10. Recalculations and Improvements

Each year, emission and sink estimates are recalculated and revised for all years in the Inventory of U.S. Greenhouse Gas Emissions and Sinks, as attempts are made to improve both the analyses themselves, through the use of better methods or data, and the overall usefulness of the report. In this effort, the United States follows the 2006 IPCC Guidelines (IPCC 2006), which states, "Both methodological changes and refinements over time are an essential part of improving inventory quality. It is *good practice* to change or refine methods" when: available data have changed; the previously used method is not consistent with the IPCC guidelines for that category; a category has become key; the previously used method is insufficient to reflect mitigation activities in a transparent manner; the capacity for inventory preparation has increased; new inventory methods become available; and for correction of errors."

The results of all methodological changes and historical data updates are presented in this section; detailed descriptions of each recalculation are contained within each source's description found in this report, if applicable. Table 10-1 summarizes the quantitative effect of these changes on U.S. greenhouse gas emissions and sinks and Table 10-2 summarizes the quantitative effect on annual net CO_2 fluxes, both relative to the previously published U.S. Inventory (i.e., the 1990 through 2009 report). These tables present the magnitude of these changes in units of teragrams of carbon dioxide equivalent (Tg CO_2 Eq.).

The Recalculations Discussion section of each source presents the details of each recalculation. In general, when methodological changes have been implemented, the entire time series (i.e., 1990 through 2009) has been recalculated to reflect the change, per IPCC (2006). Changes in historical data are generally the result of changes in statistical data supplied by other agencies.

The following emission sources and sinks, which are listed in descending order of absolute average annual change in emissions or sequestration between 1990 and 2009, underwent some of the most important methodological and historical data changes. A brief summary of the recalculations and/or improvements undertaken is provided for each source.

- *Forest Land Remaining Forest Land (CH_4 & N_2O emissions, CO_2 sink).* There were five changes in the current Inventory affected the national stock and change estimates for forest ecosystems. The basic models used to estimate HWP C stocks and change are unchanged from the previous Inventory. Adopting the method of Woodall et al. (2011a) for both live and standing dead trees affected these two pools in somewhat different ways. First, live tree C stocks are lower because the new method estimates lower biomass for most trees. However, the relative effect on net annual stock change was minimal and varied from state to state. Second, the change from modeled estimates of standing dead to the tree-based estimates (Woodall et al. 2011a, Domke et al. 2011, Woodall et al. In Press) also resulted in lower estimates of stocks, yet the newer stock-change estimates included greater sequestration throughout the 21-year interval. The remaining three changes to the Inventory originate as modifications in the forest inventory data, specifically the FIADB. A number of Sothern states revised some previously-existing inventories from the late 1990s and early 2000s. From this, stock and stock-change estimates varied slightly for seven states over the mid-part of the 1990 through 2010 interval. In some cases, C stocks increased while in others they decreased. The net effect is a slight increase in sequestration as estimated for the late 1990s and early 2000s. The fourth change is the addition of the periodic data for Alaska timberlands so that a stock-change estimate is now included for a large part of coastal Alaska. The net effect on the national totals is a slight increase in sequestration applied throughout the interval. Finally, forest area, and thus C stock, estimates were revised upward for central and western portions of Oklahoma and Texas since the previous Inventory report. These changes only affect stocks and not change because those forest lands are based on single current surveys only.

  The changes in estimation procedures for live and standing dead trees affected estimates of uncertainty. The CRM method, which is largely a function of tree volume, appears to reduce levels of individual-tree error for both live and standing dead trees. In addition, empirical (i.e., field-based measurements of individual trees) estimates of standing dead trees have replaced a stand-level model, which should further reduce error. Additional information regarding error associated with the volume and CRM models remains limited and is an active area of ongoing research (e.g., FIA National Volume/Biomass Study).

  For the current Inventory, non-CO_2 emissions were calculated using the 2006 IPCC default emission factors for CH_4 and N_2O instead of the 2003 IPCC default emission factors. These default emission factors were converted to CH_4 to CO_2 and N_2O to CO_2 emission ratios and then multiplied by CO_2 emissions to estimate CH_4 and N_2O emissions. The previous 2003 IPCC methodology provides emission ratios that are multiplied by total C emitted.

The National Association of State Foresters (NASF) releases data on land under wildland protection every several years. In 2011, NASF released these data for the year 2008, which affected the ratio of forest land to land under wildland protection for the years 2007 through 2009. For each of these three years, the updated ratio decreased the forest area burned estimates for the lower forty-eight states by around 15 percent. See the explanation in Annex 3.12 for more details on how the forestland to land under wildland protection ratio is used to calculate forest fire emissions.

In previous Inventory reports, the methodology has assumed that the C density of forest areas burned in wild and prescribed fires does not vary between years. This assumption has been in contrast to the forest C stock estimates, which are updated annually for all years based on data from the USDA Forest Service. The methodology adopted for the current Inventory improves the C density factors by incorporating dynamic C density values based on the annual C pool data provided by the USDA Forest Service for the years 1990 to 2010. As a result of this update, estimates of CO_2 and non-CO_2 emissions from wild and prescribed fires decreased by between 20 and 30 percent as compared to the estimates included in the previous Inventory. This decrease occurred because the dynamic C density values calculated were 20 to30 percent lower (depending on the year) than the C density values previously used for the methodology. For more information on how C density contributes to estimates of emissions from forest fires, see Annex 3.12.

In total, these changes resulted in a decrease in CH_4 and N_2O emissions from forest land remaining forest land across the entire time series, with an average annual decrease of 1.8 Tg CO_2 Eq. (20.1 percent) for CH_4 and 1.4 Tg CO_2 Eq. (19.2 percent) for N_2O. These changes also resulted in an increase in C sequestration across the time series, with an average annual increase of 44.9 Tg CO_2 Eq. (8.1 percent).

- *Wastewater Treatment (CH_4 & N_2O).* For domestic wastewater CH_4 calculations, the emission estimations were updated for septic systems using new research from WERF (Leverenz et al. 2010). Previously, the septic equation used MCF and BOD produced (Gg/yr) along with percent of wastewater treated and Bo to estimate emissions. In the current Inventory, that calculation was updated with a new emission factor of 10.7 g CH_4/capita/day, which uses population along with percent of wastewater treated and Bo for estimating emissions. This recalculation caused changes relative to the previous Inventory for all years. Other minor updates in input data such as population and production resulted in slight changes in the later years of the Inventory.

  For domestic wastewater N_2O calculations, an update was made to the $N_2O_{EFFLUENT}$ equation to make it more accurately reflect emissions. U.S. population is now multiplied by the fraction of the population not using septic systems for wastewater treatment. In addition, the factor for industrial and commercial co-discharged protein was previously left out of the calculations. This error was fixed in the current Inventory. These updates caused changes relative to the previous Inventory for all years. Other minor updates in input data such as population resulted in slight changes in the later years of the Inventory.

  In total, these changes resulted in an average annual decrease of 7.9 Tg CO_2 Eq. (32.0 percent) in CH_4 emissions and 0.2 Tg CO_2 Eq. (3.8 percent) in N_2O emissions from wastewater treatment for the period 1990 through 2009.

- *Enteric Fermentation (CH_4).* There were several modifications to the Enteric Fermentation methodology relative to the previous Inventory that had an effect on emission estimates, including the following:

  Emissions from bulls were estimated using Tier 2 methodology. This resulted in an increase of emissions from bulls by an average of approximately 79 percent per year compared to the previous Inventory estimates which used a Tier 1 methodology, such that bulls represent 3.4 percent of total enteric fermentation emissions from cattle. Revisions to the DE values for foraging cattle diets were applied to 1990 through 2010, resulting in an average change of less than 0.1 percent for foraging beef cattle emissions estimates for 1990 through 2006 and an average increase of 0.4 percent for 2007 through 2009. During the QA/QC process, it was realized that the one data point from 1988 (total births) had been revised by USDA since its original download. Therefore, the data point was corrected from 39,318.0 to 39,317.9 thousand births. This is a very minor change, but it is noted in detail specifically because it affects 1990 base year emissions by trickling through the transition matrix in the growing populations for 1989 and 1990. The equations used to distribute end-of-year remaining populations for feedlot cattle to the individual state populations were updated so that the population proportions reflect the current year rather than the following year populations. This did not affect total populations, but there were minor changes to the populations by state for feedlot cattle for all years.

Previously, American bison and mules, burros, and donkeys were excluded from this source category. Emission estimates are now included for these animal types for all years, and contribute an average of 0.2 percent of total emissions from enteric fermentation across the time series.

The USDA published revised estimates in several categories that affected historical emissions estimated for cattle, including slight revisions in 2009 cattle on feed population estimates for “other states” (aggregated data for states with small populations of cattle on feed), dairy cow milk production for several states, and steer and heifer placement and slaughter statistics. Additionally, calf births were revised for both the 2008 and 2009 estimates. These changes had an insignificant impact on the overall results.

There were additional population changes for goats from 2003 through 2006, sheep for 2004, 2006, and 2009, and swine in 2009, as discussed in the recalculations discussion for manure management. Historical emission estimates for goats increased an average of 12.1 percent per year compared to the previous emission estimates for the years mentioned above. All other population changes resulted in a decrease in emissions of less than 1 percent for the animal type and year noted. As a result of all these changes, overall CH_4 emissions from enteric fermentation increased an average of 2.3 Tg CO_2 Eq. (1.7 percent) per year for 1990 through 2009.

- *Agricultural Soil Management (N_2O).* County-level animal populations were updated relative to the previous Inventory report based on 2007 USDA Census of Agriculture data (USDA 2007), which changed the animal population estimates for 2002 through 2009. The N excretion values for cattle changed for 1990 through 2009. Waste management system (WMS) distributions for dairy and swine were updated based on Census of Agriculture farm size data (USDA 2007). These changes created an average annual increase of 2.0 Tg CO_2 Eq. (1.0 percent) from agricultural soil management from 1990 through 2009.
- *Stationary Combustion (CH_4 and N_2O).* Historical CH_4 and N_2O emissions from stationary sources (excluding CO_2) were revised due to a few of changes, impacting the entire time series, relative to the previous Inventory. Slight changes to emission estimates for sectors are due to revised data from EIA (2011). Wood consumption data in EIA (2011) were revised for the residential, commercial, electric power, and industrial sectors from 1990 to 2009. Additionally, a Tier 2 emission estimation methodology was applied to estimate emissions from the electric power sector across the entire time series. This primarily impacted N_2O emission estimates, as the number of coal fluidized bed boilers increased significantly from 2000 through 2005. The combination of the methodological and historical data changes resulted in an average annual increase of less than 0.1 Tg CO_2 Eq. (0.5 percent) in CH_4 emissions from stationary combustion and an average annual increase of 1.9 Tg CO_2 Eq. (13.7 percent) in N_2O emissions from stationary combustion for the period 1990 through 2009.
- *Substitution of Ozone Depleting Substances (HFCs).* A review of the window units and residential unitary air conditioning end-uses led to minor revisions in the assumed transition scenarios. Overall, these changes to the Vintaging Model had negligible effects on estimates of greenhouse gas emissions across the time series. An update to the retail food refrigeration end-uses resulted in the replacement of the medium retail food end-use with small condensing units and large condensing units. In addition, updates were made to the charge sizes, leak rates, and equipment transitions for each end-use. These changes to the Vintaging Model had a significant impact on the estimates of greenhouse gas emissions for the retail food refrigeration sector. In total, changes resulted in an average annual increase of 1.8 Tg CO_2 Eq. (0.1 percent) in HFC emissions.
- *Electrical Transmission and Distribution (SF_6).* In the current Inventory, SF_6 emission estimates for the period 1990 through 2009 were updated relative to the previous report based on 1) new data from EPA’s SF_6 Emission Reduction Partnership; 2) revisions to interpolated and extrapolated non-reported Partner data; and 3) a correction made to 1999 through 2001 reported emissions data for a Partner. Correcting the reported emissions not only directly impacted overall emissions for 1999 through 2001, but also impacted the regression coefficient used to estimate emissions for non-Partners, which is based on the relationship between transmission miles and emissions for Partners that reported emissions in 1999. Specifically, the regression coefficient for utilities with fewer than 10,000 transmission miles decreased from 1.001 kg of emissions per transmission mile to 0.89 kg of emissions per transmission mile. Based on the revisions listed above, SF_6 emissions from electrical transmission and distribution decreased between 6 and 9 percent for each year from 1990 through 2009 relative to the previous report. Based on the revisions listed above, SF_6 emissions from electrical transmission and

distribution decreased between 6 and 9 percent for each year from 1990 through 2009, with an average decrease of 1.3 Tg CO_2 Eq. (6.8 percent).

- *Non-Energy Uses of Fossil Fuels (CO_2).* Relative to the previous Inventory, emissions from non-energy uses (NEU) of fossil fuels decreased by an average of 1.2 Tg CO_2 Eq. (0.7 percent) across the entire time series. Two competing changes contributed to these recalculations. The larger of the two changes was a decrease in emissions caused by a change in petrochemical input data reported by the Energy Information Administration (EIA) in its Monthly Energy Review. In particular, a decline in EIA's estimate of petroleum coke consumed for non-energy purposes across the time series explains the majority of the decrease. The smaller of the two changes was an increase in emissions caused by EIA's revision of its methodology for calculating LPG consumed for non-energy uses in consultation with EPA. These estimates had previously been based on the assumption that the portion of LPG used for NEU remained constant at its 2004 level for the rest of the time series. For the current Inventory, EIA instead retrieved data describing the portion of LPG in NEU from Petroleum Supply Annual for the entire 1990 through 2010 time series and revised the previous assumption accordingly. Because 2004 was an uncharacteristically low year for non-energy consumption of LPG, this revision resulted in an overall increase in estimates of LPG consumed for NEU and thus an increase in estimated emissions. Combined, the net effect of these two changes was to decrease emission estimates across the time series by 1.0 Tg CO_2 Eq. (0.7 percent) since 2004.
- *Biomass – Wood (CO_2)* Wood consumption values were revised relative to the previous Inventory for 2009 based on updated information from EIA's Annual Energy Review (EIA 2011). Additionally, the change in methodology for calculating emissions from woody biomass led a decrease in emissions from the electricity generation sector and an increase in emissions for the other sectors over the time series. This adjustment of historical data for wood biomass consumption resulted in an average annual decrease in emissions from wood biomass consumption of about 1.0 Tg CO_2 Eq. (0.5 percent) from 1990 through 2009.
- *Adipic Acid Production (N_2O).* For the current Inventory, plant specific N_2O emissions data for Plant 3 were obtained directly from the plant engineer for 2005 through 2009. In the previous Inventory, 2005 through 2009 estimates of N_2O emissions from adipic acid production at Plant 3 were developed using plant production data. For the 1990 through 2009 inventory, Plant 3 emissions for, which uses thermal destruction, the N2O abatement system destruction factor was assumed to be 98.5 percent, and the abatement system utility factor was assumed to be 97 percent (IPCC 2006). This recalculation resulted in an 84 percent increase in average annual estimated N2O emissions from adipic acid production between 2005 and 2009, relative to the previous report. In total, changes resulted in an average annual increase of 0.8 Tg CO_2 Eq. (20.9 percent) in N_2O emissions

Table 10-1: Revisions to U.S. Greenhouse Gas Emissions (Tg CO_2 Eq.)

Gas/Source	1990	2005	2006	2007	2008	2009
CO_2	**0.8**	**(6.2)**	**(2.1)**	**(1.4)**	**2.8**	**(4.7)**
Fossil Fuel Combustion	(0.1)	(6.7)	(0.1)	1.0	5.6	(2.8)
Electricity Generation	NC	+	+	+	+	(7.6)
Transportation	+	+	+	(0.1)	(0.1)	8.2
Industrial	(0.1)	(6.7)	(0.1)	2.4	3.7	(3.8)
Residential	NC	+	+	(0.7)	1.1	(0.2)
Commercial	+	+	+	(0.5)	0.9	0.6
U.S. Territories	NC	NC	NC	NC	NC	+
Non-Energy Use of Fuels	1.0	0.7	(1.8)	(2.4)	(2.3)	0.4
Iron and Steel Production & Metallurgical Coke Production	0.1	0.1	0.1	0.1	0.1	0.2
Natural Gas Systems	+	+	+	+	+	+
Cement Production	NC	NC	NC	NC	NC	NC
Lime Production	NC	NC	NC	NC	NC	+
Incineration of Waste	NC	+	+	+	(0.3)	(0.6)
Limestone and Dolomite Use	NC	NC	NC	NC	NC	NC
Ammonia Production	NC	NC	NC	+	+	(0.5)
Cropland Remaining Cropland	NC	NC	NC	+	+	(0.6)
Urea Consumption for Non-Agricultural Purposes	NC	NC	NC	+	+	(0.5)
Soda Ash Production and Consumption	NC	NC	NC	NC	+	(0.7)
Petrochemical Production	NC	NC	NC	NC	NC	NC
Aluminum Production	NC	NC	NC	NC	NC	NC
Carbon Dioxide Consumption	+	+	+	+	+	+
Titanium Dioxide Production	NC	NC	NC	NC	NC	0.1
Ferroalloy Production	NC	NC	NC	NC	NC	NC
Zinc Production	+	(0.1)	(0.1)	(0.1)	(0.1)	+
Phosphoric Acid Production	NC	NC	NC	NC	+	+
Wetlands Remaining Wetlands	NC	NC	NC	NC	NC	+
Lead Production	NC	NC	NC	NC	+	NC
Petroleum Systems	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.1)
Silicon Carbide Production and Consumption	NC	NC	NC	NC	NC	NC
Land Use, Land-Use Change, and Forestry (Sink)[a]	*(20.3)*	*(29.5)*	*(46.1)*	*(47.4)*	*(47.0)*	*(47.5)*
Biomass - Wood[b]	*(0.8)*	*(1.2)*	*(1.2)*	*(1.1)*	*(1.0)*	*(2.0)*
International Bunker Fuels[b]	*NC*	+	+	+	+	*(0.8)*
Biomass - Ethanol[b]	+	+	+	+	+	*1.0*
CH_4	**(6.6)**	**(5.7)**	**(7.4)**	**(8.4)**	**(8.8)**	**(14.1)**
Natural Gas Systems	(0.2)	+	0.1	0.1	0.9	(0.3)
Enteric Fermentation	1.7	2.5	2.5	2.8	2.8	2.8
Landfills	0.3	0.2	+	0.5	(2.8)	(6.3)
Coal Mining	NC	(0.1)	(0.1)	+	(0.2)	(0.9)
Manure Management	+	1.3	1.6	1.9	2.3	1.3
Petroleum Systems	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.3)
Wastewater Treatment	(7.6)	(7.8)	(7.8)	(7.8)	(7.9)	(8.0)
Rice Cultivation	NC	NC	NC	NC	NC	NC
Stationary Combustion	+	0.1	+	0.1	0.1	0.1
Abandoned Underground Coal Mines	NC	NC	NC	(0.3)	(0.6)	(0.4)
Forest Land Remaining Forest Land	(0.7)	(1.7)	(3.6)	(5.5)	(3.1)	(2.0)
Mobile Combustion	NC	+	+	+	+	+
Composting	NC	NC	NC	NC	NC	(0.1)
Petrochemical Production	NC	NC	NC	NC	+	+
Iron and Steel Production & Metallurgical Coke Production	NC	NC	NC	NC	NC	NC
Field Burning of Agricultural Residues	(0.1)	+	+	+	+	+

Ferroalloy Production	NC	NC	NC	NC	NC	NC
Silicon Carbide Production and Consumption	NC	NC	NC	NC	NC	NC
Incineration of Waste	NC	NC	NC	NC	NC	NC
International Bunker Fuels[b]	*NC*	+	+	+	+	+
N_2O	**1.1**	**9.0**	**10.4**	**9.8**	**6.3**	**8.4**
Agricultural Soil Management	2.2	1.7	2.2	1.7	2.2	2.7
Mobile Combustion	NC	0.1	0.1	(1.3)	(0.9)	(1.4)
Stationary Combustion	(0.6)	5.9	6.3	6.6	6.9	7.9
Manure Management	0.3	0.3	0.4	0.4	0.3	0.3
Nitric Acid Production	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
Wastewater Treatment	(0.2)	(0.1)	(0.1)	+	+	(0.1)
N_2O from Product Uses	NC	NC	NC	NC	NC	NC
Forest Land Remaining Forest Land	(0.6)	(1.4)	(3.0)	(4.5)	(2.6)	(1.7)
Adipic Acid Production	NC	2.5	4.6	7.0	0.5	0.9
Composting	NC	NC	NC	NC	NC	(0.1)
Settlements Remaining Settlements	NC	NC	NC	+	(0.1)	(0.2)
Incineration of Waste	NC	NC	NC	NC	NC	NC
Field Burning of Agricultural Residues	+	+	+	+	+	+
Wetlands Remaining Wetlands	NC	NC	NC	NC	NC	+
International Bunker Fuels[b]	(1.8)	(6.4)	(8.5)	(10.6)	(13.1)	(14.6)
HFCs	**NC**	**(5.2)**	**(7.5)**	**(9.6)**	**(11.9)**	**(13.6)**
Substitution of Ozone Depleting Substances	NC	(5.2)	(7.5)	(9.6)	(11.9)	(13.6)
HCFC-22 Production	NC	NC	NC	NC	NC	NC
Semiconductor Manufacture	NC	NC	NC	NC	NC	+
PFCs	**(0.1)**	**NC**	**NC**	**NC**	**NC**	**+**
Semiconductor Manufacture	NC	NC	NC	NC	NC	+
Aluminum Production	(0.1)	NC	NC	NC	NC	NC
SF_6	**(1.7)**	**(1.2)**	**(1.1)**	**(1.1)**	**(1.2)**	**(1.0)**
Electrical Transmission and Distribution	(1.7)	(1.2)	(1.1)	(1.1)	(1.2)	(1.0)
Magnesium Production and Processing	NC	NC	NC	NC	+	+
Semiconductor Manufacture	NC	NC	NC	NC	NC	+
Net Change in Total Emissions[b]	**(6.6)**	**(9.3)**	**(7.6)**	**(10.6)**	**(12.8)**	**(25.0)**
Percent Change	**-0.1%**	**-0.1%**	**-0.1%**	**-0.1%**	**-0.2%**	**-0.4%**

+ Absolute value does not exceed 0.05 Tg CO_2 Eq. or 0.05 percent.
Parentheses indicate negative values
NC (No Change)
[a] Not included in emissions total.
[b] Excludes net CO_2 flux from Land Use, Land-Use Change, and Forestry, and emissions from International Bunker Fuels.

Note: Totals may not sum due to independent rounding.

Table 10-2: Revisions to Annual Net CO_2 Fluxes from Land Use, Land-Use Change, and Forestry (Tg CO_2 Eq.)

Component: Net CO_2 Flux From Land Use, Land-Use Change, and Forestry	**1990**	**2005**	**2006**	**2007**	**2008**	**2009**
Forest Land Remaining Forest Land	(20.3)	(29.4)	(46.1)	(47.3)	(47.3)	(47.5)
Cropland Remaining Cropland	NC	NC	NC	NC	NC	NC
Land Converted to Cropland	NC	NC	NC	NC	NC	NC
Grassland Remaining Grassland	NC	NC	NC	NC	NC	NC
Land Converted to Grassland	NC	NC	NC	NC	NC	NC
Settlements Remaining Settlements	NC	NC	NC	NC	NC	NC
Other	NC	(0.1)	+	+	0.3	+
Net Change in Total Flux	**(20.3)**	**(29.5)**	**(46.1)**	**(47.4)**	**(47.0)**	**(47.5)**
Percent Change	**-2.4%**	**-2.8%**	**-4.3%**	**-4.5%**	**-4.5%**	**-4.7%**

NC (No Change)

Note: Numbers in parentheses indicate a decrease in estimated net flux of CO_2 to the atmosphere, or an increase in net sequestration.

Note: Totals may not sum due to independent rounding.

+ Absolute value does not exceed 0.05 Tg CO_2 Eq. or 0.05 percent