Wood, Litter, and Soil Carbon

Net Sequestration/Emissions from Forest Land Remaining Forest Land

$MMTCO_2E$

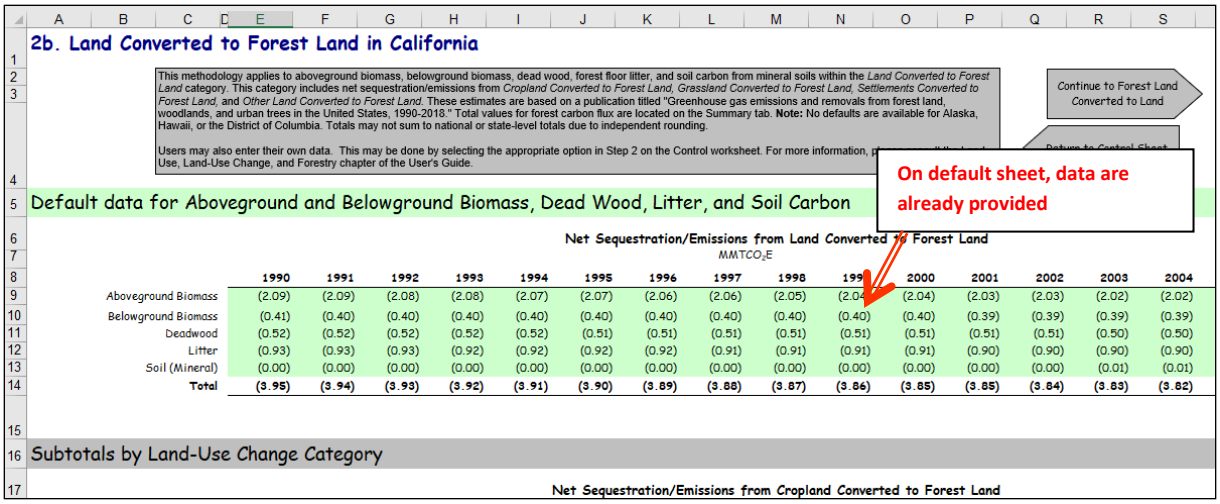
| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aboveground Biomass | (28.59) | (28.35) | (28.11) | (27.87) | (27.64) | (27.42) | (27.19) | (26.97) | (26.74) | (26.52) | (26.29) | (26.07) | (25.84) | (25.62) | (25.38) | (25.14) |
| Belowground Biomass | (6.28) | (6.23) | (6.18) | (6.12) | (6.08) | (6.03) | (5.98) | (5.93) | (5.88) | (5.83) | (5.78) | (5.73) | (5.69) | (5.64) | (5.58) | (5.53) |
| Deadwood | (5.68) | (5.72) | (5.76) | (5.79) | (5.82) | (5.84) | (5.87) | (5.89) | (5.91) | (5.94) | (5.96) | (5.99) | (6.01) | (6.04) | (6.04) | (6.04) |
| Litter | (0.38) | (0.37) | (0.37) | (0.36) | (0.36) | (0.36) | (0.36) | (0.35) | (0.35) | (0.35) | (0.35) | (0.34) | (0.34) | (0.34) | (0.33) | (0.32) |
| Soil (Mineral) | 0.61 | 0.60 | 0.58 | 0.57 | 0.57 | 0.57 | 0.57 | 0.58 | 0.58 | 0.58 | 0.58 | 0.58 | 0.58 | 0.59 | 0.58 | 0.58 |
| Soil (Organic) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | - | - | - |
| Drained Organic Soil | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Total** | **(40.32)** | **(40.07)** | **(39.82)** | **(39.58)** | **(39.32)** | **(39.07)** | **(38.82)** | **(38.56)** | **(38.31)** | **(38.06)** | **(37.80)** | **(37.55)** | **(37.30)** | **(37.04)** | **(36.75)** | **(36.45)** |

Next, click the gray navigational arrow to continue to the *Land Converted to Forest Land* worksheet.

## Land Converted to Forest Land Worksheet

This tab calculates net sequestration/emissions from *Land Converted to Forest Land*. This category includes *Cropland Converted to Forest Land, Grassland Converted to Forest Land, Settlements Converted to Forest Land, Other Land Converted to Forest Land,* and *Wetlands Converted to Forest Land*. There is no further information to enter on this tab if you are using the default data for forest carbon flux. Figure 4 shows the default worksheet for *Land Converted to Forest Land*.

**Figure 4: Example of Land Converted to Forest Land Worksheet Using Default Data**



2b. Land Converted to Forest Land in California

This methodology applies to aboveground biomass, belowground biomass, dead wood, forest floor litter, and soil carbon from mineral soils within the *Land Converted to Forest Land* category. This category includes net sequestration/emissions from *Cropland Converted to Forest Land*, *Grassland Converted to Forest Land*, *Settlements Converted to Forest Land*, and *Other Land Converted to Forest Land*. These estimates are based on a publication titled "Greenhouse gas emissions and removals from forest land, woodlands, and urban trees in the United States, 1990-2018." Total values for forest carbon flux are located on the Summary tab. **Note:** No defaults are available for Alaska, Hawaii, or the District of Columbia. Totals may not sum to national or state-level totals due to independent rounding.

Users may also enter their own data. This may be done by selecting the appropriate option in Step 2 on the Control worksheet. For more information, p
Use, Land-Use Change, and Forestry chapter of the User's Guide.

Continue to Forest Land Converted to Land

On default sheet, data are already provided

Default data for Aboveground and Belowground Biomass, Dead Wood, Litter, and Soil Carbon

Net Sequestration/Emissions from Land Converted to Forest Land
$MMTCO_2E$

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 199 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aboveground Biomass | (2.09) | (2.09) | (2.08) | (2.08) | (2.07) | (2.07) | (2.06) | (2.06) | (2.05) | (2.04) | (2.04) | (2.03) | (2.03) | (2.02) | (2.02) |
| Belowground Biomass | (0.41) | (0.40) | (0.40) | (0.40) | (0.40) | (0.40) | (0.40) | (0.40) | (0.40) | (0.40) | (0.40) | (0.39) | (0.39) | (0.39) | (0.39) |
| Deadwood | (0.52) | (0.52) | (0.52) | (0.52) | (0.52) | (0.51) | (0.51) | (0.51) | (0.51) | (0.51) | (0.51) | (0.51) | (0.51) | (0.50) | (0.50) |
| Litter | (0.93) | (0.93) | (0.93) | (0.92) | (0.92) | (0.92) | (0.92) | (0.91) | (0.91) | (0.91) | (0.91) | (0.90) | (0.90) | (0.90) | (0.90) |
| Soil (Mineral) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.01) | (0.01) |
| **Total** | **(3.95)** | **(3.94)** | **(3.93)** | **(3.92)** | **(3.91)** | **(3.90)** | **(3.89)** | **(3.88)** | **(3.87)** | **(3.86)** | **(3.85)** | **(3.85)** | **(3.84)** | **(3.83)** | **(3.82)** |

Subtotals by Land-Use Change Category

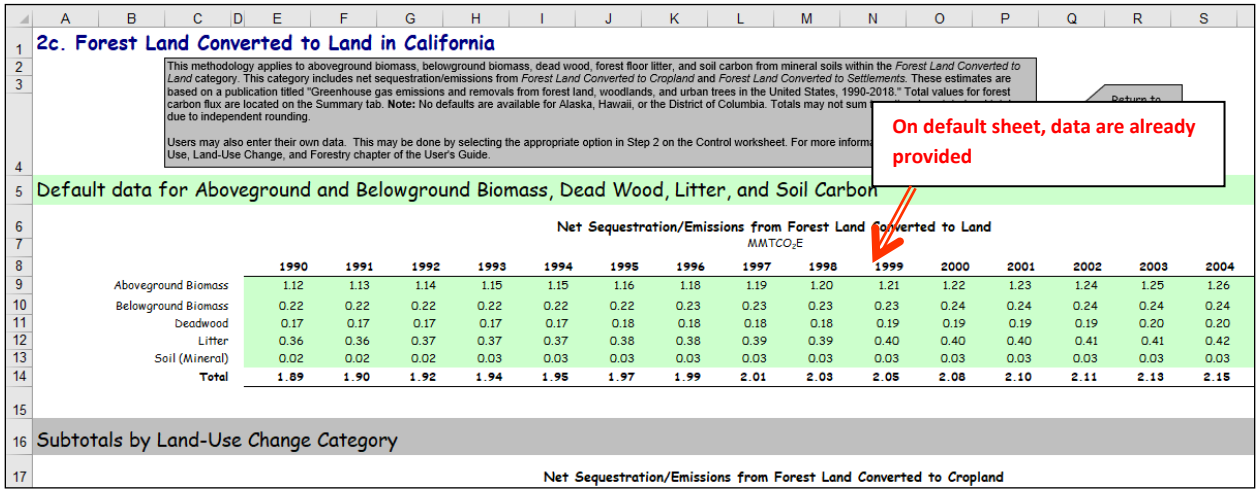
Net Sequestration/Emissions from Cropland Converted to Forest Land

Next, click the gray navigational arrow to continue to the *Forest Land Converted to Land Worksheet*.

## Forest Land Converted to Land Worksheet

This tab calculates net sequestration/emissions from *Forest Land Converted to Land*. This category includes *Forest Land Converted to Settlements, Forest Land Converted to Other Land, and Forest Land Converted to Wetlands*. Note that carbon flux from *Forest Land Converted to Cropland* and *Forest Land Converted to Grassland* is accounted for under Agricultural Soil Carbon Flux. There is no further information to enter on this tab if you are using the default data for forest carbon flux. Figure 5 shows the default worksheet for *Forest Land Converted to Land*.

**Figure 5: Example of Forest Land Converted to Land Worksheet Using Default Data**



2c. Forest Land Converted to Land in California

This methodology applies to aboveground biomass, belowground biomass, dead wood, forest floor litter, and soil carbon from mineral soils within the *Forest Land Converted to Land* category. This category includes net sequestration/emissions from *Forest Land Converted to Cropland* and *Forest Land Converted to Settlements*. These estimates are based on a publication titled "Greenhouse gas emissions and removals from forest land, woodlands, and urban trees in the United States, 1990-2018." Total values for forest carbon flux are located on the Summary tab. **Note:** No defaults are available for Alaska, Hawaii, or the District of Columbia. Totals may not sum t
due to independent rounding.

Users may also enter their own data. This may be done by selecting the appropriate option in Step 2 on the Control worksheet. For more informa
Use, Land-Use Change, and Forestry chapter of the User's Guide.

On default sheet, data are already provided

Default data for Aboveground and Belowground Biomass, Dead Wood, Litter, and Soil Carbon

Net Sequestration/Emissions from Forest Land Converted to Land
$MMTCO_2E$

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aboveground Biomass | 1.12 | 1.13 | 1.14 | 1.15 | 1.15 | 1.16 | 1.18 | 1.19 | 1.20 | 1.21 | 1.22 | 1.23 | 1.24 | 1.25 | 1.26 |
| Belowground Biomass | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.23 | 0.23 | 0.23 | 0.23 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 |
| Deadwood | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.18 | 0.18 | 0.18 | 0.18 | 0.19 | 0.19 | 0.19 | 0.19 | 0.20 | 0.20 |
| Litter | 0.36 | 0.36 | 0.37 | 0.37 | 0.37 | 0.38 | 0.38 | 0.39 | 0.39 | 0.40 | 0.40 | 0.40 | 0.41 | 0.41 | 0.42 |
| Soil (Mineral) | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| **Total** | **1.89** | **1.90** | **1.92** | **1.94** | **1.95** | **1.97** | **1.99** | **2.01** | **2.03** | **2.05** | **2.08** | **2.10** | **2.11** | **2.13** | **2.15** |

Subtotals by Land-Use Change Category

Net Sequestration/Emissions from Forest Land Converted to Cropland

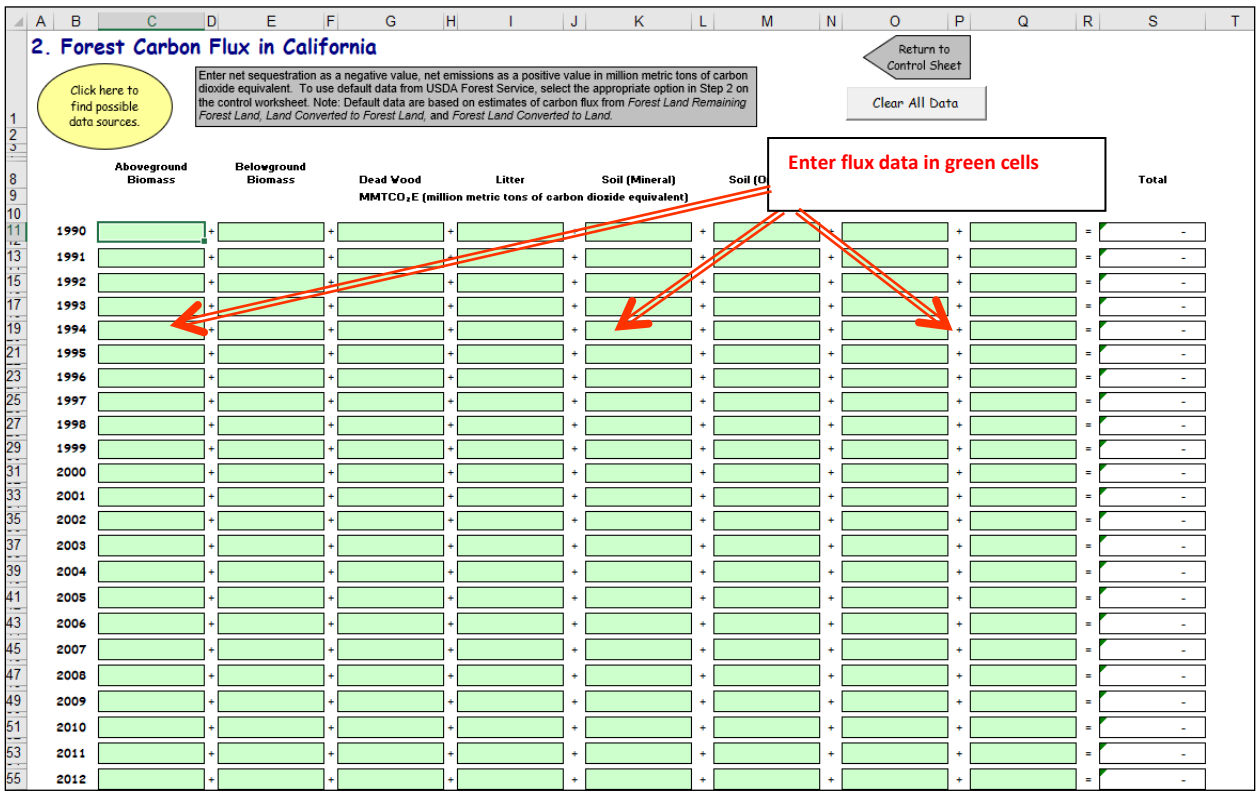
If you are using your own data on forest carbon flux, enter carbon flux data for aboveground biomass, belowground biomass, dead wood, litter, mineral and organic soils, drained organic soil, and wood products and landfills in the green cells on the C Flux-User Data tab. Figure 6 shows the worksheet where you will enter this forest carbon flux data. The method used for calculating forest carbon flux is

shown in Equation 1. The calculation is a sum of the fluxes for above- and belowground biomass, dead wood, litter, mineral and organic soils, drained organic soil, and wood products in use and in landfills. Once this sector worksheet is complete, use the gray navigational arrow to return to the control worksheet and proceed to the next step.

**Equation 1. Forest Carbon Flux Equation**

**Emissions or Sequestration ($MMTCO_2E$) =**
**Sum of carbon fluxes from aboveground biomass, belowground biomass, dead wood, litter, mineral and organic soils, drained organic soil, and wood products and landfills**

**Figure 6. Example of User-Entered Data Forest Carbon Flux Worksheet**




## Step (3) Enter Emission Factors and Activity Data for Urban Trees

### Control Worksheet

On the control worksheet, enter a carbon sequestration factor for urban trees in the appropriate yellow cell (metric tons of carbon per hectare per year). Default state-specific estimates of net sequestration are provided from Nowak et al. (2013). If the user-specific inputs do not match the default data in the control worksheet (i.e., the default value is overwritten), the text will appear red.

Trees in urban areas represent approximately 5.5 percent of total United States tree canopy cover (Nowak and Greenfield 2012). Furthermore, because trees in urban areas grow in relatively open surroundings, their growth and carbon sequestration are disproportionately large relative to forests. This section presents the methodology for calculating carbon sequestered by urban trees in your state.

After entering the appropriate sequestration factor, use the gray arrows to navigate to the Urban Trees worksheet.

## Urban Trees Worksheet

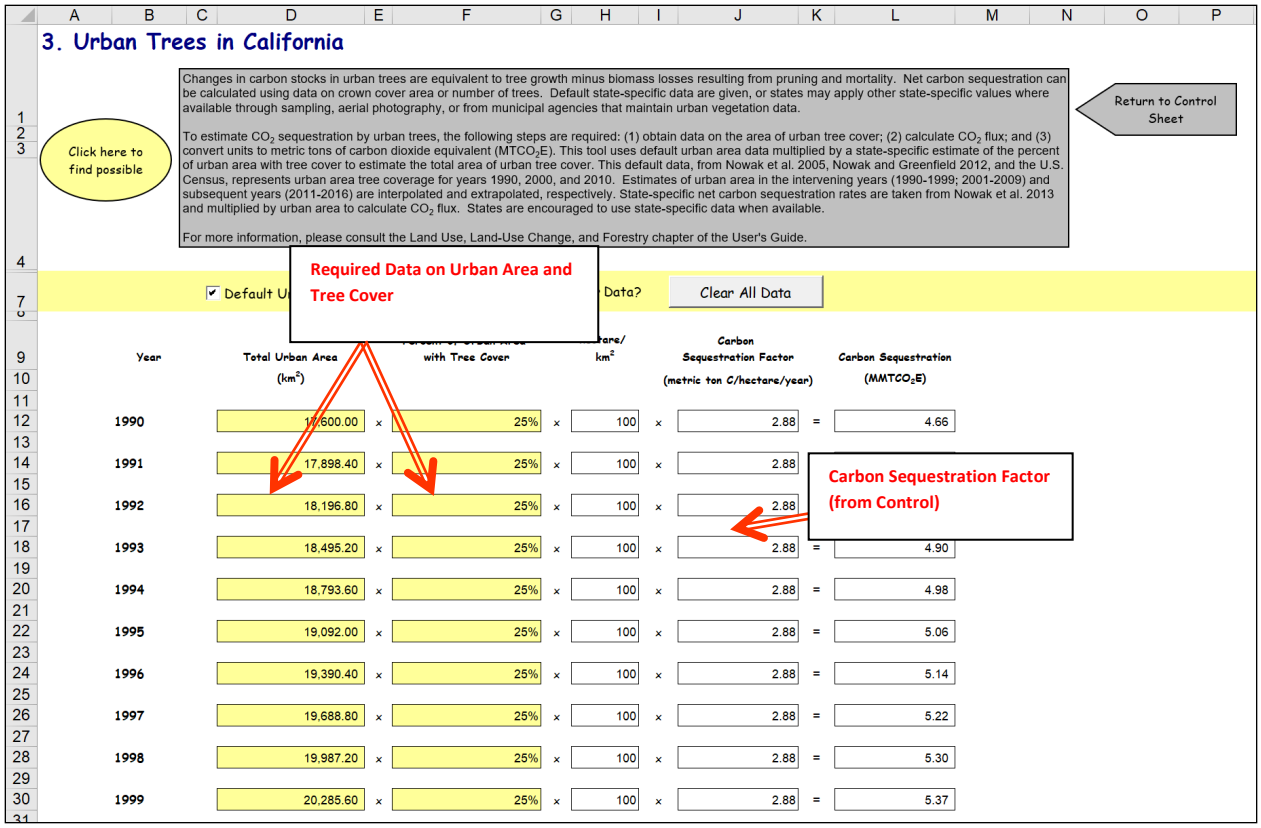
Within the Urban Trees worksheet, enter data on the total urban area in your state (in square kilometers), as well as the average percent of urban area covered by trees, in the yellow cells. An example of this worksheet is shown in Figure 7. Equation 2 shows the method used to calculate carbon sequestration in urban trees.

Default urban areas are taken from Nowak et al. (2005) and the U.S. Census (1990, 2002, 2012, and 2023). Default state-specific percentages of urban tree cover are taken from Nowak and Greenfield (2012). Once this worksheet is complete, use the gray navigational arrow to return to the control worksheet and proceed to the next step.

**Equation 2. Urban Trees Equation**

**Sequestration ($MMTCO_2E$) =**
**Total Urban Area ($km^2$) x Urban Area with Tree Cover (%)**
**x 100 ($ha/km^2$) x C Sequestration Factor (metric tons C/ha/yr) x 44/12 (ratio of $CO_2$ to C) ÷ 1,000,000 (to yield $MMTCO_2E$)**

**Figure 7. Example of Carbon Sequestration Factor Applied in the Urban Trees Worksheet**



3. Urban Trees in California

Changes in carbon stocks in urban trees are equivalent to tree growth minus biomass losses resulting from pruning and mortality. Net carbon sequestration can be calculated using data on crown cover area or number of trees. Default state-specific data are given, or states may apply other state-specific values where available through sampling, aerial photography, or from municipal agencies that maintain urban vegetation data.

To estimate $CO_2$ sequestration by urban trees, the following steps are required: (1) obtain data on the area of urban tree cover; (2) calculate $CO_2$ flux; and (3) convert units to metric tons of carbon dioxide equivalent ($MTCO_2E$). This tool uses default urban area data multiplied by a state-specific estimate of the percent of urban area with tree cover to estimate the total area of urban tree cover. This default data, from Nowak et al. 2005, Nowak and Greenfield 2012, and the U.S. Census, represents urban area tree coverage for years 1990, 2000, and 2010. Estimates of urban area in the intervening years (1990-1999; 2001-2009) and subsequent years (2011-2016) are interpolated and extrapolated, respectively. State-specific net carbon sequestration rates are taken from Nowak et al. 2013 and multiplied by urban area to calculate $CO_2$ flux. States are encouraged to use state-specific data when available.

For more information, please consult the Land Use, Land-Use Change, and Forestry chapter of the User's Guide.



| Year | Total Urban Area ($km^2$) | | Percent of Urban Area with Tree Cover | | Hectare/ $km^2$ | | Carbon Sequestration Factor (metric ton C/hectare/year) | | Carbon Sequestration ($MMTCO_2E$) |
|---|---|---|---|---|---|---|---|---|---|
| 1990 | 17,600.00 | x | 25% | x | 100 | x | 2.88 | = | 4.66 |
| 1991 | 17,898.40 | x | 25% | x | 100 | x | 2.88 | | |
| 1992 | 18,196.80 | x | 25% | x | 100 | x | 2.88 | | |
| 1993 | 18,495.20 | x | 25% | x | 100 | x | 2.88 | = | 4.90 |
| 1994 | 18,793.60 | x | 25% | x | 100 | x | 2.88 | = | 4.98 |
| 1995 | 19,092.00 | x | 25% | x | 100 | x | 2.88 | = | 5.06 |
| 1996 | 19,390.40 | x | 25% | x | 100 | x | 2.88 | = | 5.14 |
| 1997 | 19,688.80 | x | 25% | x | 100 | x | 2.88 | = | 5.22 |
| 1998 | 19,987.20 | x | 25% | x | 100 | x | 2.88 | = | 5.30 |
| 1999 | 20,285.60 | x | 25% | x | 100 | x | 2.88 | = | 5.37 |

## Step (4) Enter Emission Factors and Activity Data for $N_2O$ from Settlement Soils

### Control Worksheet

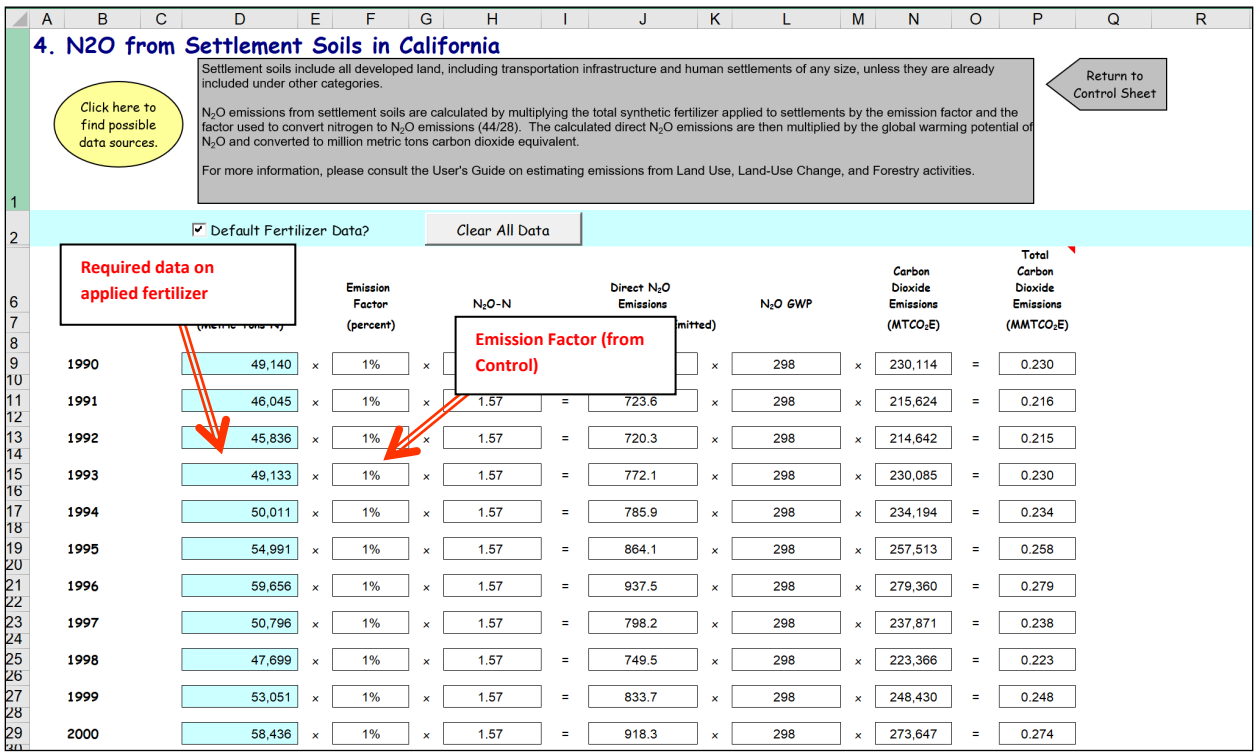
Of the fertilizers applied to soils in the United States, approximately 10 percent are applied to lawns, golf courses, and other landscaping occurring within settled areas. This section of the LULUCF module estimates $N_2O$ emissions due to the application of fertilizers to settlement soils. On the control sheet you must enter an emission factor that will be used to calculate direct emissions due to fertilizer applications. The default value of 1 percent comes from IPCC (2006). If the user-specific inputs do not match the default data in the control worksheet (i.e., the default value is overwritten), the text will appear red.

After entering the appropriate emission factor, use the gray arrows to navigate to the Non-$CO_2$ from Settlement soils worksheet.

## $N_2O$ from Settlement Soils Worksheet

To complete this worksheet enter the amount of synthetic fertilizer applied (in metric tons of nitrogen) in the light blue cells (Figure 8). Emissions are calculated by multiplying the fertilizer data by the emission factor for direct emissions of $N_2O$ (1.0 percent) to obtain the amount of emissions in $N_2O$-N/yr. This number is then converted from MT $N_2O$-N to MT $N_2O$ by multiplying by the ratio of $N_2O/N_2O$-N (44/28). This is then converted to $MMTCO_2E$ by dividing by 1,000,000 and multiplying by the GWP of $N_2O$. This calculation is shown in Equation 3. Once this worksheet is complete, use the gray navigational arrow to return to the control worksheet and proceed to emissions from forest fires.

**Figure 8. Example of Fertilizer Data Applied in the Settlement Soils Worksheet**




| | | Emission Factor (percent) | | $N_2O$-N | | Direct $N_2O$ Emissions | | $N_2O$ GWP | | Carbon Dioxide Emissions ($MTCO_2E$) | | Total Carbon Dioxide Emissions ($MMTCO_2E$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1990 | 49,140 | 1% | | | | | | 298 | | 230,114 | | 0.230 |
| 1991 | 46,045 | 1% | | 1.57 | | 723.6 | | 298 | | 215,624 | | 0.216 |
| 1992 | 45,836 | 1% | | 1.57 | | 720.3 | | 298 | | 214,642 | | 0.215 |
| 1993 | 49,133 | 1% | | 1.57 | | 772.1 | | 298 | | 230,085 | | 0.230 |
| 1994 | 50,011 | 1% | | 1.57 | | 785.9 | | 298 | | 234,194 | | 0.234 |
| 1995 | 54,991 | 1% | | 1.57 | | 864.1 | | 298 | | 257,513 | | 0.258 |
| 1996 | 59,656 | 1% | | 1.57 | | 937.5 | | 298 | | 279,360 | | 0.279 |
| 1997 | 50,796 | 1% | | 1.57 | | 798.2 | | 298 | | 237,871 | | 0.238 |
| 1998 | 47,699 | 1% | | 1.57 | | 749.5 | | 298 | | 223,366 | | 0.223 |
| 1999 | 53,051 | 1% | | 1.57 | | 833.7 | | 298 | | 248,430 | | 0.248 |
| 2000 | 58,436 | 1% | | 1.57 | | 918.3 | | 298 | | 273,647 | | 0.274 |

**Equation 3. Equation for Direct N2O Emissions from Settlement Soils**

**Emissions ($MMTCO_2E$) =**
**Total Synthetic Fertilizer Applied to Settlement Soils (metric ton N) x Emission Factor (percent) x 0.01 (metric tons $N_2O$-N/metric ton N) x 44/28 (Ratio of $N_2O$ to $N_2O$-N) x 265 (GWP) ÷ 1,000,000 ($MT/MMTCO_2E$)**

## Step (5) Enter Emission Factors and Activity Data for Non-$CO_2$ from Forest Fires

### Control Worksheet

On the control worksheet, the following data must be entered in the appropriate yellow cells for forest fires: (1) emission factors for $N_2O$ and $CH_4$ for forest and savanna (grams of gas per kg dry matter combusted), (2) combustion efficiency by vegetation type (%), and (3) average biomass density in the state (kg dry matter per hectare). Default emission factors and combustion efficiencies are from IPCC (2006). Default biomass densities are adapted from Smith et al. (2001) and U.S. EPA (2003). States are encouraged to use this more detailed data if it is available and well documented. If the user-specific inputs do not match the default data in the control worksheet (i.e., the default value is overwritten), the text will appear red.

When a forest (or savanna) burns, the $CO_2$ emissions are included in the overall flux of forest carbon that is calculated in the forest carbon flux worksheet. However, forest fires also cause emissions of $N_2O$ and $CH_4$ that are not accounted for under forest carbon flux because they are non-$CO_2$ emissions. This section presents the methodology for calculating $N_2O$ and $CH_4$ emissions from forest fires.

After entering the appropriate emission factors for forest fires, use the gray arrows to navigate to the Non-$CO_2$ from Forest Fires worksheet.

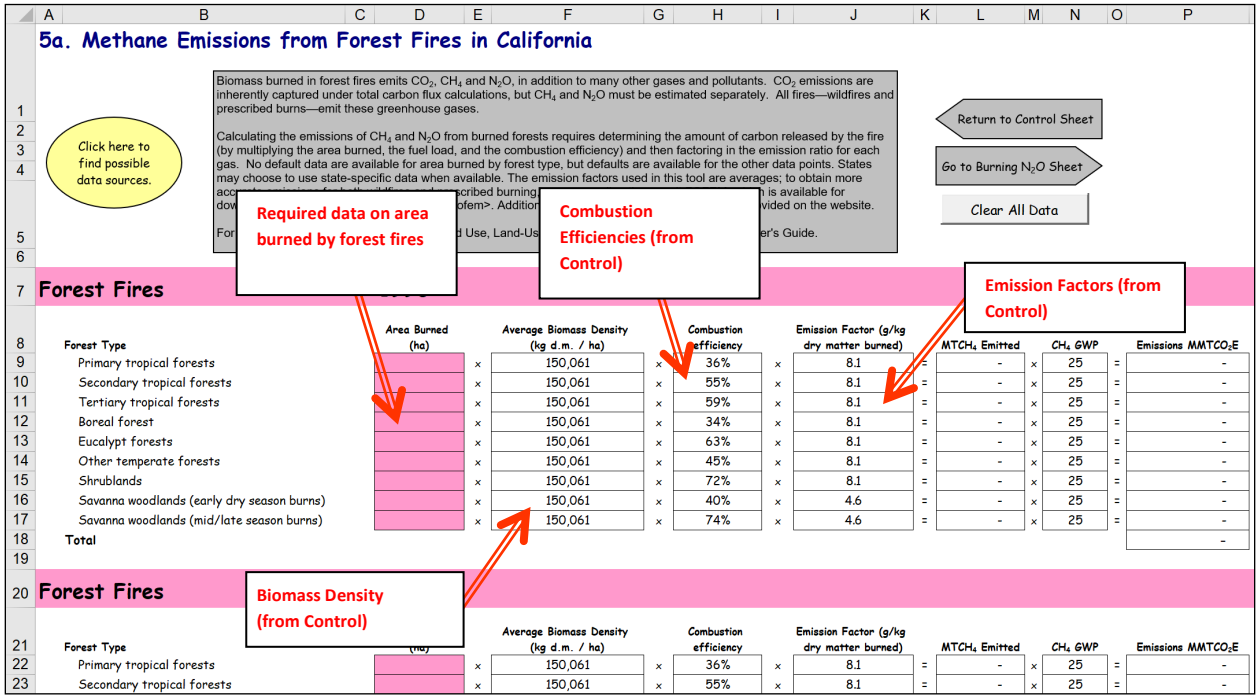
### Non-$CO_2$ from Forest Fires Worksheets

Within the Forest Fires worksheet, enter the area (hectares) burned per year in the pink cells. Because there is no default data available on area burned by state, you must rely on outside sources for this information (see Box 1 for suggestions). Equation 4 shows the method used to calculate $N_2O$ and $CH_4$ emissions from forest fires. An example of this worksheet is shown in Figure 9. Once this sector worksheet is complete, use the gray navigational arrow to return to the control worksheet and proceed to the next category.

**Equation 4. Forest Fires Emissions Equation**

**Emissions ($MMTCO_2E$) =**
**Area Burned (ha) x Average Biomass Density (kg dry matter/ha) x Combustion Efficiency (%) x Emission Factor (g gas/kg dry matter burned) x GWP**

**Figure 9. Example of Forest Fire Data Applied in the Forest Fire Worksheet**




## Step (6) Enter Emission Factors and Activity Data for Landfilled Yard Trimming and Food Scraps

### Control Worksheet

When wastes of biogenic origin (such as yard trimming and food scraps) are landfilled and do not completely decompose, the carbon that remains is stored. This section of the LULUCF module estimates the carbon stored in landfills by yard trimmings and food scraps.

Because the Landfilled Yard Trimmings and Food Scraps sector involves complicated calculations, the gray navigational arrow on the control worksheet takes you directly to the Landfilled Yard Trimmings and Food Scraps worksheet.

### Landfilled Yard Trimmings and Food Scraps Worksheet

The Landfilled Yard Trimmings and Food Scraps sector worksheet calculates net carbon flux by estimating the change in landfilled carbon stocks between years, based on methodologies presented in IPCC (2003) and IPCC (2006). The LULUCF module uses Equation 5 to calculate carbon sequestration associated with landfilled yard trimmings and food scraps. Carbon stock estimates were calculated by: determining the mass of landfilled carbon resulting from yard trimmings or food scraps discarded in a given year; adding the accumulated landfilled carbon from previous years; and subtracting the portion of carbon landfilled in previous years that has decomposed.

**Equation 5. Landfilled Yard Trimmings and Food Scraps Equation**

$$LFC_{i,t} = \sum_{n} W_{i,n} \times (1 - MC_i) \times ICC_i \times \{[CS_i \times ICC_i] + [(1 - (CS_i \times ICC_i)) \times e^{-k \times (t-n)}]\}$$

**where,**

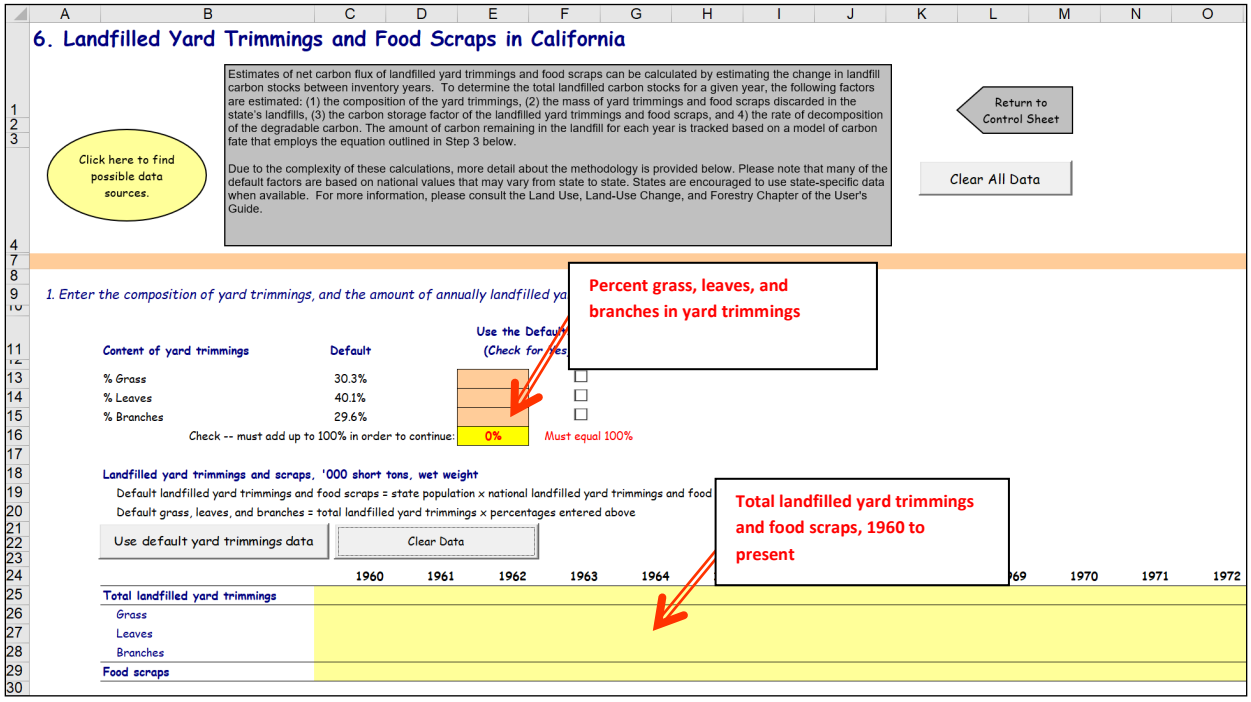
| | |
|---|---|
| **t** | **= the year for which carbon stocks are being estimated,** |
| **LFC i,t** | **= the stock of carbon in landfills in year t, for waste i (grass, leaves, branches, food scraps)** |
| **Wi,n** | **= the mass of waste i disposed in landfills in year n, in units of wet weight** |
| **n** | **= the year in which the waste was disposed, where 1960 < n < t** |
| **MCi** | **= moisture content of waste i,** |
| **CSi** | **= the proportion of initial carbon that is stored for waste i,** |
| **ICCi** | **= the initial carbon content of waste i,** |
| **e** | **= the natural logarithm, and** |
| **k** | **= the first order rate constant for waste i, and is equal to 0.693 divided by the half-life for decomposition.** |

To determine the total landfilled carbon stocks for a given year, the tool employs: (1) the composition of the yard trimmings; (2) the mass of yard trimmings and food scraps discarded in landfills; (3) the carbon storage factor of the landfilled yard trimmings and food scraps adjusted by mass balance; and (4) the rate of decomposition of the degradable carbon.

Due to the number of factors involved, the Landfilled Yard Trimmings and Food Scraps sector worksheet is arranged by a series of steps. To complete this sector worksheet, follow the steps below.

1. Enter the amount of landfilled yard trimmings and food scraps.
    a. Enter the composition of yard trimmings in the orange cells as a percent of grass, leaves, and branches. Default percentages are available by clicking on the check boxes to the right of the orange input cells and are provided by Oshins and Block (2000). Figure 10 displays the inputs cells where this information is entered. If the user-specific inputs do not match the default data in the worksheet (i.e., the default value is overwritten), the text will appear red.
    b. Enter the total annual landfilled yard trimmings and food scraps from 1960 to the present in short tons of wet weight in the yellow input cells. Default data are provided by clicking on the gray “Use default yard trimmings data” button above the yellow input cells. The tool uses the percentage entered for yard trimmings in the previous step to allocate the amount of yard trimmings distributed among grass, leaves, and branches. The default data from U.S. EPA (2020) is a national total for yard trimmings and food scraps and is distributed to each state based on state population U.S. Census Bureau (2026).

**Figure 10. Landfilled Yard Trimmings and Food Scraps Worksheet, Step 1**

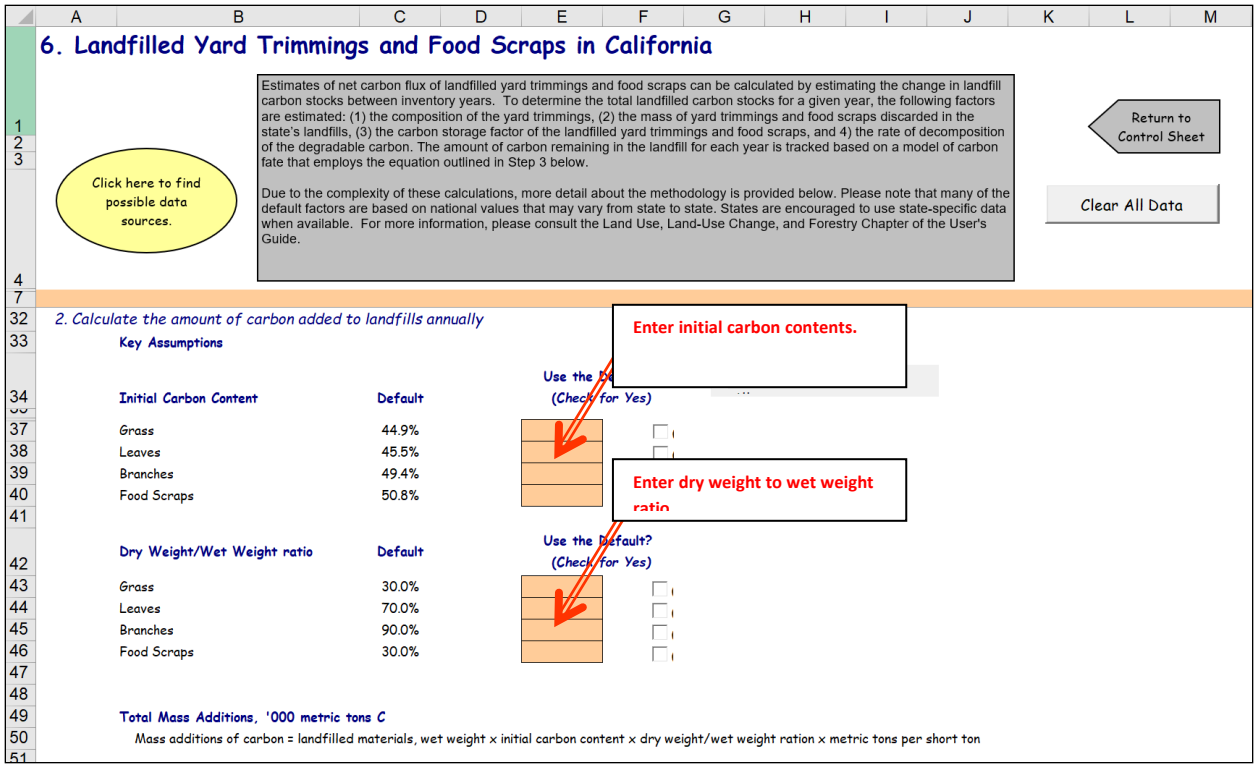



2. Calculate the amount of carbon added to landfills annually.

    a. Enter the initial carbon content percent for grass, leaves, branches, and food scraps in the orange cells, as shown in Figure 11. The default percentages are taken from Barlaz (1998). If the user-specific inputs do not match the default data in the worksheet (i.e., the default value is overwritten), the text will appear red.

    b. Enter the dry weight to wet weight ratio for grass, leaves, branches, and food scraps, also shown in Figure 13. This default information is drawn from Tchobanoglous, et al. (1993). If the user-specific inputs do not match the default data in the worksheet (i.e., the default value is overwritten), the text will appear red.

**Figure 11. Landfilled Yard Trimmings and Food Scraps Worksheet, Step 2**



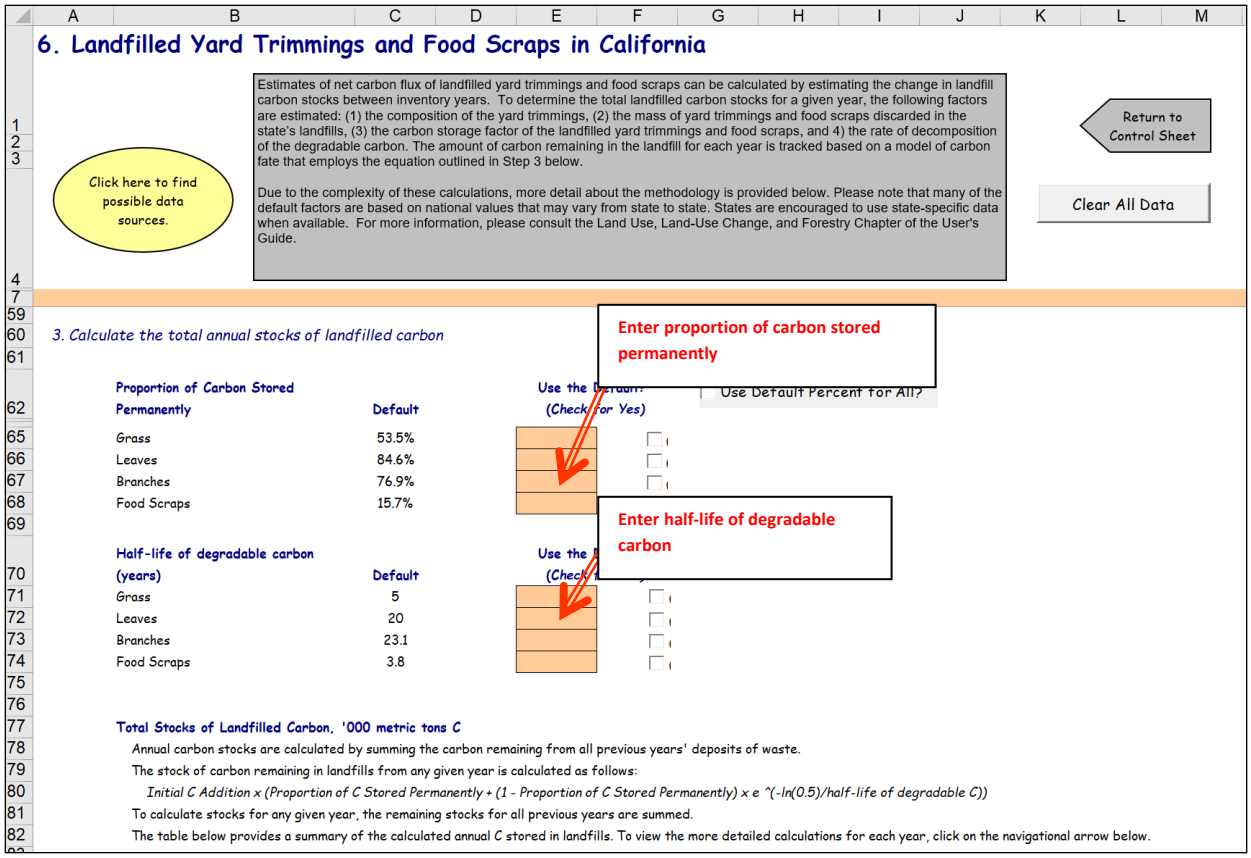

3. Calculate the total annual stocks of landfilled carbon.

    a. In the orange input cells, enter the proportion of carbon from each material stored in landfills indefinitely, as shown in Figure 12. Or use the default proportions, based on Barlaz (1998, 2005, and 2008). If the user-specific inputs do not match the default data in the worksheet (i.e., the default value is overwritten), the text will appear red.

    b. Enter the half-life of the degradable carbon in each of the materials in years, shown in Figure 14. The default data are from IPCC (2006). If the user-specific inputs do not match the default data in the worksheet (i.e., the default value is overwritten), the text will appear red.

Once this sector worksheet is complete, use the gray navigational arrow to return to the control worksheet.

**Figure 12. Landfilled Yard Trimmings and Food Scraps Worksheet, Step 3**

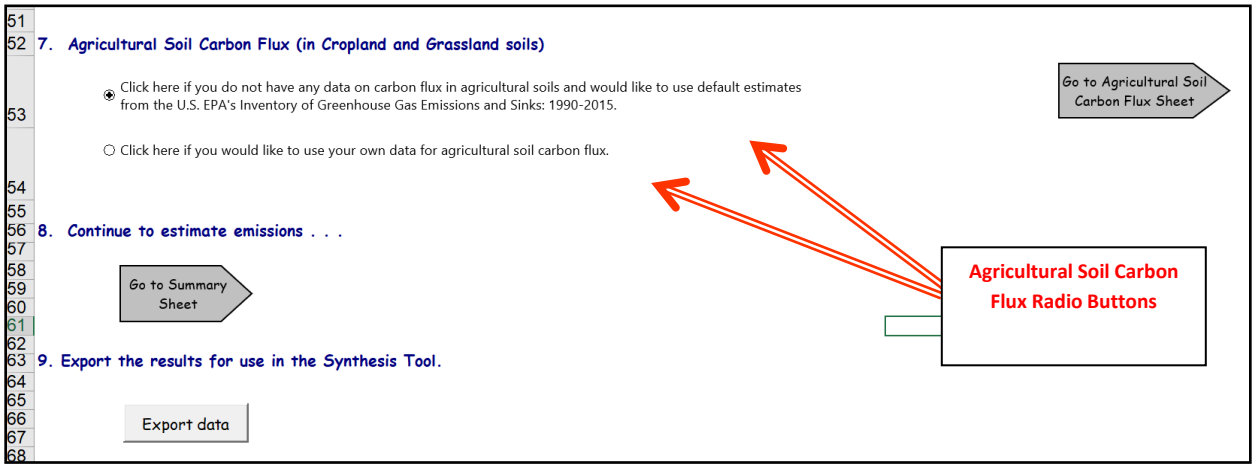



## Step (7) Select an Option for Agricultural Soil Carbon Flux

### Control Worksheet

The control worksheet allows you to either select the default data provided or to enter user-specified data to be used throughout the tool. To proceed with the default data, select the first radio button under step 7 on the control worksheet. If you would like to use your own state-specific data, select the second radio button under step 7 of the control worksheet. See Figure 13 for an example of the radio buttons in step 7.

**Figure 13. Control Worksheet for the LULUCF Module**




Carbon is continuously cycled through the cropland and grassland ecosystems and the atmosphere. The amount of carbon stored in cropland varies according to crop type, management practices (e.g., rotation, tillage, drainage), and soil and climate variables. The amount of carbon stored in grassland depends on management practices (e.g., irrigation) and is also impacted by inter-annual climate variability, such as increased rainfall (IPCC 2006). Soil is the primary carbon pool in both cropland and grassland (U.S. EPA 2025a). Default data for agricultural soil carbon flux was updated in 2023 to include carbon flux from aboveground biomass, belowground biomass, deadwood, and litter in cropland and grassland ecosystems.

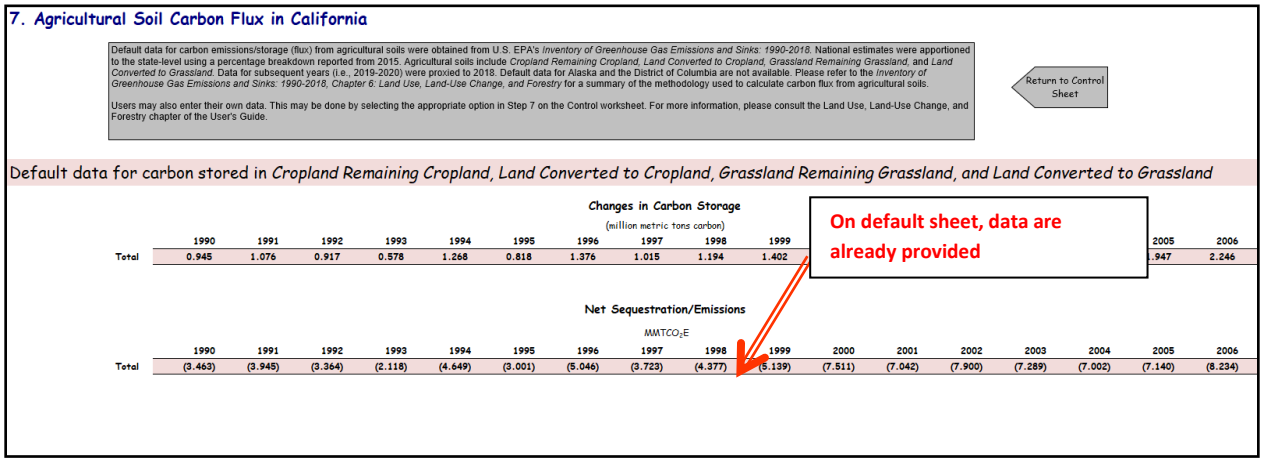
The net change in agricultural soil carbon is the change in the amount of carbon stored primarily in mineral and organic soils over time. This section presents the methodology for calculating agricultural soil carbon flux.

After completing the control worksheet for this sector, use the gray arrows to navigate to the Agricultural Soil Carbon Flux worksheet.

## Agricultural Soil Carbon Flux Worksheet

If you are using the default data for agricultural soil carbon flux estimates, there is no further information to enter. Figure 14 shows the default agricultural soil carbon worksheet.

**Figure 14. Example of Agricultural Soil Carbon Flux Worksheet Using Default Data**



7. Agricultural Soil Carbon Flux in California

Default data for carbon emissions/storage (flux) from agricultural soils were obtained from U.S. EPA's *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2018*. National estimates were apportioned to the state-level using a percentage breakdown reported from 2015. Agricultural soils include *Cropland Remaining Cropland, Land Converted to Cropland, Grassland Remaining Grassland,* and *Land Converted to Grassland*. Data for subsequent years (i.e., 2019-2020) were provided to 2018. Default data for Alaska and the District of Columbia are not available. Please refer to the *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2018, Chapter 6: Land Use, Land-Use Change, and Forestry* for a summary of the methodology used to calculate carbon flux from agricultural soils.

Users may also enter their own data. This may be done by selecting the appropriate option in Step 7 on the Control worksheet. For more information, please consult the Land Use, Land-Use Change, and Forestry chapter of the User's Guide.

Return to Control Sheet

Default data for carbon stored in *Cropland Remaining Cropland, Land Converted to Cropland, Grassland Remaining Grassland,* and *Land Converted to Grassland*

Changes in Carbon Storage (million metric tons carbon)

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 0.945 | 1.076 | 0.917 | 0.578 | 1.268 | 0.818 | 1.376 | 1.015 | 1.194 | 1.402 | .947 | 2.246 |

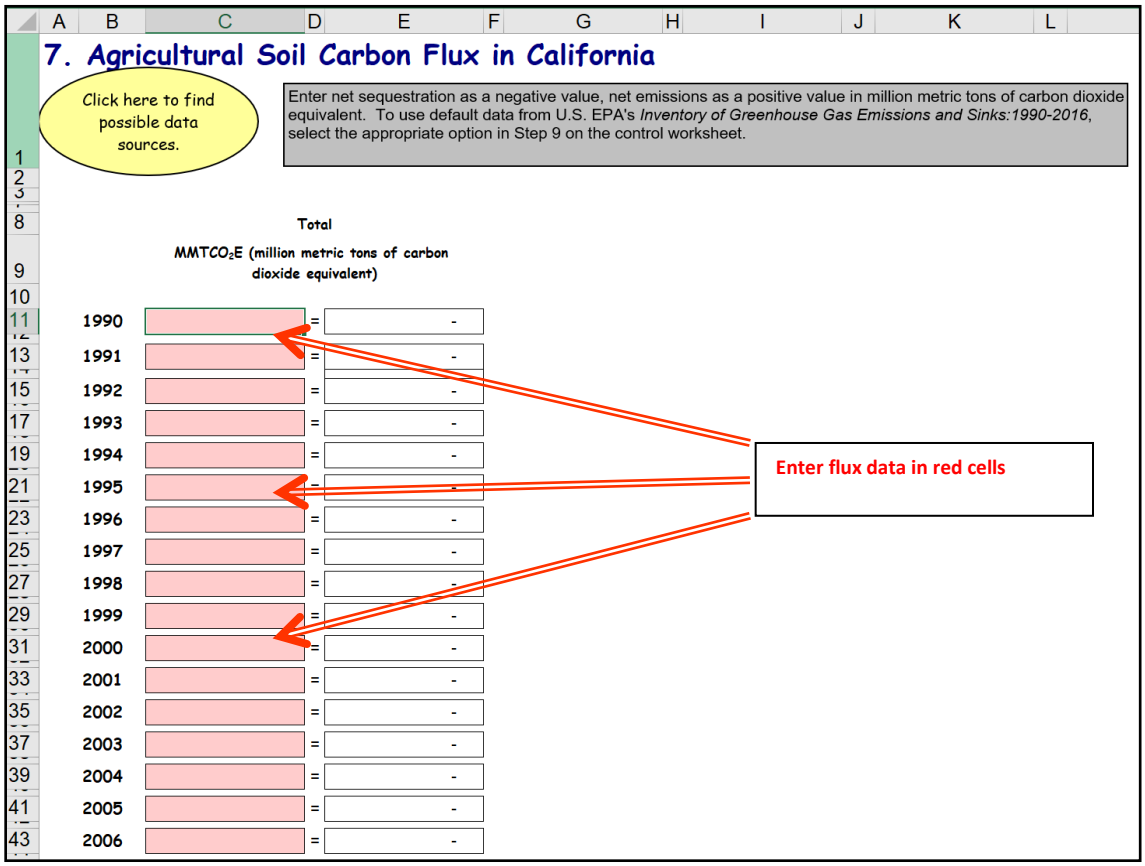
Net Sequestration/Emissions MMT$CO_2$E

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | (3.463) | (3.945) | (3.364) | (2.118) | (4.649) | (3.001) | (5.046) | (3.723) | (4.377) | (5.139) | (7.511) | (7.042) | (7.900) | (7.289) | (7.002) | (7.140) | (8.234) |



If you are using your own data on agricultural soil carbon flux, in the red cells enter total carbon flux data for cropland and grasslands (including land recently converted to cropland and grassland). Figure 15 shows the worksheet where you will enter agricultural soil carbon flux data. Once this sector worksheet is complete, use the gray navigational arrow to return to the control worksheet and proceed to the next step.

**Figure 15. Example of User-Entered Data Agricultural Soil Carbon Flux Worksheet**



7. Agricultural Soil Carbon Flux in California

Click here to find possible data sources.

Enter net sequestration as a negative value, net emissions as a positive value in million metric tons of carbon dioxide equivalent. To use default data from U.S. EPA's *Inventory of Greenhouse Gas Emissions and Sinks:1990-2016*, select the appropriate option in Step 9 on the control worksheet.

| | Total MMT$CO_2$E (million metric tons of carbon dioxide equivalent) | | |
|---|---|---|---|
| 1990 | | = | - |
| 1991 | | = | - |
| 1992 | | = | - |
| 1993 | | = | - |
| 1994 | | = | - |
| 1995 | | = | - |
| 1996 | | = | - |
| 1997 | | = | - |
| 1998 | | = | - |
| 1999 | | = | - |
| 2000 | | = | - |
| 2001 | | = | - |
| 2002 | | = | - |
| 2003 | | = | - |
| 2004 | | = | - |
| 2005 | | = | - |
| 2006 | | = | - |

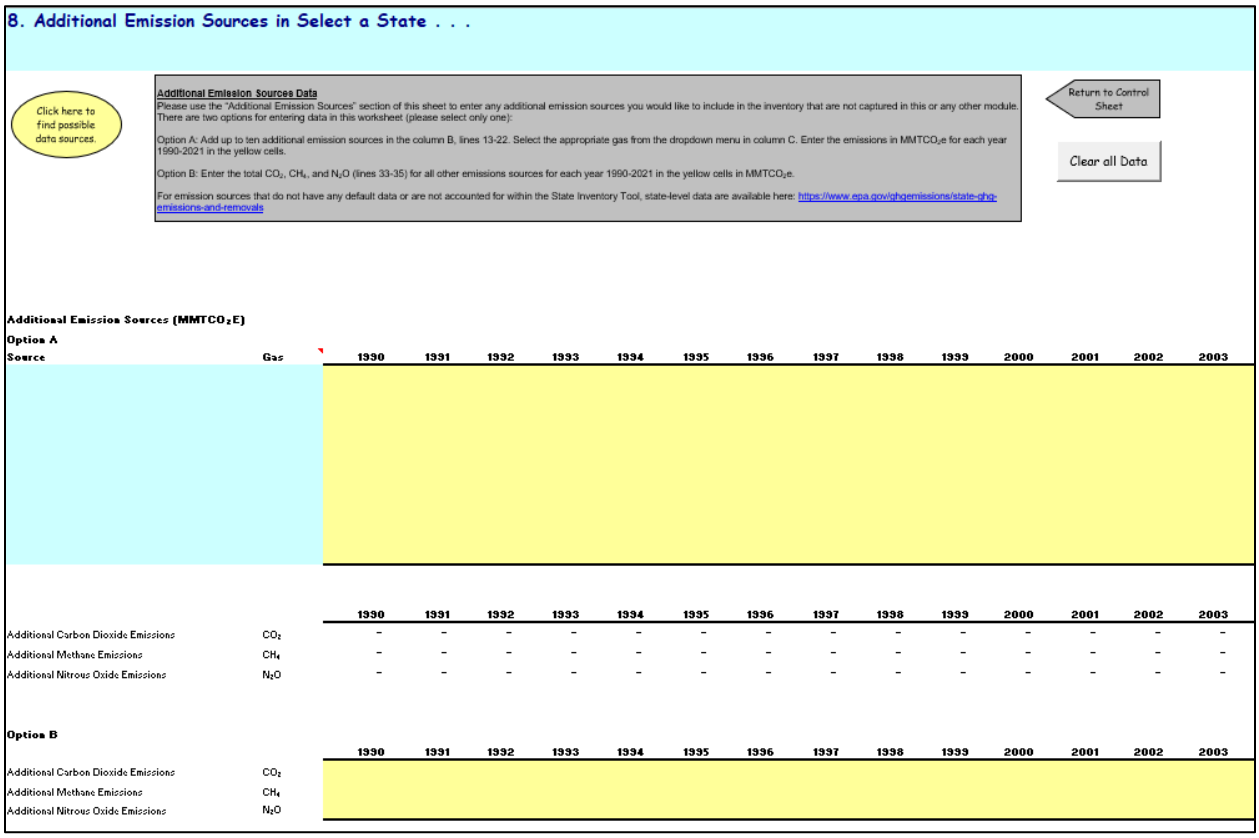
## Step (8) Add Additional Emissions Sources to Additional Sources Worksheet if Applicable

Users may use this worksheet to input data about additional emissions sources that are not included in this module or any other module. Additional emissions sources should be reported in $MMTCO_2e$. Figure 16 shows two options for entering data into this worksheet (please select only one):

Option A: Add up to ten additional emission sources in column B, lines 13-22. Enter the emissions in $MMTCO_2e$ for each year 1990-2021 in the yellow cells.

Option B: Enter the $CO_2$, $N_2O$, and $CH_4$ (lines 33-35) for all other emissions sources for each year 1990-2021 in the yellow cells in $MMTCO_2e$.

**Figure 16. Example Additional Emissions Sources Worksheet**



8. Additional Emission Sources in Select a State . . .

Click here to find possible data sources.

Additional Emission Sources Data
Please use the "Additional Emission Sources" section of this sheet to enter any additional emission sources you would like to include in the inventory that are not captured in this or any other module. There are two options for entering data in this worksheet (please select only one):

Option A: Add up to ten additional emission sources in the column B, lines 13-22. Select the appropriate gas from the dropdown menu in column C. Enter the emissions in $MMTCO_2e$ for each year 1990-2021 in the yellow cells.

Option B: Enter the total $CO_2$, $CH_4$, and $N_2O$ (lines 33-35) for all other emissions sources for each year 1990-2021 in the yellow cells in $MMTCO_2e$.

For emission sources that do not have any default data or are not accounted for within the State Inventory Tool, state-level data are available here: https://www.epa.gov/ghgemissions/state-ghg-emissions-and-removals

Return to Control Sheet

Clear all Data

Additional Emission Sources ($MMTCO_2E$)

Option A

| Source | Gas | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | |

| | | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Additional Carbon Dioxide Emissions | $CO_2$ | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Additional Methane Emissions | $CH_4$ | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Additional Nitrous Oxide Emissions | $N_2O$ | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

Option B

| | | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Additional Carbon Dioxide Emissions | $CO_2$ | | | | | | | | | | | | | | |
| Additional Methane Emissions | $CH_4$ | | | | | | | | | | | | | | |
| Additional Nitrous Oxide Emissions | $N_2O$ | | | | | | | | | | | | | | |

For emission sources that do not have any default data or are not accounted for within the State Inventory Tool, state-level data are available here: https://www.epa.gov/ghgemissions/state-ghg-emissions-and-removals

## Step (9) Review Summary Information

The steps above provide estimates of total emissions and sequestration from land use, land-use change, and forestry activities. The information from each sector worksheet is collected on the summary worksheet, which displays results in $MMTCO_2E$. Figure 17 shows the summary worksheet that sums the

emissions and sinks from all components of the LULUCF module. In addition, the results are displayed in graphical format at the bottom of the summary worksheets. Depending on whether the user entered their own data for forest carbon flux or used the default data provided by the module, additional rows may be shown to summarize emissions totals from *Forest Land Remaining Forest Land, Land Converted to Forest Land,* and *Forest Land Converted to Land.*

**Figure 17. Example of the Emissions Summary Worksheet in the LULUCF Module**

8. Summary of Land Use, Land-Use Change, and Forestry Emissions and Sequestration for California

Return to Control Sheet

Review discussion of uncertainty associated with these results

***Note: The Land Use, Land-Use Change, and Forestry module no longer estimates carbon dioxide emissions from Liming of Soils and Urea Fertilization. These categories are now estimated in the Agriculture module.***

Emissions were not calculated for the following sector: Forest Fires. If you skipped any of these by mistake, please return to the control worksheet and complete each skipped source.

**Emissions* ($MMTCO_2E$)**

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Forest Carbon Flux | (54.54) | (54.29) | (54.05) | (50.04) | (49.78) | (49.53) | (49.27) | (49.02) | (48.77) | (48.51) | (48.26) | (48.01) |
| *Aboveground Biomass* | (28.59) | (28.35) | (28.11) | (27.87) | (27.64) | (27.42) | (27.19) | (26.97) | (26.74) | (26.52) | (26.29) | (26.07) |
| *Belowground Biomass* | (6.28) | (6.23) | (6.18) | (6.12) | (6.08) | (6.03) | (5.98) | (5.93) | (5.88) | (5.83) | (5.78) | (5.73) |
| *Deadwood* | (5.68) | (5.72) | (5.76) | (5.79) | (5.82) | (5.84) | (5.87) | (5.89) | (5.91) | (5.94) | (5.96) | (5.99) |
| *Litter* | (0.38) | (0.37) | (0.37) | (0.36) | (0.36) | (0.36) | (0.36) | (0.35) | (0.35) | (0.35) | (0.35) | (0.34) |
| *Soil (Mineral)* | 0.61 | 0.60 | 0.58 | 0.57 | 0.57 | 0.57 | 0.57 | 0.58 | 0.58 | 0.58 | 0.58 | 0.58 |
| *Soil (Organic)* | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| *Drained Organic Soil* | - | - | - | - | - | - | - | - | - | - | - | - |
| *Total wood products and landfills* | (14.22) | (14.22) | (14.22) | (10.46) | (10.46) | (10.46) | (10.46) | (10.46) | (10.46) | (10.46) | (10.46) | (10.46) |
| Urban Trees | (4.66) | (4.74) | (4.82) | (4.90) | (4.98) | (5.06) | (5.14) | (5.22) | (5.30) | (5.37) | (5.45) | (5.47) |
| Landfilled Yard Trimmings and Food Scraps | (2.94) | (2.80) | (2.77) | (2.42) | (2.12) | (1.74) | (1.44) | (1.53) | (1.52) | (1.43) | (1.42) | (1.46) |
| *Grass* | (0.24) | (0.22) | (0.22) | (0.17) | (0.14) | (0.10) | (0.06) | (0.06) | (0.07) | (0.06) | (0.06) | (0.07) |
| *Leaves* | (1.18) | (1.14) | (1.13) | (0.98) | (0.87) | (0.73) | (0.60) | (0.58) | (0.56) | (0.52) | (0.49) | (0.51) |
| *Branches* | (1.18) | (1.13) | (1.12) | (0.97) | (0.85) | (0.71) | (0.58) | (0.55) | (0.54) | (0.49) | (0.46) | (0.48) |
| *Landfilled Food Scraps* | (0.34) | (0.30) | (0.31) | (0.29) | (0.26) | (0.21) | (0.20) | (0.33) | (0.35) | (0.36) | (0.41) | (0.41) |
| Forest Fires | - | - | - | - | - | - | - | - | - | - | - | - |
| *$CH_4$* | - | - | - | - | - | - | - | - | - | - | - | - |
| *$N_2O$* | - | - | - | - | - | - | - | - | - | - | - | - |
| $N_2O$ from Settlement Soils | 0.23 | 0.22 | 0.21 | 0.23 | 0.23 | 0.26 | 0.28 | 0.24 | 0.22 | 0.25 | 0.27 | 0.30 |
| Agricultural Soil Carbon Flux | (3.46) | (3.95) | (3.36) | (2.12) | (4.65) | (3.00) | (5.05) | (3.72) | (4.38) | (5.14) | (7.51) | (7.04) |
| **Total** | **(65.38)** | **(65.56)** | **(64.79)** | **(59.24)** | **(61.29)** | **(59.07)** | **(60.61)** | **(59.25)** | **(59.74)** | **(60.21)** | **(62.37)** | **(61.69)** |

*** Note that parentheses indicate net sequestration.**

# 1.3 UNCERTAINTY

In the upper right-hand corner of the summary worksheet is a button: "Review discussion of uncertainty associated with these results." By clicking on this button, you are taken to a worksheet that discusses the uncertainty surrounding the activity data and emission factors, and how the uncertainty estimates for this source category affect the uncertainty of the emission estimates for your state.

# 1.4 REFERENCES

Barlaz, M.A. 2008. Corrections to Previously Published Carbon Storage Factors. In a letter report to Randy Freed of ICF International. February 28, 2008.

Barlaz, M.A. 2005. “Decomposition of Leaves,” letter report to Randy Freed of ICF International, June 29, 2005.

Barlaz, M.A. 1998. “Carbon Storage during Biodegradation of Municipal Solid Waste Components in Laboratory-Scale Landfills.” *Global Biogeochemical Cycles* 12: 373-380.

Domke, Grant M.; Walters, Brian F.; Nowak, David J.; Smith, James, E.; Ogle, Stephen M.; Coulston, J.W.; Wirth, T.C. 2026. Greenhouse gas emissions and removals from forest land, woodlands, and urban trees in the United States, 1990-2023. Resource Update FS-382. Madison, WI: U.S. Department of Agriculture, Forest Service, Northern Research Station. 5 p. https://www.fs.usda.gov/rds/archive/catalog/RDS-2026-0031.

IPCC. 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4: Agriculture, Forestry, and Other Land Use. The National Greenhouse Gas Inventories Programme, The Intergovernmental Panel on Climate Change. [H.S. Eggleston, L. Buendia, K. Miwa, T. Ngara, and K. Tanabe (eds.)]. Hayama, Kanagawa, Japan.

IPCC. 2003. *Good Practice Guidance for Land Use, Land-Use Change, and Forestry*. J. Penman and others, editors. IPCC National Greenhouse Gas Inventories Programme. Available online at http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.htm.

M. Desai, V. Camobreco, T. Hedger, W. Irving, K. Rewcastle, J. Steller, L. Barbieri, M. Weitz, T. Murumkar, A. Fawcett, J. Lou, R. Cui, and N. Hultman. (2026). Greenhouse Gas Inventory and Analysis for the United States: 1990-2024. Center for Global Sustainability, University of Maryland, College Park.

Nowak, D.J., E.J. Greenfield, R.E. Hoehn, and E. Lapoint. 2013. Carbon Storage and Sequestration by Trees in Urban and Community Areas of the United States. Environmental Pollution 178: 229-236. March 12, 2013.

Nowak, D.J., E.J. Greenfield. 2018. Declining urban and community tree cover in the United States. Urban Forestry & Urban Greening (32) pp. 32-35. https://www.fs.usda.gov/treesearch/pubs/55941

Nowak, D.J. and E.J. Greenfield. 2012. Tree and impervious cover in the United States. Journal of Landscape and Urban Planning (107) pp. 21-30.

Nowak, D.J., J.T. Walton, L.G. Kaya, and J.F. Dwyer. 2005. "The Increasing Influence of Urban Environments on U.S. Forest Management." Journal of Forestry 103(8):377–382.

Oshins, C., and D. Block. 2000. “Feedstock Composition at Composting Sites.” *Biocycle* 41(9):31-34.

Smith, J. 2014. Estimates of Forest Carbon Stocks and Flux: 1990-2014. E-mail correspondence between ICF and Jim Smith, USDA Forest Service. October 1, 2014 and January 27, 2015.

Smith, W. Brad; Vissage, John S.; Darr, David R.; Sheffield, Raymond M. 2001. *Forest Resources of the United States, 1997.* Gen. Tech. Rep. NC-219. St. Paul, MN: United States Department of Agriculture, Forest Service, North Central Research Station. 190 p.

Tchobanoglous, G., H. Theisen, and S.A. Vigil. 1993. *Integrated Solid Waste Management, 1st edition*. McGraw-Hill, NY. Cited by Barlaz (1998).

U.S. Census Bureau. 2026. *State Population Totals and Components of Change: 2020-2025.* Available online at: https://www.census.gov/data/tables/time-series/demo/popest/2020s-state-total.html.

U.S. Census Bureau. 2023. *A state-sorted list of all 2020 Census Urban Areas for the U.S., Puerto Rico, and Island Areas first sorted by state FIPS code, then sorted by Urban Area Census (UACE) code*. Available online at: https://www.census.gov/programs-surveys/geography/guidance/geo-areas/urban-rural.html

U.S. Census Bureau. 2021. *National Population Totals: 2010-2020.* U.S. Census Bureau, Washington, DC. Available online at: https://www.census.gov/programs-surveys/popest/technical-documentation/research/evaluation-estimates/2020-evaluation-estimates/2010s-totals-national.html

U.S. Census Bureau. 2012. Census 2010 Urbanized Area and Urban Cluster Information. Available at: https://www2.census.gov/geo/docs/reference/ua/ua_st_list_all.txt.

U.S. Census Bureau. 2002. Census 2000 Urbanized Area and Urban Cluster Information. Available at: https://www.census.gov/programs-surveys/geography/guidance/geo-areas/urban-rural/2000-urbanized-areas.html.

U.S. Census Bureau. 1990. Census 1990 Urbanized Area and Urban Cluster Information.

U.S. EPA. 2003. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2001*. Office of Atmospheric Protection, U.S. Environmental Protection Agency. Available at: https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2001.

U.S. EPA. 2020. *Advancing Sustainable Materials Management: Facts and Figures for 2018*. United States Environmental Protection Agency, Washington, DC. Available at https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/advancing-sustainable-materials-management.

U.S. EPA. 2024. Methodology report for inventory of U.S. greenhouse gas emissions and sinks by state: 1990–2022 (EPA-430-R-24-006). September. https://www.epa.gov/system/files/documents/2024-09/method-report_ghgibystate-508-september.pdf

U.S. EPA. 2025a. Inventory of U.S. greenhouse gas emissions and sinks: 1990–2023 (EPA 430-R-25-003) [Unpublished annual report released via Freedom of Information Act Request]

U.S. EPA. 2025b. DRAFT_AllStateGHGData_90-23. Unpublished Excel data file released via Freedom of Information Act request.