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 both the *IPCC Good Practice Guidance* (IPCC 2000) and 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 made in this year's report 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 2011 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's section presents the details of each recalculation. In general, when methodological changes have been implemented, the entire time series (i.e., 1990 through 2011) 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 ten emission sources and sinks, which are listed in absolute descending order of annual change in emissions or sequestration between 1990 and 2011, underwent some of the most significant methodological and historical data changes. A brief summary of the recalculations and/or improvements undertaken is provided for each of the ten sources.

- *Agricultural Soil Management (N_2O).* Methodological recalculations in the current Inventory were associated with the following improvements: 1) Driving the DAYCENT simulations with input data for the excretion of C and N onto Pasture/Range/Paddock based on national livestock population data instead being internally generated by the DAYCENT model (note that revised total PRP N additions increased from 6.9 to 7.2 Tg N on average); 2) expanding the number of experimental study sites used to quantify model uncertainty for direct N_2O emissions and bias correction; 3) refining the temperature algorithm that is used for simulating crop production and carbon inputs to the soil in the DAYCENT biogeochemical model; and (4) recalculation of Tier 2 organic soil N_2O emissions using annual data from the NRI rather than estimating emissions for every 5 years and holding emissions constant between the years. These changes resulted in an increase in emissions of approximately 23 per cent on average relative to the previous Inventory and a decrease in the upper bound of the 95 percent confidence interval for direct N_2O emissions from 40 to 29 percent. The differences are mainly due to the refinement of temperature algorithm in the model and expansion of the number of field studies used to develop the statistical function for estimating uncertainty in the model structure and parameters. In particular, additional studies showed very high N_2O emissions during some years that were not captured by DAYCENT. This resulted in a relatively large adjustment in a portion of the DAYCENT simulated N_2O emissions to capture the high N_2O emission rates.

- *Land Use, Land-Use Change, and Forestry (CO_2).* Changes were driven by modification to the flux estimates for Settlements Remaining Settlements and Cropland Remaining Cropland. These changes were influenced by the following:
    - A major change was made in the urban trees methodology, which previously relied on a national estimate of net sequestration per unit tree cover, a national estimate of urban area, and national estimate of tree cover percentage. The new methodology uses reported state level estimates of gross sequestration, state level totals for urban area, and state level urban tree cover percentages.
    - Changes were made to mineral and organic soil carbon stocks methodology temperature algorithm that is used for simulating crop production and carbon inputs to the soil in the DAYCENT biogeochemical model; increasing the number of experimental sites that are used to evaluate the structural uncertainty in the DAYCENT model; and recalculation of Tier 2 organic soil C emissions.
    - The quantity of applied minerals reported for agricultural liming in the previous Inventory for 2010 has been revised; the updated activity data for 2010 for limestone are approximately 29 thousand metric tons less and the 2010 data for dolomite are approximately 433 thousand metric tons greater than the data used for the previous Inventory. And updated published 2011 data from the *Minerals Yearbook* have replaced those used in the previous Inventory to calculate the quantity of minerals applied to soil and the emissions from liming.
    - In the current Inventory, July to December 2009 and July to December 2010 urea application data were updated based on new activity data for fertilizer years 2010 and 2011, and the 2009 and 2010 emission estimates were revised accordingly. Similarly, the July to December 2011 urea application data were updated with assumptions for fertilizer year 2012, and the 2011 emission estimate was revised accordingly.

- *Natural Gas Systems (CH_4).* EPA received information and data related to the emission estimates through the Inventory preparation process and previous Inventories' formal public notice periods. EPA carefully evaluated all relevant information provided, and updates were made to estimates for completions with hydraulic fracturing and workovers with hydraulic fracturing (refracturing), Natural GasSTAR reductions, and well counts and completion and workover counts. Emission estimates will continue to be refined to reflect the most robust data and information available. The recalculations in the current Inventory relative to the previous report primarily impacted CH_4 emission estimates in the production sector, which for the year 2011, decreased from 53.4 Tg CO_2 Eq. in the previous Inventory to 42.6 Tg CO_2 Eq. in the current Inventory.

- *Substitution of Ozone Depleting Substances (HFCs).* A review of the Mobile Vehicle Air Conditioning (MVAC) light-duty vehicle (LDV) and light-duty truck (LDT) end-uses led to revisions in the assumed transition scenarios, stock and growth rate assumptions, and equipment lifetime. Updated annual sales and registration data was used to update the installed base, annual growth rate, and lifetime for the MVAC end-uses. In addition, although HFC-134a has been the dominant refrigerant in MVACs since the 1990s, an additional transition to HFO-1234yf was added to the Vintaging Model beginning with vehicles manufactured in 2012 to reflect a recent shift in new vehicles to HFO-1234yf. Overall, these changes to the Vintaging Model increased GHG emissions on average by 7 percent across the time series relative to the previous report.

- *Enteric Fermentation (CH_4).* Recalculations were made relative to the previous Inventory due to changes in activity data, including the following:
    - In the previous Inventory, aggregation in the 1992 feedlot cattle was linked incorrectly. This correction resulted in a decrease in emissions for that year of 0.2 percent.
    - The USDA published minor revisions in several categories that affected historical emissions estimated for cattle in 2011, including dairy cow milk production for several states and cattle populations for January 1, 2012. These changes had an insignificant impact on the overall results.
    - Calves 4-6 months were added to emissions estimates for the first time in the current Inventory. The inclusion of calves has increased emissions from beef cattle by approximately 3 percent per year. In addition, for the first time calf populations for enteric fermentation were differentiated into dairy and beef calves. During this process, total calf populations were updated slightly, so that the enteric fermentation calf populations differ an average of 0.9 percent per year from manure management calf populations.

- Horse population data was obtained for 1987 and 1992 from USDA census data, resulting in a change in population estimates for 1990 through 1996. This resulted in an average decrease of 6.3 percent for those years relative to the previous report.
- Populations of American bison and mules and asses were revised to extrapolate data beyond the 2007 census based on a linear trend rather than following trends in bison slaughter and holding values constant. These changes resulted in average decrease of 3.2 percent and increase of 31.4 percent, respectively, for those years. Additionally, the name of this population group was revised from mules, burros, and donkeys to mules and asses to be consistent with the IPCC CRF tables.

- *Wastewater Treatment (CH_4 and N_2O).* In the current Inventory, production data were updated to reflect revised USDA National Agricultural Statistics Service (NASS) datasets, relative to the previous report. In addition, a new source of data was identified for pulp and paper production and incorporated into the current Inventory. These data were used to revise production values of wood pulp and paper and paperboard for 2002 through 2012. In addition, the most recent USDA Economic Research Service (ERS) data were used to update protein values from 1990 through 2006. The updated ERS data also resulted in small changes in forecasted values from 2007. Using the information summarized in Bicknell, et al. (2013) and Aguiar, et al. (2013), both pulp and paper and petroleum refining estimates were updated to be consistent with the most current and representative data available for these industries. Primarily due to these new data, overall industry emissions from industrial wastewater treatment decreased by 40 percent from the 1990-2011 Inventory report. In addition, an improved forecasting methodology for domestic wastewater resulted in small changes to both N_2O and CH_4 emissions beginning in 2005.

- *Carbon Emitted from Non-Energy Uses of Fossil Fuels (CO_2).* Relative to the previous Inventory, emissions from non-energy uses of fossil fuels decreased by an average of 3.2 Tg CO_2 Eq. (2.3 percent) across the entire time series. Changes ranged from an increase of about 3 Tg CO_2 Eq. in 1990 to a decrease of about 13 Tg CO_2 Eq. in 2009. The main catalyst for these recalculations was changes to historic fossil fuel consumption input data acquired from the Energy Information Administration (EIA). The EIA annually revises its fossil fuel consumption estimates, which may affect previously-reported Inventory emissions from non-energy uses of fossil fuels. Since the methodology for calculating emissions from non-energy uses of fossil fuels remained the same relative to the previous Inventory, changes to consumption input data is the primary cause of the recalculations. Overall, the net effect of these changes was a slight decrease in emission estimates across the entire time series. In addition, EPA's *National Emissions Inventory (NEI) Air Pollutant Emissions Trends Data* released updated data in December 2013, which included new data through 2011 and revised data for previous years. Additionally, EPA's *MSW Facts and Figures* was released in February 2014, which included data for 2012 and revised data for prior years.

- *Coal Mining (CH_4).* For the current Inventory, updated mine maps were received for the Jim Walter Resources Blue Creek #4 and #7 mines (JWR 2010) that showed changes in the planned locations of areas to be mined through. The updated mine plans provided a more accurate depiction of the dates and locations at which the pre-drainage wells were mined through. As a result, the mined-through dates were adjusted for some wells relative to the previous Inventory, and underground emissions avoided values changed slightly for 2011. Prior to the current Inventory, vented degasification emissions from underground coal mines were typically estimated based on drainage efficiencies reported by either the mining company or Mine Safety and Health Administration (MSHA). However, beginning in 2011, underground coal mines began reporting CH_4 emissions from degasification systems to EPA under its GHGRP, which requires degasification quantities to be measured weekly, thus offering a more accurate account than previous methods. As a result, data reported to EPA's GHGRP in 2012 were used to estimate vented degasification volumes for those mines. In 2012, GHGRP-reported vented degasification emission totals were approximately 30 percent lower when compared to the previous estimation method; however, the difference only represents approximately 1.5 percent of the overall coal mining emission inventory. In 2012, the surface mining emission factor was revised downward from 200 percent to 150 percent of the average *in situ* CH_4 content of the mined coal seam. In previous Inventory reports, a 200 percent factor was used as a conservative measure due to a lack of U.S. data. Based on surface mine emissions studies conducted used in Canada and Australia (King 1994, Saghatfi 2013), this emission factor was adjusted to more closely align with those studies where actual measurements have been taken of similar coals. While the gas content of the coal accounts for CH_4 liberated from the mined coal, this emission factor accounts for

additional CH_4 released from the over- and under-lying strata surrounding the mined coal seam. The change was made across the entire time series.

- *Fossil Fuel Combustion (CO_2).* The Energy Information Administration (EIA 2014) updated energy consumption statistics across the time series relative to the previous Inventory. One such revision is the inclusion of past residential coal estimates into commercial coal statistics for the years 2008 to 2011. These revisions primarily impacted the previous emission estimates from 2008 to 2011; however, additional revisions to industrial and transportation petroleum consumption as well as industrial natural gas and coal consumption impacted emission estimates across the time series. Overall, these changes resulted in an average annual increase of 1.3 Tg CO_2 Eq. (less than 0.1 percent) in CO_2 emissions from fossil fuel combustion for the period 1990 through 2011, relative to the previous report.

- *Rice Cultivation (CH_4).* An updated literature review of rice emission factor estimates was conducted for the current Inventory, resulting in an updated set of regional rice emission factors. In the previous Inventory, two U.S. average emission factors were applied to rice area harvested—one for the primary crop (210 kg CH_4/hectare-season) and one for the ratoon crop (780 kg CH_4/hectare-season). The updated emission factors, based on the recent literature, replace the primary crop emission factor with two California-specific emission factors based on flooding practices and an updated non-California primary crop emission factor of 237 kg CH_4/hectare-season. The new emission factors were applied across the full time series, as they represent the same assumptions about rice cultivation practices. The change in emission factors resulted, on average, in an 8.3 percent increase in emissions from 1990 to 2011.

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

Gas/Source	1990	2005	2008	2009	2010	2011	Average Annual Change
CO_2	**(0.1)**	**2.9**	**(7.9)**	**(11.8)**	**(14.1)**	**(20.7)**	**(1.5)**
Fossil Fuel Combustion	(3.5)	4.2	2.8	3.3	(3.2)	(6.1)	1.3
Electricity Generation	+	+	+	+	+	+	+
Transportation	+	+	0.5	(1.5)	1.2	2.9	0.1
Industrial	(3.5)	4.2	2.1	4.9	(4.7)	(4.5)	1.3
Residential	+	+	(0.7)	(0.7)	0.2	(3.8)	(0.2)
Commercial	+	+	1.0	0.6	0.1	(0.6)	+
U.S. Territories	NC	+	NC	NC	NC	(0.1)	+
Non-Energy Use of Fuels	3.4	(1.7)	(11.5)	(15.9)	(12.0)	(13.2)	(3.2)
Natural Gas Systems	+	0.1	0.1	+	+	2.7	0.2
Cement Production	+	0.7	0.6	0.4	0.3	0.4	0.6
Lime Production	(0.1)	(0.3)	(0.4)	(0.2)	(0.3)	(0.3)	(0.3)
Other Process Uses of Carbonates	NC	NC	NC	NC	NC	0.2	+
Glass Production	NC	NC	NC	NC	NC	NC	NC
Soda Ash Production and Consumption	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
Carbon Dioxide Consumption	NC	NC	NC	NC	0.1	+	+
Incineration of Waste	NC	+	+	+	+	0.1	+
Titanium Dioxide Production	NC	NC	NC	NC	NC	(0.2)	+
Aluminum Production	NC	NC	NC	NC	NC	NC	NC
Iron and Steel Production & Metallurgical Coke Production	NC	NC	NC	NC	NC	(4.3)	(0.2)
Ferroalloy Production	NC	NC	NC	NC	NC	NC	NC
Ammonia Production	NC	NC	0.5	0.6	0.5	0.6	0.1
Urea Consumption for Non-Agricultural Purposes	NC	NC	NC	+	0.4	(0.3)	+
Phosphoric Acid Production	0.1	0.1	+	+	+	+	0.1
Petrochemical Production	NC	NC	NC	NC	NC	NC	NC
Silicon Carbide Production and Consumption	NC	NC	NC	NC	NC	NC	NC
Lead Production	NC	NC	NC	NC	NC	NC	NC

Zinc Production	NC	NC	NC	NC	+	+	+
Cropland Remaining Cropland	NC	NC	NC	+	0.2	(0.3)	+
Wetlands Remaining Wetlands	NC	NC	NC	NC	NC	+	+
Petroleum Systems	+	NC	NC	NC	+	+	+
Land Use, Land-Use Change, and Forestry (Sink)[a]	*(36.6)*	*(32.9)*	*(78.4)*	*(79.0)*	*(79.2)*	*(75.3)*	*(30.7)*
Biomass – Wood[a]	+	+	*1.9*	*4.5*	*(0.5)*	*2.4*	*0.5*
International Bunker Fuels[a]	*NC*	*NC*	*NC*	*NC*	*NC*	*0.3*	+
Biomass – Ethanol[a]	*NC*	*NC*	*NC*	+	+	*0.1*	+
CH_4	**(4.2)**	**(7.9)**	**(12.8)**	**(7.3)**	**(7.2)**	**(8.9)**	**(8.0)**
Stationary Combustion	+	+	0.1	0.4	0.1	0.1	+
Mobile Combustion	NC	+	+	+	+	+	+
Coal Mining	(3.0)	(3.3)	(3.6)	(3.2)	(3.2)	(3.4)	(3.1)
Abandoned Underground Coal Mines	NC	NC	NC	NC	NC	+	+
Natural Gas Systems	(4.8)	(7.0)	(11.8)	(7.8)	(8.9)	(11.5)	(8.2)
Petroleum Systems	0.6	(0.4)	(1.2)	(1.4)	(1.3)	(1.0)	(0.1)
Petrochemical Production	NC	NC	NC	NC	NC	NC	NC
Silicon Carbide Production and Consumption	NC	NC	NC	NC	NC	NC	NC
Iron and Steel Production & Metallurgical Coke Production	NC	NC	NC	NC	NC	NC	NC
Ferroalloy Production	NC	NC	NC	NC	NC	NC	NC
Enteric Fermentation	5.2	5.5	5.6	5.5	5.6	5.6	5.5
Manure Management	+	+	+	+	+	+	+
Rice Cultivation	0.6	0.7	0.6	0.6	0.7	0.5	0.6
Field Burning of Agricultural Residues	0.1	+	+	+	+	0.1	+
Forest Land Remaining Forest Land	+	0.1	0.1	0.1	0.1	(0.2)	+
Landfills	+	(0.4)	0.7	2.0	3.2	4.3	0.4
Wastewater Treatment	(2.8)	(3.1)	(3.3)	(3.4)	(3.4)	(3.3)	(3.2)
Composting	NC	NC	NC	NC	NC	+	+
Incineration of Waste	NC	NC	NC	NC	NC	NC	NC
International Bunker Fuels[a]	*NC*	*NC*	*NC*	*NC*	*NC*	+	+
N_2O	**54.3**	**59.7**	**73.6**	**73.5**	**65.4**	**60.3**	**56.4**
Stationary Combustion	+	+	+	0.1	+	(0.4)	+
Mobile Combustion	NC	+	+	+	+	+	+
Adipic Acid Production	NC	NC	NC	NC	NC	NC	NC
Nitric Acid Production	NC	NC	NC	NC	+	0.3	+
Manure Management	+	NC	NC	NC	NC	+	+
Agricultural Soil Management	54.2	59.8	73.6	73.6	65.6	60.6	56.4
Field Burning of Agricultural Residues	+	+	+	+	+	+	+
Wastewater Treatment	NC	(0.2)	(0.1)	(0.2)	(0.2)	(0.2)	(0.1)
N_2O from Product Uses	NC	NC	NC	NC	NC	NC	NC
Incineration of Waste	NC	NC	NC	NC	NC	NC	NC
Settlements Remaining Settlements	NC	NC	NC	+	+	+	+
Forest Land Remaining Forest Land	+	0.1	0.1	0.1	+	(0.2)	+
Composting	NC	NC	NC	NC	NC	+	+
Wetlands Remaining Wetlands	NC	NC	NC	NC	NC	NC	NC
International Bunker Fuels[a]	*NC*	*NC*	*NC*	*NC*	*NC*	+	+
HFCs	**NC**	**4.8**	**18.6**	**23.2**	**22.7**	**19.6**	**6.2**
Substitution of Ozone Depleting Substances	NC	4.8	18.7	23.3	22.9	19.8	6.2
HCFC-22 Production	NC	NC	NC	NC	NC	NC	NC
Semiconductor Manufacture	NC	+	(0.1)	(0.1)	(0.2)	(0.2)	+
PFCs	**NC**	**(0.6)**	**(1.5)**	**(1.2)**	**(2.2)**	**(1.0)**	**(0.4)**
Aluminum Production	NC	NC	NC	NC	NC	NC	NC
Semiconductor Manufacture	NC	(0.6)	(1.5)	(1.2)	(2.2)	(1.0)	(0.4)
SF_6	**NC**	**(0.3)**	**(0.7)**	**(0.2)**	**(0.3)**	**1.4**	**(0.1)**
Electrical Transmission and Distribution	NC	(0.1)	(0.2)	(0.5)	(0.5)	0.2	(0.1)
Semiconductor Manufacture	NC	(0.2)	(0.4)	(0.3)	(0.6)	(0.2)	(0.1)

Magnesium Production and Processing	NC		+		+	0.7	0.9	1.5	0.1
Net Change in Total Emissions[b]	**50.0**		**58.5**		**69.3**	**76.2**	**64.4**	**50.7**	
Percent Change	**0.8%**		**0.8%**		**1.0%**	**1.2%**	**0.9%**	**0.8%**	

+ Absolute value does not exceed +.05 Tg CO_2 Eq. or +.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**		**2008**	**2009**	**2010**	**2011**	**Average Annual Change**
Forest Land Remaining Forest Land	(7.8)		(22.2)		(37.7)	(38.1)	(38.1)	(33.6)	(9.3)
Cropland Remaining Cropland	(17.8)		(8.8)		(24.7)	(24.7)	(24.7)	(24.7)	(11.5)
Land Converted to Cropland	5.8		7.3		2.3	2.3	2.3	2.3	5.3
Grassland Remaining Grassland	(4.3)		6.6		(0.4)	(0.5)	(0.6)	(0.7)	1.9
Land Converted to Grassland	0.3		2.0		0.3	0.2	0.2	0.2	1.2
Settlements Remaining Settlements	(12.9)		(17.4)		(17.9)	(18.1)	(18.2)	(18.4)	(16.0)
Other	NC		(0.4)		(0.3)	(0.3)	(0.2)	(0.4)	(0.1)
Net Change in Total Flux	**(36.6)**		**(32.9)**		**(78.4)**	**(79.0)**	**(79.2)**	**(75.3)**	
Percent Change	**-4.6%**		**-3.3%**		**-8.7%**	**-8.9%**	**-8.9%**	**-8.3%**	

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