User's Guide for Estimating Emissions and Sinks from Land Use, Land-Use Change, and Forestry Using the State Inventory Tool

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

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1.1 Getting Started

The Land Use, Land-Use Change, and Forestry (hereafter, LULUCF) module was developed using Microsoft® Excel 2000. While the module will operate with older versions of Excel, it functions best with Excel 2000 or later. If you are using Excel 2007, instructions for opening the module will vary as outlined in the Excel basics below. Some of the Excel basics are outlined in the sections below. Before you use the LULUCF module, make sure your computer meets the system requirements. In order to install and run the LULUCF module, you must have:

- IBM-PC compatible computer with the Windows 95 operating system or later;
- Microsoft® Excel 1997 or later, with calculation set to automatic and macros enabled;
- Hard drive with at least 20MB free; and
- Monitor display setting of 800 x 600 or greater.

Microsoft Excel Settings

Excel 2003 and Earlier: For the SIT modules to function properly, Excel must be set to automatic calculation. To check this setting, launch Microsoft Excel before opening the LULUCF module. Go to the Tools menu and select "Options…" Click on the "Calculations" tab and make sure that the radio button next to "Automatic" is selected, and then click on "OK" to close the window. The security settings (discussed next) can also be adjusted at this time.

Excel 2007: For the SIT modules to function properly, Excel must be set to automatic calculation. Go to the Formulas ribbon and select "Calculation Options." Make sure that the box next to the "Automatic" option is checked from the pop-up menu.

Microsoft Excel Security

Excel 2003 and Earlier: Since the SIT employs macros, you must have Excel security set to medium (recommended) or low (not recommended). To change this setting, launch Microsoft Excel before opening the LULUCF module. Once in Excel, go to the Tools menu, click on the Macro sub-menu, and then select "Security" (see Figure 1). The Security pop-up box will appear. Click on the "Security Level" tab and select medium. When set to high, macros are automatically disabled; when set to medium, Excel will give you the choice to enable macros; when set to low, macros are always enabled.

When Excel security is set to medium, users are asked upon opening the module whether to enable macros. Macros must be enabled in order for the LULUCF module to work. Once they are enabled, the module will open to the control worksheet. A message box will appear welcoming the user to the module. Clicking on the "x" in the upper-right-hand corner of the message box will close it.

Excel 2007: If Excel's security settings are set at the default level a Security Warning appears above the formula box in Excel when the LULUCF module is initially opened. The Security Warning lets the user know that some active content from the spreadsheet has been disabled, meaning that Excel has prevented the macros in the spreadsheet from functioning. Since SIT needs macros in order to function properly, the user must click the "Options" button in the security message and then select, "Enable this content" in the pop-up box. Enabling the macro content for the SIT in this way only enables macros temporarily in Excel but does not change the macro security settings. Once macros are enabled, a message box will appear welcoming the user to module. Click on the “x” in the upper right-hand corner to close the message box.

If the Security Warning does not appear when the module is first opened, it may be necessary to change the security settings for macros. To change the setting, first exit out of the LULUCF module and re-launch Microsoft Excel before opening the LULUCF module. Next, click on the Microsoft Excel icon in the top left of the screen. Scroll to the bottom of the menu and select the “Excel Options” button to the right of the main menu. When the Excel Options box appears, select “Trust Center” in left hand menu of the box. Next, click the gray “Trust Center Settings” button. When the Trust Center options box appears, click “Macro Settings” in the left hand menu and select “Disable all macros with notification.” Once the security level has been adjusted, open the Stationary Combustion module and enable macros in the manner described in the preceding paragraph.

Viewing and Printing Data and Results

The LULUCF module contains some features to allow users to adjust the screen view and the appearance of the worksheets when they are printed. Once a module has been opened, you can adjust the zoom by going to the Module Options Menu, and either typing in a zoom percentage or selecting one from the drop down menu. In addition, data may not all appear on a single screen within each worksheet; if not, you may need to scroll up or down to view additional information.

You may also adjust the print margins of the worksheets to ensure that desired portions of the LULUCF module are printed. To do so, go to the File menu, and then select “Print Preview.” Click on “Page Break Preview” and drag the blue lines to the desired positions (see Figure 2). To print this view, go to the File menu, and click “Print.” To return to the normal view, go to the File menu, click “Print Preview,” and then click “Normal View.”

Figure 1. Changing Security Settings

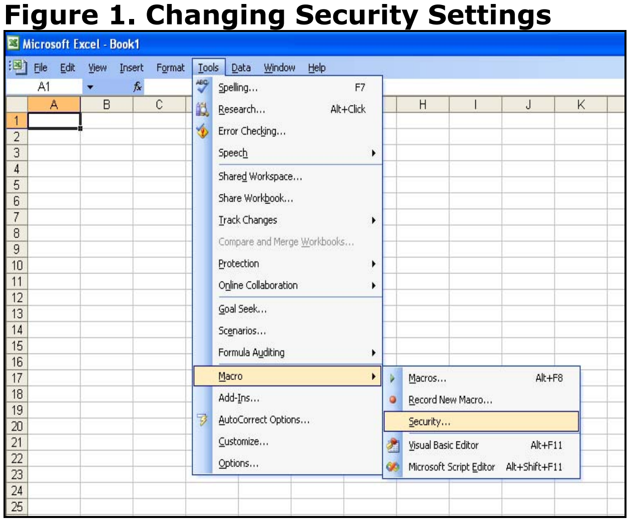
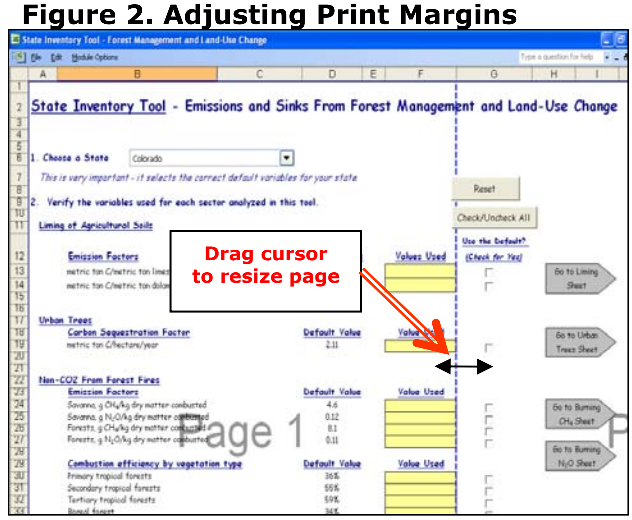


Figure 2. Adjusting Print Margins



1.2 Module Overview

This User's Guide accompanies and explains the LULUCF module of the SIT. The SIT was developed in conjunction with EPA's Emissions Inventory Improvement Program (EIIP). Prior to the development of the SIT, EPA developed the States Workbook for estimating greenhouse gas emissions. In 1998, EPA revisited the States Workbook and expanded it to follow the format of EIIP guidance documents for criteria air pollutants. The result was a comprehensive, stepwise approach to estimating greenhouse gas emissions at the state level. This detailed methodology was appreciated by states with the capacity to devote considerable time and resources to the development of emission inventories. For other states, the EIIP guidance was overwhelming and impractical for them to follow from scratch. EPA recognized the resource constraints facing the states and developed the SIT. The ten modules of the SIT corresponded to the EIIP chapters and attempted 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.

Since most state inventories developed today rely heavily on the tools, User's Guides have been developed for each of the SIT modules. These User's Guides contain the most up-to-date methodologies that are, for the most part, consistent with the Inventory of U.S. Greenhouse Gas Emissions and Sinks. Volume VIII of the EIIP guidance is a historical document that was last updated in August 2004, and while these documents can be a valuable reference, they contain outdated emissions factors and in some cases outdated methodologies. States can refer to Volume VIII of the EIIP guidance documents if they are interested in obtaining additional information not found in the SIT or the companion User's Guide.

When humans use and alter the biosphere through land-use change and forest management activities, the balance between the emission and uptake of greenhouse gases (GHGs) changes, affecting their atmospheric concentration; this balance between emission and uptake is known as net GHG flux. Such activities can include clearing an area of forest to create cropland, restocking a logged forest, draining a wetland, or allowing a pasture to revert to grassland. Carbon in the form of yard trimmings and food scraps can also be sequestered in landfills, as well as in trees in urban areas. In addition to carbon flux from forest management, urban trees, and landfills, other sources of GHGs under the category of land use, land-use change, and forestry are CO_2 emissions from liming of agricultural soils, emissions of methane (CH_4), and nitrous oxide (N_2O) from forest fires, and N_2O emissions from fertilization of settlement soils.

The LULUCF module calculates CO_2, CH_4, and N_2O emissions from liming of soils, fertilization of settlement soils, and forest fires, as well as carbon flux from forest management, urban trees, and landfilled yard trimmings and food scraps. 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.

1.2.1 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).

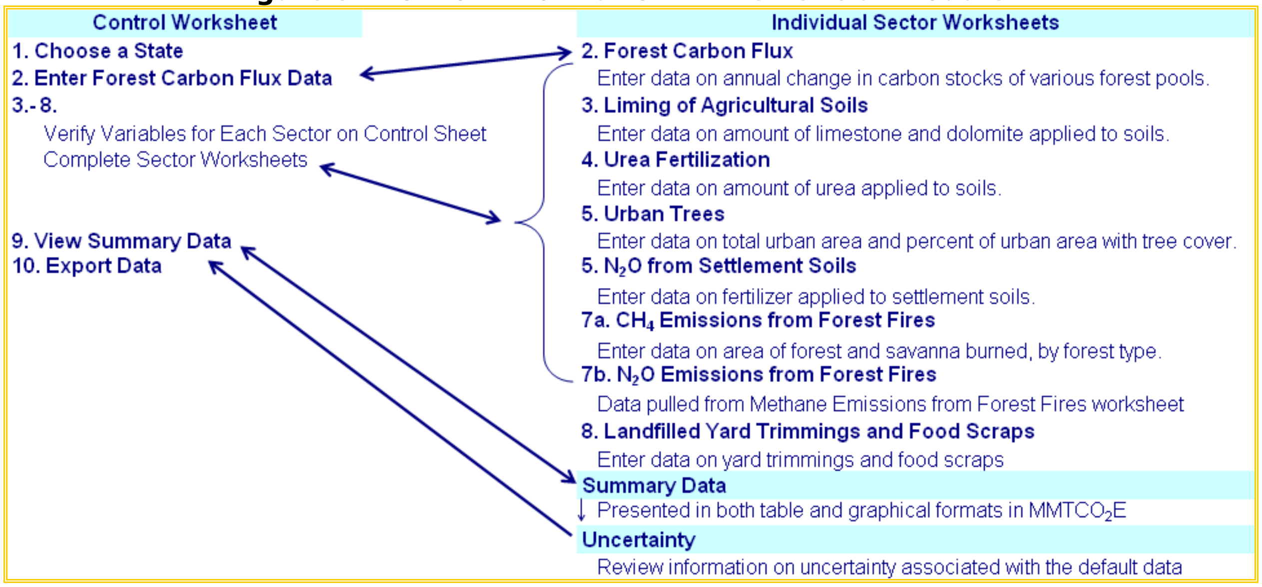
Table 1 Required data inputs for the LULUCF module.

Forestry Worksheets	**Input Data Required**
Forest Carbon Flux	Carbon emitted from or sequestered in aboveground biomass, belowground biomass, dead wood, litter, soil organic carbon, wood products and landfills (million metric tons)
Liming of Agricultural Soils	Emission factors for CO_2 emitted from use of crushed limestone and dolomite (ton C/ton limestone) Total limestone and dolomite applied to soils (metric tons)
Urea Fertilization	Emission factors for CO_2 emitted from the use of urea as a fertilizer (tons C/ ton urea) Total urea applied to soils (metric tons)
Urban Trees	Carbon sequestration factor for urban trees (metric ton C/hectare/year) Total urban area (square kilometers) Urban area tree cover (percent)
N_2O from Settlement Soils	Direct N_2O emission factor for managed soils (percent) 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) Combustion efficiency of different vegetation types (percent) Average biomass density (kilograms dry matter per hectare) Area burned (hectares)
Landfilled Yard Trimmings and Food Scraps	Grass, leaves, and branches constituting yard trimmings (percent) Yard trimmings and foods scraps landfilled, 1960-present (tons) Initial carbon content of yard trimmings and food scraps (percent) Dry weight/wet weight ratio of yard trimmings and foods scraps (percent) Proportion of carbon stored permanently for yard trimmings and foods scraps (percent) Half-life of degradable carbon for yard trimmings and foods scraps (years)

1.2.2 Tool Layout

Since there are multiple steps to complete within the LULUCF module, it is important to have an understanding of the module's overall design. The layout of the LULUCF module and the purpose of its worksheets are presented in Figure 3.

Figure 3. 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.

1.3 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; liming of agricultural soils; urban trees; N_2O from settlement soils; non-CO_2 emissions from forest fires; and carbon storage in landfilled yard trimmings and food scraps. Since 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 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 http://www.nifc.gov/fire_info/fire_stats.htm
- 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 http://fire.org. Additional instructions for using the model are provided on the website.
- Land management agencies (e.g., the US 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.

There are eight general steps involved in estimating emissions using the LULUCF module: (1) select a state; (2) select an option for carbon flux; (3) enter emission factors and activity data for liming of agricultural soils; (4) enter emission factors and activity data for urea fertilization; (5) enter emission factors and activity data for urban trees; (6) enter emission factors and activity data for N_2O from settlement soils; (7) enter emission factors and activity data for non-CO_2 emissions from forest fires; (8) enter emission factors and activity data for landfilled yard trimmings and food scraps; (9) review summary information; and (10) export data. The general equations used to calculate GHG emissions from land use, land-use change, and forestry are provided below.

Step (1) Select a State

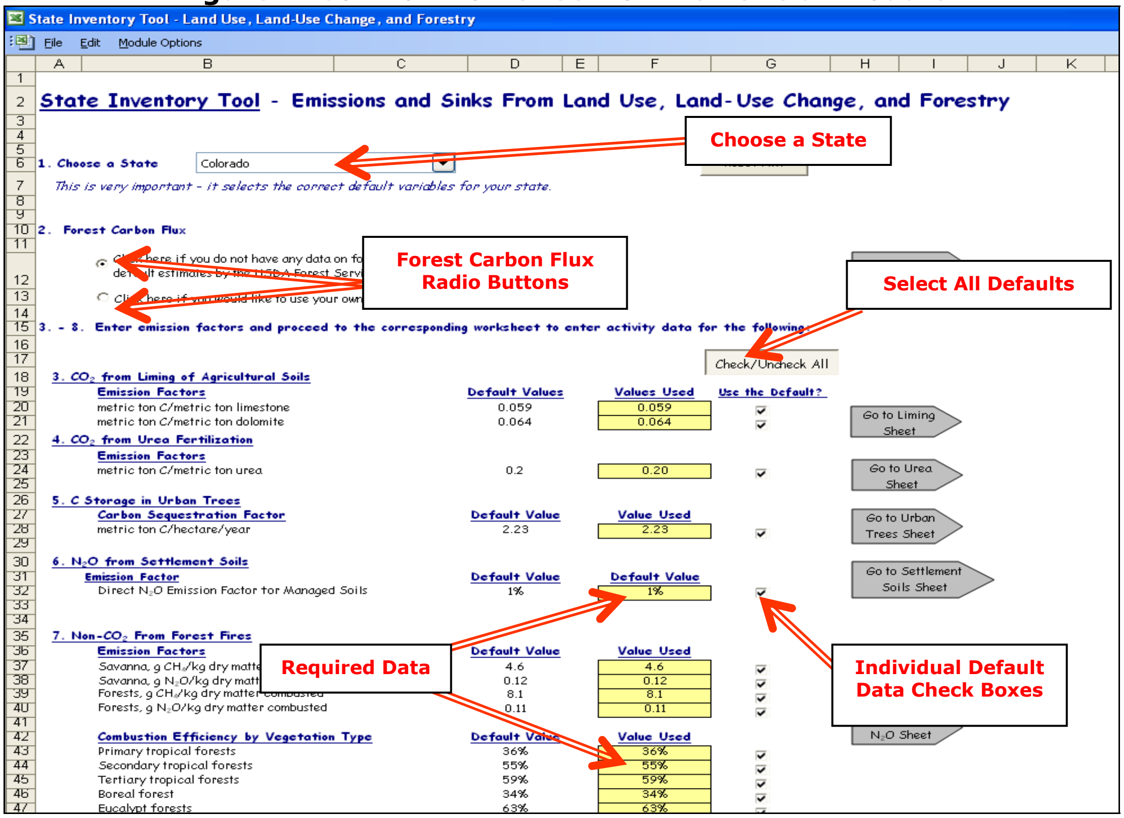
To begin, select the state you are interested in evaluating. By selecting a state, the rest of the tool will automatically reset to reflect the appropriate state default data and assumptions for use in subsequent steps of the tool.

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. 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 4 for an example of the radio buttons in step 2.

Figure 4. Control Worksheet for the LULUCF Module



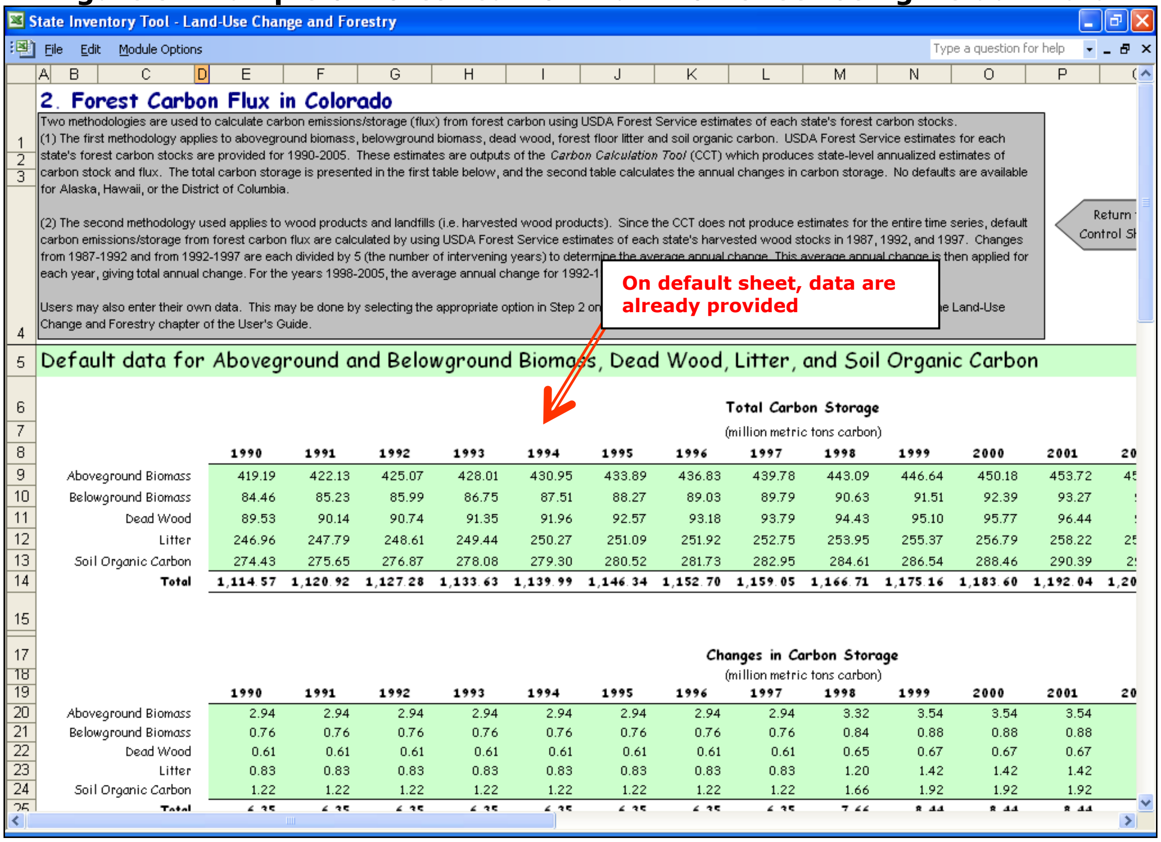
As a result of biological processes (e.g., growth and mortality) and anthropogenic activities (e.g., harvesting, thinning, and other removals), carbon is continuously cycled through ecosystem components, as well as between the forest ecosystem and the atmosphere. For example, the growth of trees results 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.

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

Forest Carbon Flux Worksheet

If you are using the default data for carbon flux estimates, there is no further information to enter. Figure 5 shows the default forest carbon worksheet.

Figure 5. Example of Forest Carbon Flux Worksheet Using Default Data

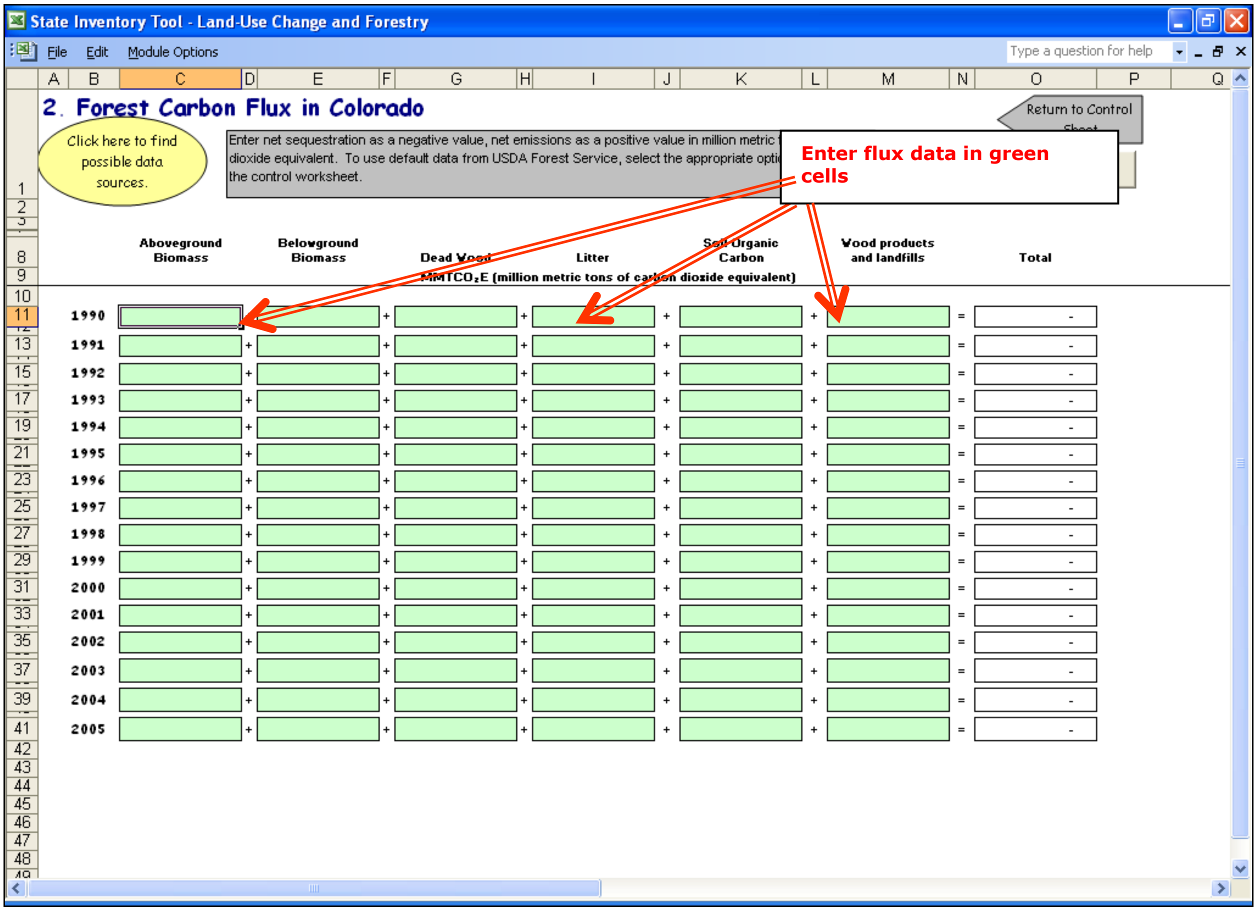


If you are using your own data on forest carbon flux, in the green cells enter carbon flux data for aboveground biomass, belowground biomass, dead wood, litter, soil organic carbon, and wood products and landfills. Figure 6 shows the worksheet where you will enter this forest carbon flux data. The method 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, soil organic carbon, 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, soil organic carbon, 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 Liming of Agricultural Soils

Control Worksheet

The data entered in the control worksheet for this sector are emission factors for limestone and dolomite used in liming of agricultural soils. These emission factors should be in metric tons of carbon per metric ton of limestone (or dolomite). The default values are based on West & McBride (2005); if emission factors other than module defaults are available for limestone and dolomite, you should document their source carefully. 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.

Limestone ($CaCO_3$) and dolomite ($CaMg(CO_3)_2$) are added to soils by land managers to remedy acidification. When these compounds come in contact with acidic soils, they degrade, thereby generating CO_2. This section presents the methodology for calculating the CO_2 emissions from the application of limestone and dolomite to agricultural soils.

After entering the appropriate emission factors, use the gray arrows to navigate to the Liming of Agricultural Soils worksheet.

Liming of Agricultural Soils Worksheet

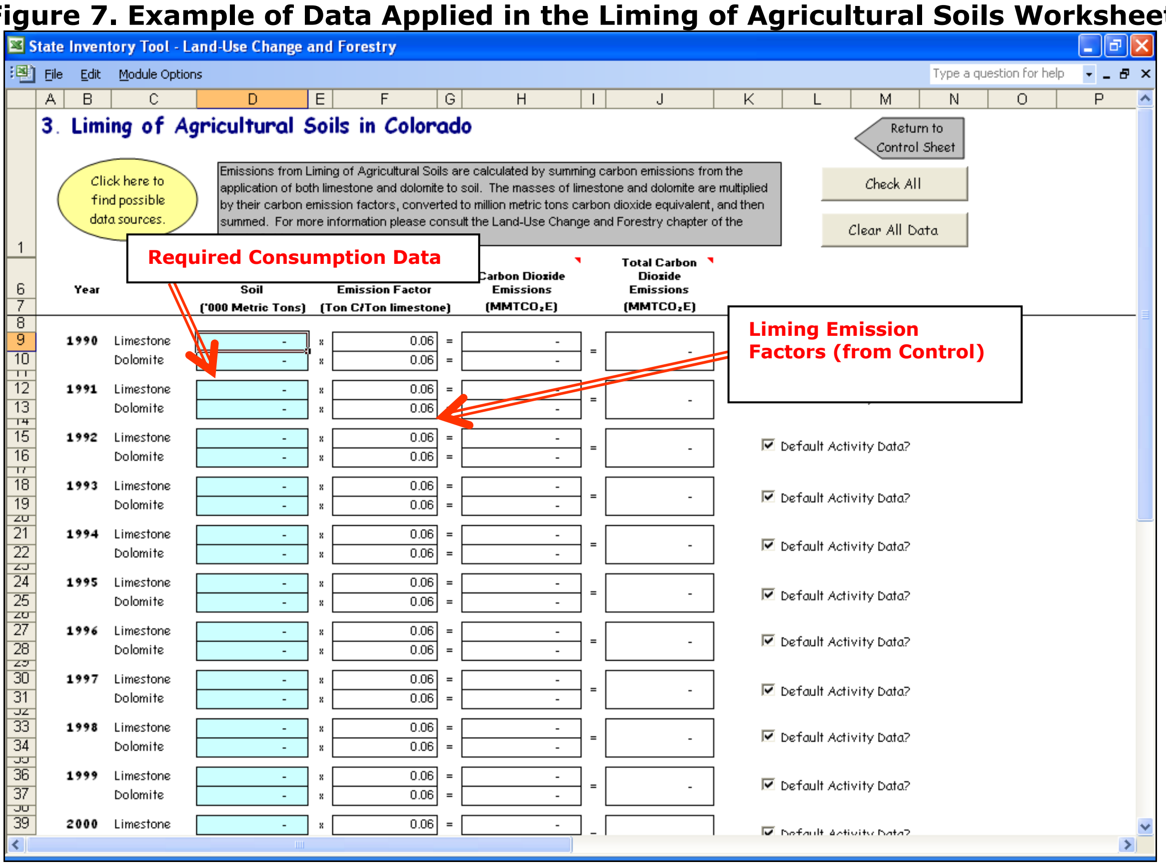
Within the Liming of Agricultural Soils worksheet, enter the total limestone and dolomite applied to soil in the light blue cells, in thousands of metric tons. An example of this worksheet is shown in Figure 7. Equation 2 shows the method used to calculate CO_2 emissions from liming of agricultural soils.

Default data are provided for most states if you wish to use them; however states are encouraged to use more detailed data if it is available and well documented. The default data are from the United States Geological Survey (USGS 2015). Once this worksheet is complete, use the gray navigational arrow to return to the control worksheet and proceed to the next source category.

Equation 2. Liming Emissions Equation

Emissions ($MMTCO_2E$) =
Total Limestone or Dolomite Applied to Soil (1000 metric tons) × Emission Factor (tons C/ton limestone or dolomite) × 44/12 (ratio of CO_2 to C) ÷ 1,000,000 (to yield $MMTCO_2E$)

Figure 7. Example of Data Applied in the Liming of Agricultural Soils Worksheet



Step (4) Enter Emission Factors and Activity Data for Urea Fertilization

Control Worksheet

The data entered in the control worksheet for this sector is an emission factor for urea application as a fertilizer to soils. The emission factor should be in metric tons of carbon per metric ton of urea. The default emission factor is based on IPCC (2006); if emission factors other than module defaults are available for urea fertilization, you should document their source carefully. 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.

Urea is used as a fertilizer that results in CO_2 emissions that were fixed during the industrial production process. According to U.S. EPA (2016), urea in the presence of water and urease enzymes is converted into ammonium (NH_4^+), hydroxyl ion (OH^-), and bicarbonate (HCO_3^-). The bicarbonate then evolves into CO_2 and water. This section presents the methodology for calculating the CO_2 emissions from the application of urea to agricultural soils.

After entering the appropriate emission factors, use the gray arrows to navigate to the Urea Fertilization worksheet.

Urea Fertilization Worksheet

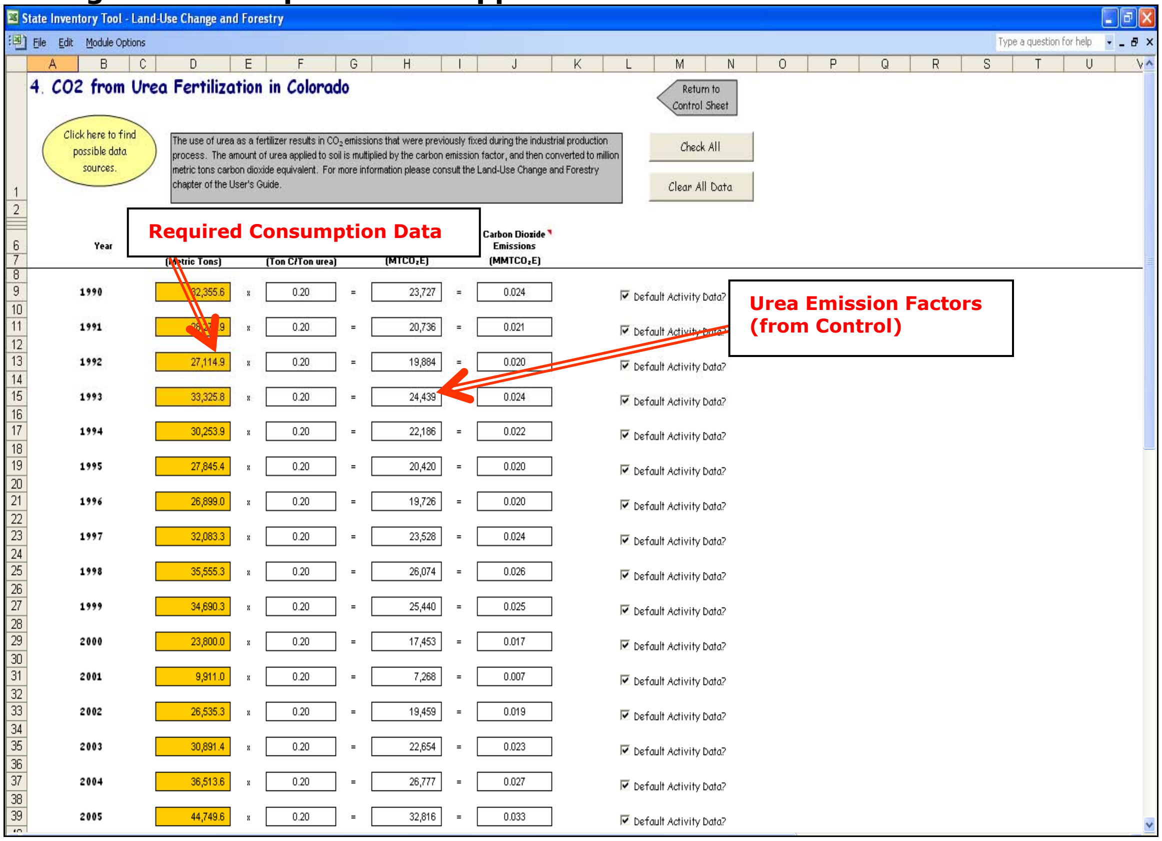
Within the Urea Fertilization worksheet, enter the total urea applied to soil in the orange cells, in metric tons. An example of this worksheet is shown in Figure 8. Equation 3 shows the method used to calculate CO_2 emissions from the application of urea to agricultural soils.

Default data are provided for most states if you wish to use them; however states are encouraged to use more detailed data if it is available and well documented. The default data on the amount of fertilizer applied were derived from state-level fertilizer sales data provided in TVA (1991 through 1994) and AAPFCO (2013). Once this worksheet is complete, use the gray navigational arrow to return to the control worksheet and proceed to the next source category.

Equation 3. Urea Emissions Equation

Emissions (MMTCO_2E) =
Total Urea Applied to Soil (metric tons) × Emission Factor (tons C/ton urea) × 44/12 (ratio of CO_2 to C) ÷ 1,000,000 (to yield MMTCO_2E)

Figure 8. Example of Data Applied in the Urea Fertilization Worksheet



Step (5) 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). The default value provided is from Nowak and Crane (2002); however, states are encouraged to use 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.

Trees in urban areas represent approximately 2.8 percent of total United States tree canopy cover (Nowak et al. 2001). 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

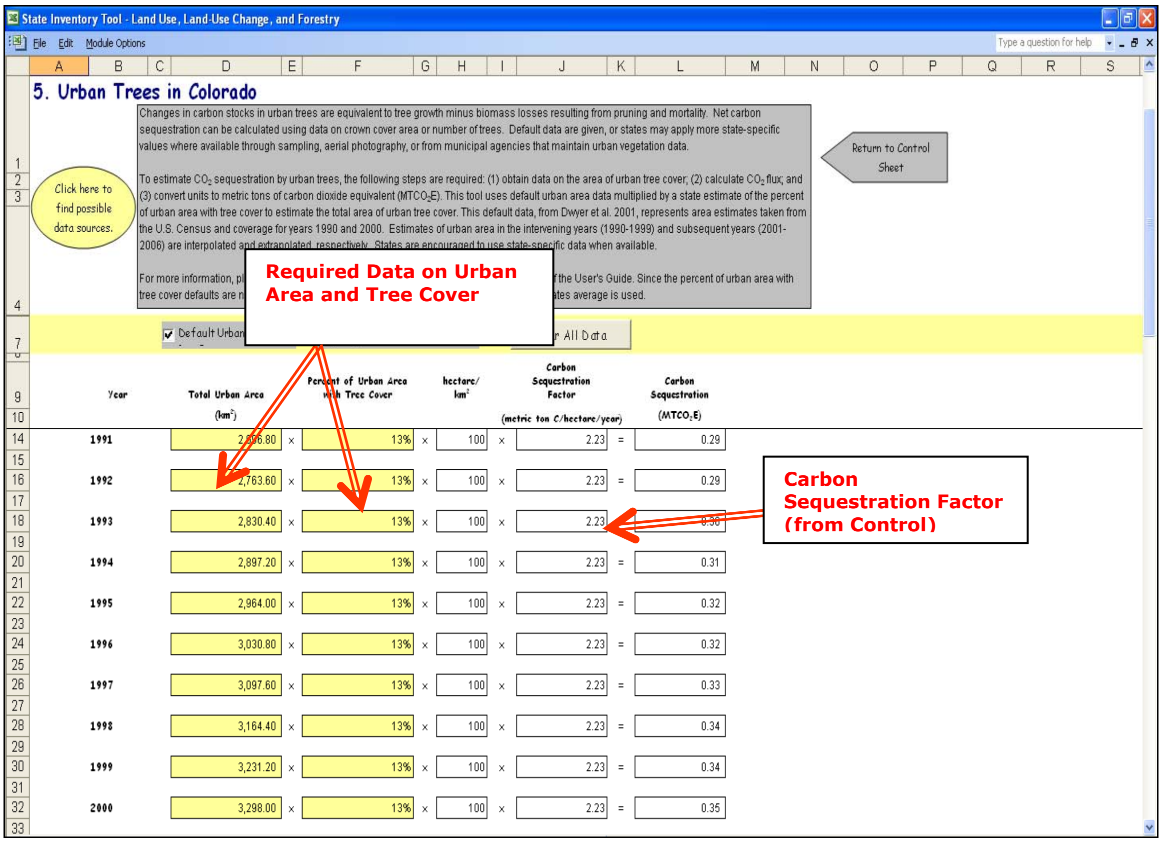
Within the Urban Trees worksheet, enter data on the total urban area in your state (in square kilometers), as well as the average percent of urban area covered by trees, in the yellow cells. An example of this worksheet is shown in Figure 9. Equation 4 shows the method used to calculate carbon sequestration in urban trees.

Default urban areas are taken from Nowak et al. (2005) and default percent urban tree cover is from Dwyer et al. (2000). However, states are encouraged to use more detailed data if it is available and well documented. Once this worksheet is complete, use the gray navigational arrow to return to the control worksheet and proceed to the next step.

Equation 4. Urban Trees Equation

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

Figure 9. Example of Carbon Sequestration Factor Applied in the Urban Trees Worksheet



Step (6) Enter Emission Factors and Activity Data for N_2O from Settlement Soils

Control Worksheet

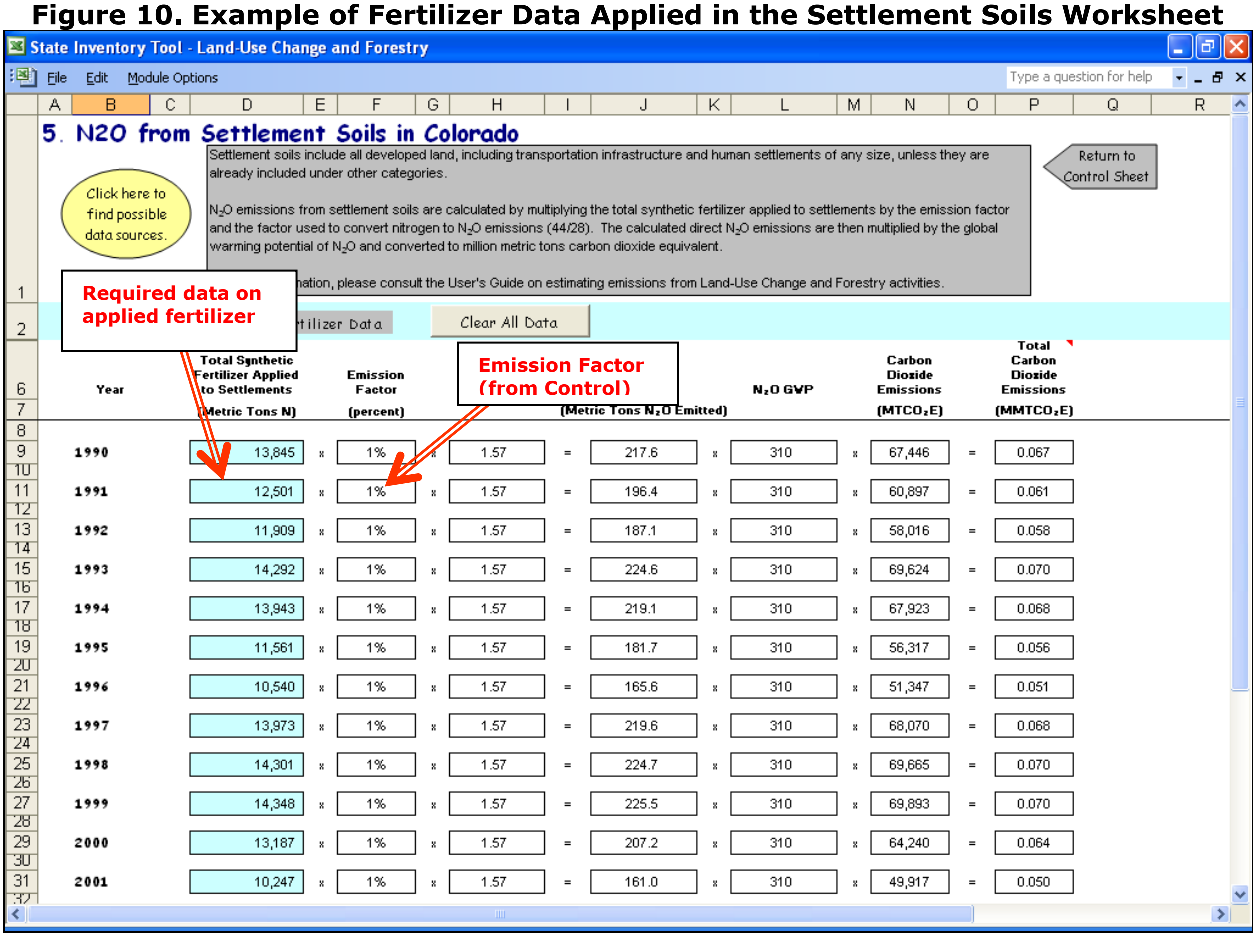
Of the fertilizers applied to soils in the United States, approximately 10 percent are applied to lawns, golf courses, and other landscaping occurring within settled areas. This section of the LULUCF module estimates N_2O emissions due to the application of fertilizers to settlement soils. On the control 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 10). 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 5. Once this worksheet is complete, use the gray navigational arrow to return to the control worksheet and proceed to emissions from forest fires.

Figure 10. Example of Fertilizer Data Applied in the Settlement Soils Worksheet



Equation 5. Emission Equation for Direct N_2O Emissions from Settlement Soils

Emissions ($MMTCO_2E$) =
Total Synthetic Fertilizer Applied to Settlement Soils (metric ton N) × Emission Factor (percent) × 0.01 (metric tons N_2O-N/metric ton N) × 44/28 (Ratio of N_2O to N_2O-N) × 298 (GWP) ÷ 1,000,000 ($MT/MMTCO_2E$)

Step (7) 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 (2016). 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, discussed in step (6) below. However, forest fires also cause emissions of N_2O and CH_4 that are not accounted for under forest carbon flux, since 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.

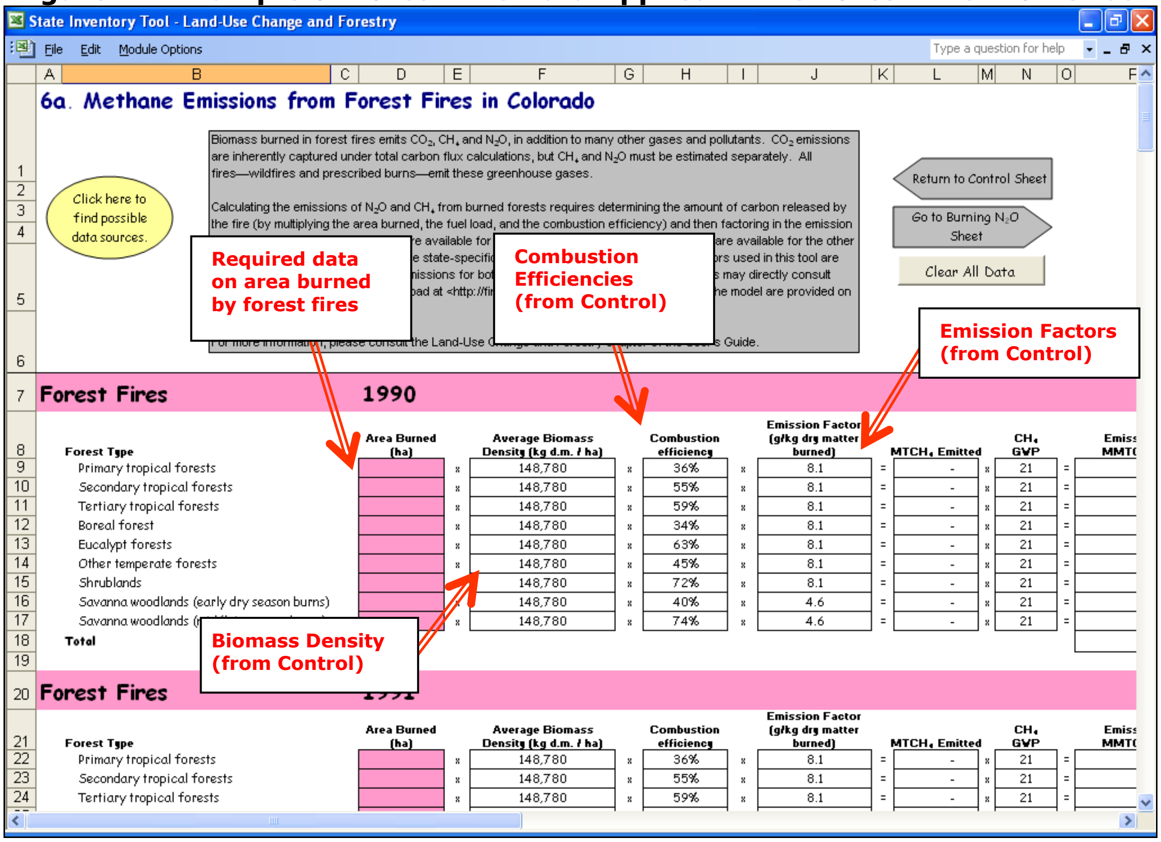
Non-CO_2 from Forest Fires Worksheets

Within the Forest Fires worksheet, enter the area (hectares) burned per year in the pink cells. Since 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 6 shows the method used to calculate N_2O and CH_4 emissions from forest fires. An example of this worksheet is shown in Figure 11. Once this sector worksheet is complete, use the gray navigational arrow to return to the control worksheet and proceed to the next category.

Equation 6. Forest Fires Emissions Equation

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

Figure 11. Example of Forest Fire Data Applied in the Forest Fire Worksheet



Step (8) Enter Emission Factors and Activity Data for Landfilled Yard Trimmings 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 effectively removed from the global carbon cycle. This section of the LULUCF module estimates the carbon stored in landfills by yard trimmings and food scraps.

Since 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 7 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 7. 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.

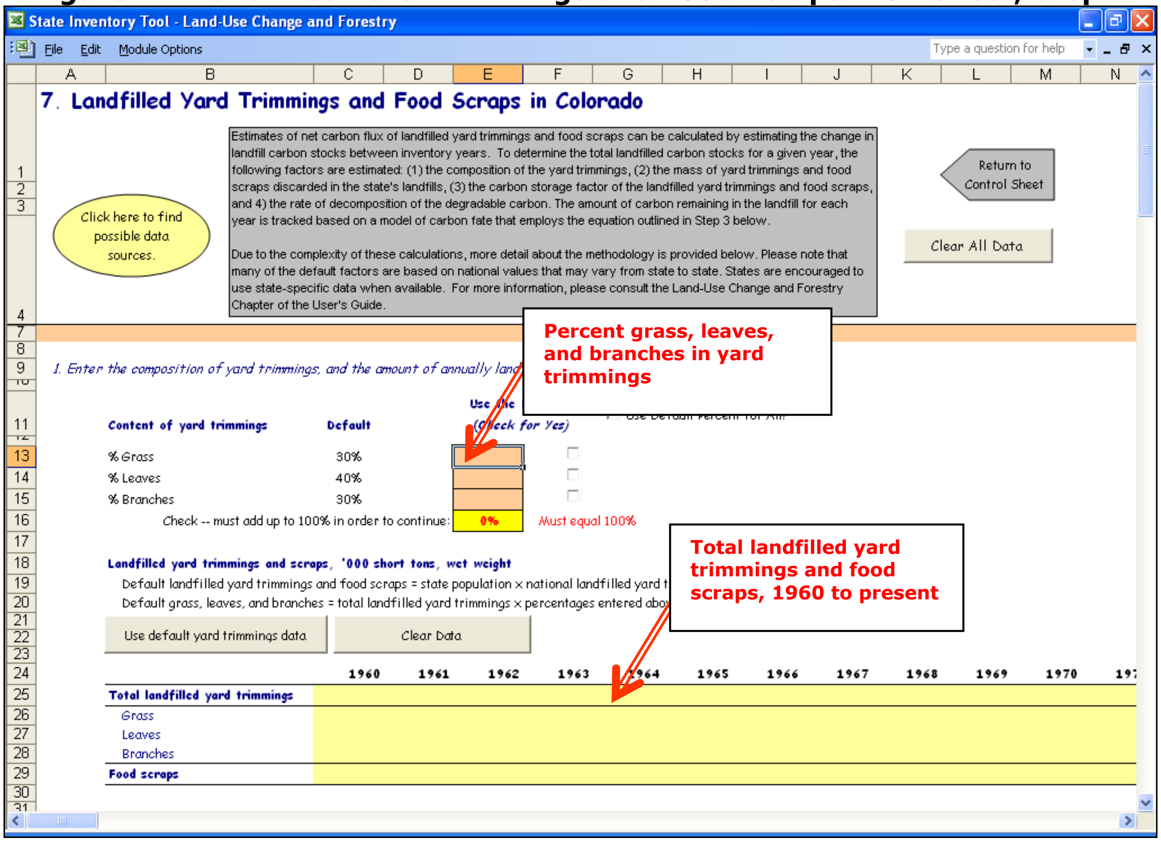
Due to the number of factors involved, the Landfilled Yard Trimmings and Food Scraps sector worksheet is arranged by a series of steps. To complete this sector worksheet, follow the steps below.

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 12 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 (2015) is a national total for yard trimmings and food scraps, and is distributed to each state based on state population.

Figure 12. Landfilled Yard Trimmings and Food Scraps Worksheet, Step 1

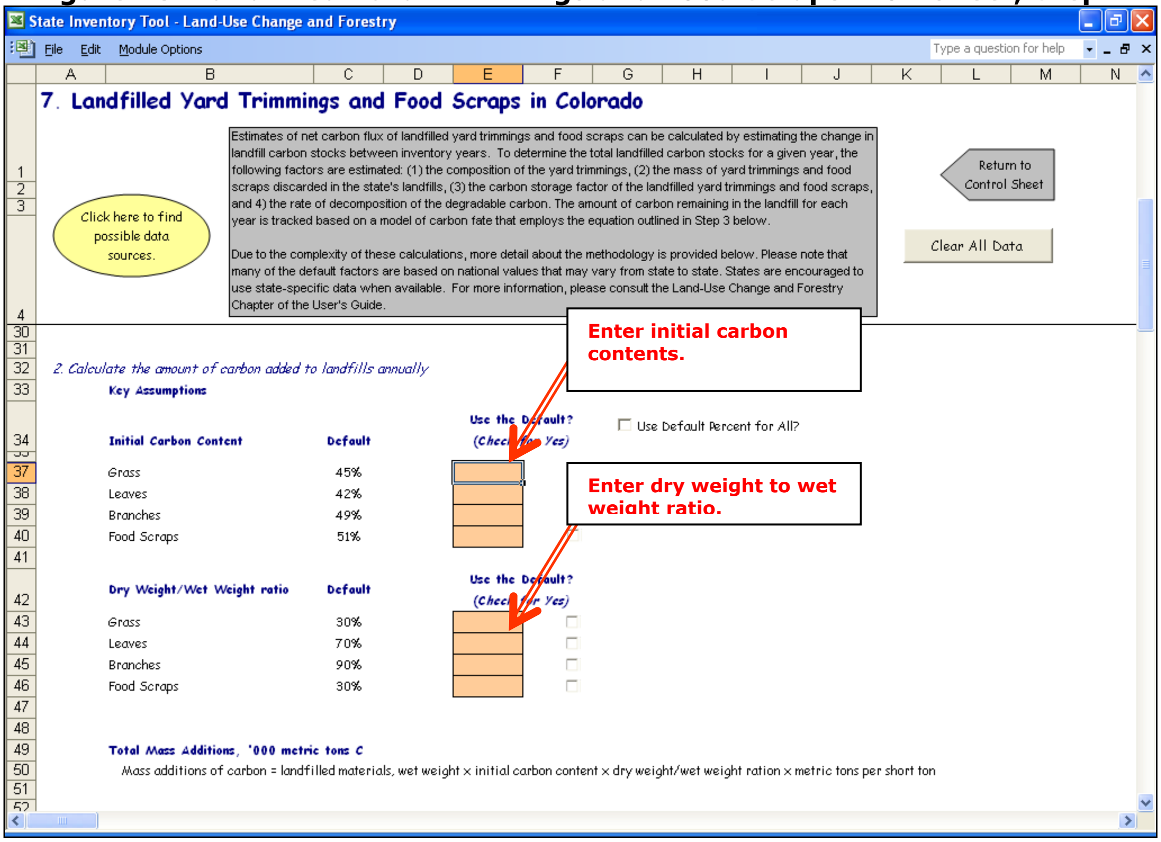


2. Calculate the amount of carbon added to landfills annually.

    a. Enter the initial carbon content percent for grass, leaves, branches, and food scraps in the orange cells, as shown in Figure 13. The default percents 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 13. Landfilled Yard Trimmings and Food Scraps Worksheet, Step 2



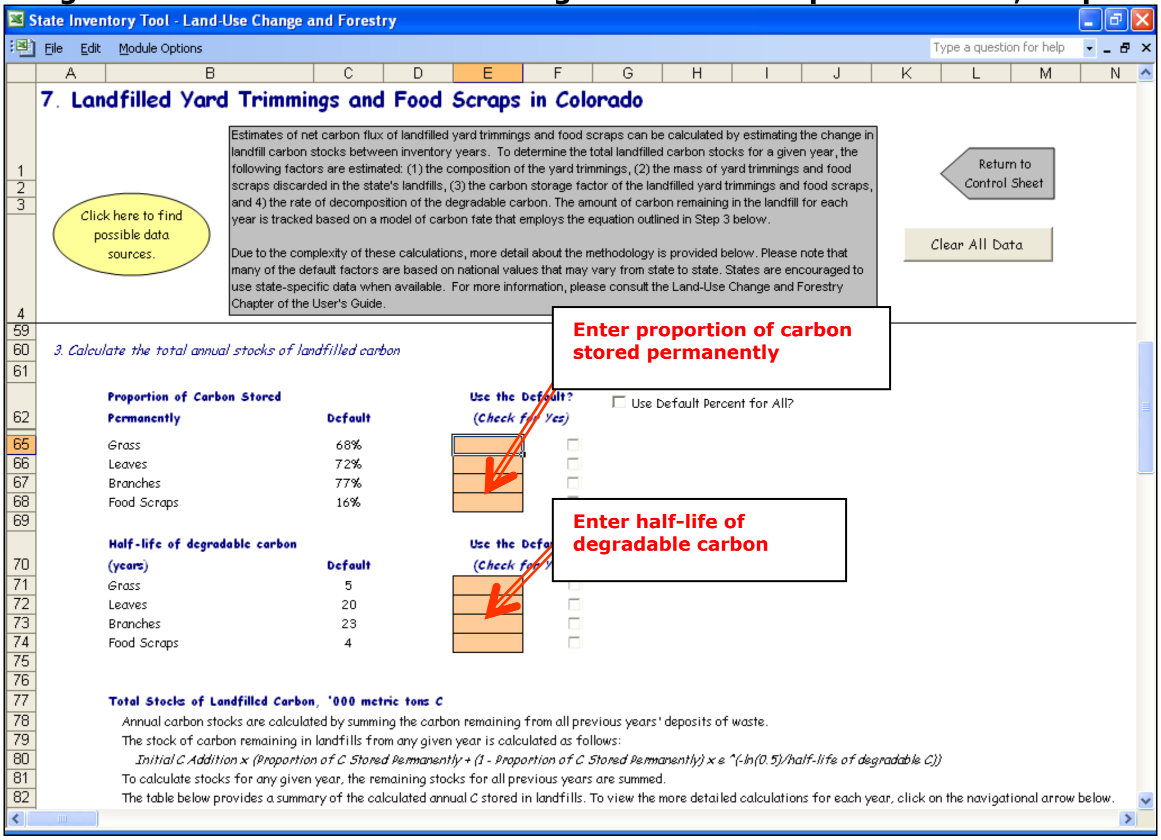
3. Calculate the total annual stocks of landfilled carbon.

   a. In the orange input cells, enter the proportion of carbon from each material stored in landfills indefinitely, as shown in Figure 14. 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.

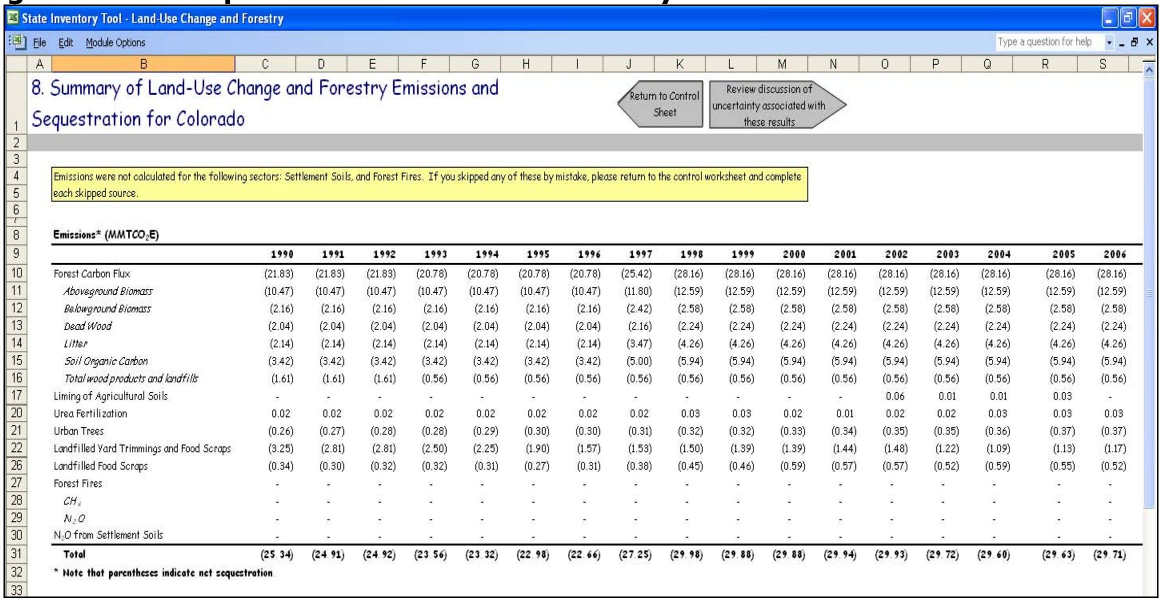
Figure 14. Landfilled Yard Trimmings and Food Scraps Worksheet, Step 3



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 15 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.

Figure 15. Example of the Emissions Summary Worksheet in the LULUCF Module



Emissions were not calculated for the following sectors: Settlement Soils, and 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	2002	2003	2004	2005	2006
Forest Carbon Flux	(21.83)	(21.83)	(21.83)	(20.78)	(20.78)	(20.78)	(20.78)	(25.42)	(28.16)	(28.16)	(28.16)	(28.16)	(28.16)	(28.16)	(28.16)	(28.16)	(28.16)
Aboveground Biomass	(10.47)	(10.47)	(10.47)	(10.47)	(10.47)	(10.47)	(10.47)	(11.80)	(12.59)	(12.59)	(12.59)	(12.59)	(12.59)	(12.59)	(12.59)	(12.59)	(12.59)
Belowground Biomass	(2.16)	(2.16)	(2.16)	(2.16)	(2.16)	(2.16)	(2.16)	(2.42)	(2.58)	(2.58)	(2.58)	(2.58)	(2.58)	(2.58)	(2.58)	(2.58)	(2.58)
Dead Wood	(2.04)	(2.04)	(2.04)	(2.04)	(2.04)	(2.04)	(2.04)	(2.16)	(2.24)	(2.24)	(2.24)	(2.24)	(2.24)	(2.24)	(2.24)	(2.24)	(2.24)
Litter	(2.14)	(2.14)	(2.14)	(2.14)	(2.14)	(2.14)	(2.14)	(3.47)	(4.26)	(4.26)	(4.26)	(4.26)	(4.26)	(4.26)	(4.26)	(4.26)	(4.26)
Soil Organic Carbon	(3.42)	(3.42)	(3.42)	(3.42)	(3.42)	(3.42)	(3.42)	(5.00)	(5.94)	(5.94)	(5.94)	(5.94)	(5.94)	(5.94)	(5.94)	(5.94)	(5.94)
Total wood products and landfills	(1.61)	(1.61)	(1.61)	(0.56)	(0.56)	(0.56)	(0.56)	(0.56)	(0.56)	(0.56)	(0.56)	(0.56)	(0.56)	(0.56)	(0.56)	(0.56)	(0.56)
Liming of Agricultural Soils	-	-	-	-	-	-	-	-	-	-	-	-	0.06	0.01	0.01	0.03	-
Urea Fertilization	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.02	0.01	0.02	0.02	0.03	0.03	0.03
Urban Trees	(0.26)	(0.27)	(0.28)	(0.28)	(0.29)	(0.30)	(0.30)	(0.31)	(0.32)	(0.32)	(0.33)	(0.34)	(0.35)	(0.35)	(0.36)	(0.37)	(0.37)
Landfilled Yard Trimmings and Food Scraps	(3.25)	(2.81)	(2.81)	(2.50)	(2.25)	(1.90)	(1.57)	(1.53)	(1.50)	(1.39)	(1.39)	(1.44)	(1.48)	(1.22)	(1.09)	(1.13)	(1.17)
Landfilled Food Scraps	(0.34)	(0.30)	(0.32)	(0.32)	(0.31)	(0.27)	(0.31)	(0.38)	(0.45)	(0.46)	(0.59)	(0.57)	(0.57)	(0.52)	(0.59)	(0.55)	(0.52)
Forest Fires	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CH_4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
N_2O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
N_2O from Settlement Soils	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	**(25.34)**	**(24.91)**	**(24.92)**	**(23.56)**	**(23.32)**	**(22.98)**	**(22.66)**	**(27.25)**	**(29.98)**	**(29.88)**	**(29.88)**	**(29.94)**	**(29.93)**	**(29.72)**	**(29.60)**	**(29.63)**	**(29.71)**

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

Step (10) Export Data

The final step is to export the summary data. Exporting data allows the estimates from each module to be combined later by the Synthesis Module to produce a comprehensive GHG inventory for the state.

To access the “Export Data” button, return to the control worksheet and scroll down to the bottom (10). Click on the “Export Data” button and a message box will open that reminds the user to make sure all steps of the module have been completed. If you make any changes to the LULUCF module later, you will then need to re-export the results.

> **Note: the resulting export file should not be modified.** The export file contains a summary worksheet that allows users to view the results, as well as a separate data worksheet with an unformatted version of the results. The second worksheet, the data worksheet, contains the information that is exported to the Synthesis Tool. Users may not modify that worksheet. Adding/removing rows, moving data, or making other modifications jeopardize the ability of the Synthesis Module to accurately analyze the data.

Clicking “OK” prompts you to save the file. The file is already named, so you only need to choose a convenient place to save the file. After the file is saved, a message box will appear indicating that the data was successfully exported.

While completing the modules, you are encouraged to save each completed module; doing so will enable you to easily make changes without re-running it entirely.

Following data export, the module may be reset and run for an additional state. Alternatively, you may run the remaining modules of the SIT to obtain a comprehensive profile of emissions for your state.

1.4 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.

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