

Table of Contents

TABLE OF CONTENTS	VI
LIST OF TABLES, FIGURES, AND BOXES	IX
EXECUTIVE SUMMARY	ES-1
ES.1 Background Information	ES-2
ES.2 Recent Trends in U.S. Greenhouse Gas Emissions and Sinks	ES-4
ES.3 Overview of Sector Emissions and Trends	ES-18
ES.4 Other Information	ES-23
1. INTRODUCTION.....	1-1
1.1 Background Information	1-3
1.2 National Inventory Arrangements	1-10
1.3 Inventory Process	1-13
1.4 Methodology and Data Sources.....	1-15
1.5 Key Categories	1-16
1.6 Quality Assurance and Quality Control (QA/QC).....	1-21
1.7 Uncertainty Analysis of Emission Estimates.....	1-22
1.8 Completeness	1-24
1.9 Organization of Report.....	1-25
2. TRENDS IN GREENHOUSE GAS EMISSIONS	2-1
2.1 Recent Trends in U.S. Greenhouse Gas Emissions and Sinks.....	2-1
2.2 Emissions by Economic Sector	2-23
2.3 Precursor Greenhouse Gas Emissions (CO, NO _x , NMVOCs, and SO ₂).....	2-34
3. ENERGY	3-1
3.1 Fossil Fuel Combustion (CRF Source Category 1A)	3-5
3.2 Carbon Emitted from Non-Energy Uses of Fossil Fuels (CRF Source Category 1A5).....	3-44
3.3 Incineration of Waste (CRF Source Category 1A5).....	3-51
3.4 Coal Mining (CRF Source Category 1B1a)	3-55
3.5 Abandoned Underground Coal Mines (CRF Source Category 1B1a).....	3-60
3.6 Petroleum Systems (CRF Source Category 1B2a)	3-64

3.7	Natural Gas Systems (CRF Source Category 1B2b)	3-80
3.8	Abandoned Oil and Gas Wells (CRF Source Categories 1B2a and 1B2b)	3-99
3.9	Energy Sources of Precursor Greenhouse Gas Emissions.....	3-103
3.10	International Bunker Fuels (CRF Source Category 1: Memo Items)	3-104
3.11	Wood Biomass and Biofuels Consumption (CRF Source Category 1A)	3-109
4.	INDUSTRIAL PROCESSES AND PRODUCT USE	4-1
4.1	Cement Production (CRF Source Category 2A1)	4-8
4.2	Lime Production (CRF Source Category 2A2)	4-12
4.3	Glass Production (CRF Source Category 2A3).....	4-17
4.4	Other Process Uses of Carbonates (CRF Source Category 2A4)	4-20
4.5	Ammonia Production (CRF Source Category 2B1).....	4-24
4.6	Urea Consumption for Non-Agricultural Purposes	4-28
4.7	Nitric Acid Production (CRF Source Category 2B2).....	4-31
4.8	Adipic Acid Production (CRF Source Category 2B3)	4-35
4.9	Caprolactam, Glyoxal and Glyoxylic Acid Production (CRF Source Category 2B4).....	4-39
4.10	Silicon Carbide Production and Consumption (CRF Source Category 2B5)	4-42
4.11	Titanium Dioxide Production (CRF Source Category 2B6).....	4-45
4.12	Soda Ash Production (CRF Source Category 2B7).....	4-48
4.13	Petrochemical Production (CRF Source Category 2B8)	4-51
4.14	HCFC-22 Production (CRF Source Category 2B9a).....	4-58
4.15	Carbon Dioxide Consumption (CRF Source Category 2B10).....	4-61
4.16	Phosphoric Acid Production (CRF Source Category 2B10)	4-64
4.17	Iron and Steel Production (CRF Source Category 2C1) and Metallurgical Coke Production	4-68
4.18	Ferroalloy Production (CRF Source Category 2C2)	4-77
4.19	Aluminum Production (CRF Source Category 2C3).....	4-81
4.20	Magnesium Production and Processing (CRF Source Category 2C4)	4-86
4.21	Lead Production (CRF Source Category 2C5).....	4-91
4.22	Zinc Production (CRF Source Category 2C6).....	4-94
4.23	Semiconductor Manufacture (CRF Source Category 2E1)	4-99
4.24	Substitution of Ozone Depleting Substances (CRF Source Category 2F).....	4-112
4.25	Electrical Transmission and Distribution (CRF Source Category 2G1).....	4-121
4.26	Nitrous Oxide from Product Uses (CRF Source Category 2G3).....	4-128
4.27	Industrial Processes and Product Use Sources of Precursor Gases	4-131
5.	AGRICULTURE	5-1
5.1	Enteric Fermentation (CRF Source Category 3A).....	5-3
5.2	Manure Management (CRF Source Category 3B)	5-9
5.3	Rice Cultivation (CRF Source Category 3C)	5-17

5.4	Agricultural Soil Management (CRF Source Category 3D).....	5-23
5.5	Liming (CRF Source Category 3G)	5-42
5.6	Urea Fertilization (CRF Source Category 3H).....	5-45
5.7	Field Burning of Agricultural Residues (CRF Source Category 3F).....	5-47
6.	LAND USE, LAND-USE CHANGE, AND FORESTRY	6-1
6.1	Representation of the U.S. Land Base.....	6-8
6.2	Forest Land Remaining Forest Land (CRF Category 4A1).....	6-22
6.3	Land Converted to Forest Land (CRF Category 4A2)	6-43
6.4	Cropland Remaining Cropland (CRF Category 4B1)	6-50
6.5	Land Converted to Cropland (CRF Category 4B2).....	6-59
6.6	Grassland Remaining Grassland (CRF Category 4C1)	6-65
6.7	Land Converted to Grassland (CRF Category 4C2).....	6-74
6.8	Wetlands Remaining Wetlands (CRF Category 4D1).....	6-80
6.9	Land Converted to Wetlands (CRF Category 4D2)	6-98
6.10	Settlements Remaining Settlements (CRF Category 4E1)	6-101
6.11	Land Converted to Settlements (CRF Category 4E2)	6-120
6.12	Other Land Remaining Other Land (CRF Category 4F1).....	6-125
6.13	Land Converted to Other Land (CRF Category 4F2).....	6-126
7.	WASTE.....	7-1
7.1	Landfills (CRF Source Category 5A1).....	7-3
7.2	Wastewater Treatment (CRF Source Category 5D)	7-19
7.3	Composting (CRF Source Category 5B1).....	7-35
7.4	Waste Incineration (CRF Source Category 5C1)	7-38
7.5	Waste Sources of Precursor Greenhouse Gases	7-38
8.	OTHER	8-1
9.	RECALCULATIONS AND IMPROVEMENTS	9-1
10.	REFERENCES	10-1

List of Tables, Figures, and Boxes

Tables

Table ES-1: Global Warming Potentials (100-Year Time Horizon) Used in this Report.....	ES-3
Table ES-2: Recent Trends in U.S. Greenhouse Gas Emissions and Sinks (MMT CO ₂ Eq.)	ES-6
Table ES-3: CO ₂ Emissions from Fossil Fuel Combustion by End-Use Sector (MMT CO ₂ Eq.).....	ES-12
Table ES-4: Recent Trends in U.S. Greenhouse Gas Emissions and Sinks by Chapter/IPCC Sector (MMT CO ₂ Eq.)	ES-18
Table ES-5: U.S. Greenhouse Gas Emissions and Removals (Net Flux) from Land Use, Land-Use Change, and Forestry (MMT CO ₂ Eq.)	ES-22
Table ES-6: U.S. Greenhouse Gas Emissions Allocated to Economic Sectors (MMT CO ₂ Eq.).....	ES-24
Table ES-7: U.S. Greenhouse Gas Emissions by Economic Sector with Electricity-Related Emissions Distributed (MMT CO ₂ Eq.).....	ES-25
Table ES-8: Recent Trends in Various U.S. Data (Index 1990 = 100).....	ES-26
Table 1-1: Global Atmospheric Concentration, Rate of Concentration Change, and Atmospheric Lifetime of Selected Greenhouse Gases	1-4
Table 1-2: Global Warming Potentials and Atmospheric Lifetimes (Years) Used in this Report	1-9
Table 1-3: Comparison of 100-Year GWP values	1-10
Table 1-4: Key Categories for the United States (1990 and 2017)	1-16
Table 1-5: Estimated Overall Inventory Quantitative Uncertainty (MMT CO ₂ Eq. and Percent)	1-23
Table 1-6: IPCC Sector Descriptions.....	1-25
Table 1-7: List of Annexes	1-25
Table 2-1: Recent Trends in U.S. Greenhouse Gas Emissions and Sinks (MMT CO ₂ Eq.)	2-3
Table 2-2: Recent Trends in U.S. Greenhouse Gas Emissions and Sinks (kt).....	2-5
Table 2-3: Recent Trends in U.S. Greenhouse Gas Emissions and Sinks by Chapter/IPCC Sector (MMT CO ₂ Eq.)	2-8
Table 2-4: Emissions from Energy (MMT CO ₂ Eq.).....	2-10
Table 2-5: CO ₂ Emissions from Fossil Fuel Combustion by End-Use Sector (MMT CO ₂ Eq.).....	2-12
Table 2-6: Emissions from Industrial Processes and Product Use (MMT CO ₂ Eq.)	2-16
Table 2-7: Emissions from Agriculture (MMT CO ₂ Eq.)	2-18
Table 2-8: U.S. Greenhouse Gas Emissions and Removals (Net Flux) from Land Use, Land-Use Change, and Forestry (MMT CO ₂ Eq.)	2-20
Table 2-9: Emissions from Waste (MMT CO ₂ Eq.)	2-23
Table 2-10: U.S. Greenhouse Gas Emissions Allocated to Economic Sectors (MMT CO ₂ Eq. and Percent of Total in 2017).....	2-24
Table 2-11: Electric Power-Related Greenhouse Gas Emissions (MMT CO ₂ Eq.).....	2-26
Table 2-12: U.S. Greenhouse Gas Emissions by Economic Sector and Gas with Electricity-Related Emissions Distributed (MMT CO ₂ Eq.) and Percent of Total in 2017.....	2-28
Table 2-13: Transportation-Related Greenhouse Gas Emissions (MMT CO ₂ Eq.)	2-30

Table 2-14: Recent Trends in Various U.S. Data (Index 1990 = 100).....	2-33
Table 2-15: Emissions of NO _x , CO, NMVOCs, and SO ₂ (kt)	2-35
Table 3-1: CO ₂ , CH ₄ , and N ₂ O Emissions from Energy (MMT CO ₂ Eq.)	3-2
Table 3-2: CO ₂ , CH ₄ , and N ₂ O Emissions from Energy (kt)	3-3
Table 3-3: CO ₂ , CH ₄ , and N ₂ O Emissions from Fossil Fuel Combustion (MMT CO ₂ Eq.).....	3-5
Table 3-4: CO ₂ , CH ₄ , and N ₂ O Emissions from Fossil Fuel Combustion (kt).....	3-6
Table 3-5: CO ₂ Emissions from Fossil Fuel Combustion by Fuel Type and Sector (MMT CO ₂ Eq.)	3-6
Table 3-6: Annual Change in CO ₂ Emissions and Total 2017 CO ₂ Emissions from Fossil Fuel Combustion for Selected Fuels and Sectors (MMT CO ₂ Eq. and Percent).....	3-7
Table 3-7: CO ₂ , CH ₄ , and N ₂ O Emissions from Fossil Fuel Combustion by Sector (MMT CO ₂ Eq.).....	3-11
Table 3-8: CO ₂ , CH ₄ , and N ₂ O Emissions from Fossil Fuel Combustion by End-Use Sector (MMT CO ₂ Eq.)....	3-12
Table 3-9: CO ₂ Emissions from Stationary Fossil Fuel Combustion (MMT CO ₂ Eq.)	3-13
Table 3-10: CH ₄ Emissions from Stationary Combustion (MMT CO ₂ Eq.).....	3-13
Table 3-11: N ₂ O Emissions from Stationary Combustion (MMT CO ₂ Eq.).....	3-14
Table 3-12: Electric Power Generation by Fuel Type (Percent).....	3-15
Table 3-13: CO ₂ Emissions from Fossil Fuel Combustion in Transportation End-Use Sector (MMT CO ₂ Eq.) ...	3-23
Table 3-14: CH ₄ Emissions from Mobile Combustion (MMT CO ₂ Eq.).....	3-26
Table 3-15: N ₂ O Emissions from Mobile Combustion (MMT CO ₂ Eq.)	3-27
Table 3-16: Carbon Intensity from Direct Fossil Fuel Combustion by Sector (MMT CO ₂ Eq./QBtu)	3-32
Table 3-17: Approach 2 Quantitative Uncertainty Estimates for CO ₂ Emissions from Energy-Related Fossil Fuel Combustion by Fuel Type and Sector (MMT CO ₂ Eq. and Percent).....	3-34
Table 3-18: Approach 2 Quantitative Uncertainty Estimates for CH ₄ and N ₂ O Emissions from Energy-Related Stationary Combustion, Including Biomass (MMT CO ₂ Eq. and Percent)	3-39
Table 3-19: Approach 2 Quantitative Uncertainty Estimates for CH ₄ and N ₂ O Emissions from Mobile Sources (MMT CO ₂ Eq. and Percent)	3-42
Table 3-20: CO ₂ Emissions from Non-Energy Use Fossil Fuel Consumption (MMT CO ₂ Eq. and Percent)	3-45
Table 3-21: Adjusted Consumption of Fossil Fuels for Non-Energy Uses (TBtu).....	3-46
Table 3-22: 2017 Adjusted Non-Energy Use Fossil Fuel Consumption, Storage, and Emissions.....	3-46
Table 3-23: Approach 2 Quantitative Uncertainty Estimates for CO ₂ Emissions from Non-Energy Uses of Fossil Fuels (MMT CO ₂ Eq. and Percent)	3-48
Table 3-24: Approach 2 Quantitative Uncertainty Estimates for Storage Factors of Non-Energy Uses of Fossil Fuels (Percent)	3-48
Table 3-25: CO ₂ , CH ₄ , and N ₂ O Emissions from the Incineration of Waste (MMT CO ₂ Eq.).....	3-52
Table 3-26: CO ₂ , CH ₄ , and N ₂ O Emissions from the Incineration of Waste (kt)	3-52
Table 3-27: Municipal Solid Waste Generation (Metric Tons) and Percent Combusted (BioCycle dataset)	3-53
Table 3-28: Approach 2 Quantitative Uncertainty Estimates for CO ₂ and N ₂ O from the Incineration of Waste (MMT CO ₂ Eq. and Percent).....	3-54
Table 3-29: Coal Production (kt).....	3-55
Table 3-30: CH ₄ Emissions from Coal Mining (MMT CO ₂ Eq.)	3-56

Table 3-31: CH ₄ Emissions from Coal Mining (kt)	3-56
Table 3-32: Approach 2 Quantitative Uncertainty Estimates for CH ₄ Emissions from Coal Mining (MMT CO ₂ Eq. and Percent)	3-59
Table 3-33: CH ₄ Emissions from Abandoned Coal Mines (MMT CO ₂ Eq.).....	3-60
Table 3-34: CH ₄ Emissions from Abandoned Coal Mines (kt)	3-61
Table 3-35: Number of Gassy Abandoned Mines Present in U.S. Basins in 2017, Grouped by Class According to Post-Abandonment State	3-62
Table 3-36: Approach 2 Quantitative Uncertainty Estimates for CH ₄ Emissions from Abandoned Underground Coal Mines (MMT CO ₂ Eq. and Percent)	3-63
Table 3-37: CH ₄ Emissions from Petroleum Systems (MMT CO ₂ Eq.).....	3-65
Table 3-38: CH ₄ Emissions from Petroleum Systems (kt CH ₄).....	3-66
Table 3-39: CO ₂ Emissions from Petroleum Systems (MMT CO ₂)	3-66
Table 3-40: CO ₂ Emissions from Petroleum Systems (kt CO ₂).....	3-66
Table 3-41: N ₂ O Emissions from Petroleum Systems (metric tons CO ₂ Eq.)	3-66
Table 3-42: N ₂ O Emissions from Petroleum Systems (metric tons N ₂ O).....	3-66
Table 3-43: Approach 2 Quantitative Uncertainty Estimates for CH ₄ and CO ₂ Emissions from Petroleum Systems (MMT CO ₂ Eq. and Percent)	3-69
Table 3-44: Recalculations of CO ₂ in Petroleum Systems (MMT CO ₂).....	3-71
Table 3-45: Recalculations of CH ₄ in Petroleum Systems (MMT CO ₂ Eq.)	3-71
Table 3-46: HF Oil Well Completions National CH ₄ Emissions (Metric Tons CH ₄)	3-72
Table 3-47: HF Oil Well Completions National CO ₂ Emissions (kt CO ₂)	3-72
Table 3-48: Count of Oil Wells Drilled	3-72
Table 3-49: HF Oil Well Workovers National CH ₄ Emissions (Metric Tons CH ₄)	3-73
Table 3-50: HF Oil Well Workovers National CO ₂ Emissions (kt CO ₂)	3-73
Table 3-51: Production Storage Tank National CH ₄ Emissions (Metric Tons CH ₄)	3-74
Table 3-52: Production Storage Tank National CO ₂ Emissions (kt CO ₂).....	3-74
Table 3-53: Pneumatic Controller National CH ₄ Emissions (Metric Tons CH ₄)	3-74
Table 3-54: Associated Gas Venting and Flaring National CO ₂ Emissions (kt CO ₂).....	3-75
Table 3-55: Miscellaneous Production Flaring National CO ₂ Emissions (kt CO ₂).....	3-75
Table 3-56: Chemical Injection Pump National CH ₄ Emissions (Metric Tons CH ₄)	3-75
Table 3-57: Heater National CH ₄ Emissions (Metric Tons CH ₄)	3-76
Table 3-58: Producing Oil Well Count Data	3-76
Table 3-59: Oil Production Data (Million Barrels).....	3-77
Table 3-60: Crude Oil Transportation National CO ₂ Emissions (kt CO ₂)	3-77
Table 3-61: N ₂ O National Emissions (Metric Tons N ₂ O)	3-77
Table 3-62: Quantity of CO ₂ Captured and Extracted for EOR Operations (MMT CO ₂)	3-79
Table 3-63: Quantity of CO ₂ Captured and Extracted for EOR Operations (kt)	3-80
Table 3-64: CH ₄ Emissions from Natural Gas Systems (MMT CO ₂ Eq.) ^a	3-82

Table 3-65: CH ₄ Emissions from Natural Gas Systems (kt) ^a	3-82
Table 3-66: Calculated Potential CH ₄ and Captured/Combusted CH ₄ from Natural Gas Systems (MMT CO ₂ Eq.)	3-83
Table 3-67: Non-combustion CO ₂ Emissions from Natural Gas Systems (MMT).....	3-83
Table 3-68: Non-combustion CO ₂ Emissions from Natural Gas Systems (kt).....	3-83
Table 3-69: N ₂ O Emissions from Natural Gas Systems (Metric Tons CO ₂ Eq.).....	3-84
Table 3-70: N ₂ O Emissions from Natural Gas Systems (Metric Tons N ₂ O)	3-84
Table 3-71: Approach 2 Quantitative Uncertainty Estimates for CH ₄ and Non-combustion CO ₂ Emissions from Natural Gas Systems (MMT CO ₂ Eq. and Percent).....	3-86
Table 3-72: Recalculations of CO ₂ in Natural Gas Systems (MMT CO ₂).....	3-88
Table 3-73: Recalculations of CH ₄ in Natural Gas Systems (MMT CO ₂ Eq.)	3-89
Table 3-74: Count of Gas Wells Drilled.....	3-89
Table 3-75: HF Gas Well Completions National CO ₂ Emissions (kt CO ₂)	3-90
Table 3-76: Gathering Pipelines National CH ₄ Emissions (Metric Tons CH ₄)	3-90
Table 3-77: Gathering Stations National CH ₄ Emissions (Metric Tons CH ₄)	3-90
Table 3-78: Miscellaneous Production Flaring National Emissions (kt CO ₂)	3-91
Table 3-79: Production Segment Gas Engines National Emissions (Metric Tons CH ₄)	3-91
Table 3-80: Production Segment Pneumatic Controller National Emissions (Metric Tons CH ₄)	3-91
Table 3-81: Liquids Unloading National Emissions (Metric Tons CH ₄).....	3-92
Table 3-82: Production Segment Storage Tanks National Emissions (kt CO ₂)	3-92
Table 3-83: HF Gas Well Workovers National Emissions (Metric Tons CH ₄)	3-92
Table 3-84: HF Gas Well Workovers National Emissions (kt CO ₂)	3-93
Table 3-85: Producing Gas Well Count Data	3-93
Table 3-86: AGR National CO ₂ Emissions (kt CO ₂)	3-94
Table 3-87: Processing Segment Flares National CO ₂ Emissions (kt CO ₂).....	3-94
Table 3-88: Processing Segment Gas Engines National Emissions (Metric Tons CH ₄).....	3-94
Table 3-89: Transmission Pipeline Blowdowns National CH ₄ Emissions (Metric Tons CH ₄).....	3-95
Table 3-90: Transmission Pipeline Blowdowns National CO ₂ Emissions (kt CO ₂)	3-95
Table 3-91: LNG Storage Station National CH ₄ Emissions (Metric Tons CH ₄)	3-95
Table 3-92: LNG Storage Station National CO ₂ Emissions (kt CO ₂)	3-95
Table 3-93: LNG Import/Export Terminal National CH ₄ Emissions (Metric Tons CH ₄)	3-96
Table 3-94: LNG Import/Export Terminal National CO ₂ Emissions (kt CO ₂)	3-96
Table 3-95: N ₂ O National Emissions (Metric Tons N ₂ O)	3-97
Table 3-96: CH ₄ Emissions from Abandoned Oil and Gas Wells (MMT CO ₂ Eq.)	3-100
Table 3-97: CH ₄ Emissions from Abandoned Oil and Gas Wells (kt).....	3-100
Table 3-98: CO ₂ Emissions from Abandoned Oil and Gas Wells (MMT CO ₂)	3-100
Table 3-99: CO ₂ Emissions from Abandoned Oil and Gas Wells (kt).....	3-100
Table 3-100: Abandoned Oil Wells Activity Data, CH ₄ and CO ₂ Emissions (Metric Tons).....	3-101

Table 3-101: Abandoned Gas Wells Activity Data, CH ₄ and CO ₂ Emissions (Metric Tons).....	3-101
Table 3-102: Approach 2 Quantitative Uncertainty Estimates for CH ₄ and CO ₂ Emissions from Petroleum and Natural Gas Systems (MMT CO ₂ Eq. and Percent).....	3-102
Table 3-103: NO _x , CO, and NMVOC Emissions from Energy-Related Activities (kt).....	3-103
Table 3-104: CO ₂ , CH ₄ , and N ₂ O Emissions from International Bunker Fuels (MMT CO ₂ Eq.)	3-105
Table 3-105: CO ₂ , CH ₄ , and N ₂ O Emissions from International Bunker Fuels (kt)	3-106
Table 3-106: Aviation Jet Fuel Consumption for International Transport (Million Gallons).....	3-107
Table 3-107: Marine Fuel Consumption for International Transport (Million Gallons)	3-107
Table 3-108: CO ₂ Emissions from Wood Consumption by End-Use Sector (MMT CO ₂ Eq.)	3-109
Table 3-109: CO ₂ Emissions from Wood Consumption by End-Use Sector (kt)	3-109
Table 3-110: CO ₂ Emissions from Ethanol Consumption (MMT CO ₂ Eq.).....	3-110
Table 3-111: CO ₂ Emissions from Ethanol Consumption (kt)	3-110
Table 3-112: CO ₂ Emissions from Biodiesel Consumption (MMT CO ₂ Eq.)	3-110
Table 3-113: CO ₂ Emissions from Biodiesel Consumption (kt).....	3-111
Table 3-114: Woody Biomass Consumption by Sector (Trillion Btu)	3-111
Table 3-115: Ethanol Consumption by Sector (Trillion Btu)	3-111
Table 3-116: Biodiesel Consumption by Sector (Trillion Btu).....	3-112
Table 4-1: Emissions from Industrial Processes and Product Use (MMT CO ₂ Eq.)	4-3
Table 4-2: Emissions from Industrial Processes and Product Use (kt)	4-4
Table 4-3: CO ₂ Emissions from Cement Production (MMT CO ₂ Eq. and kt).....	4-9
Table 4-4: Clinker Production (kt).....	4-10
Table 4-5: Approach 2 Quantitative Uncertainty Estimates for CO ₂ Emissions from Cement Production (MMT CO ₂ Eq. and Percent).....	4-11
Table 4-6: CO ₂ Emissions from Lime Production (MMT CO ₂ Eq. and kt).....	4-13
Table 4-7: Potential, Recovered, and Net CO ₂ Emissions from Lime Production (kt).....	4-13
Table 4-8: High-Calcium- and Dolomitic-Quicklime, High-Calcium- and Dolomitic-Hydrated, and Dead-Burned-Dolomite Lime Production (kt)	4-14
Table 4-9: Adjusted Lime Production (kt).....	4-14
Table 4-10: Approach 2 Quantitative Uncertainty Estimates for CO ₂ Emissions from Lime Production (MMT CO ₂ Eq. and Percent).....	4-16
Table 4-11: CO ₂ Emissions from Glass Production (MMT CO ₂ Eq. and kt)	4-18
Table 4-12: Limestone, Dolomite, and Soda Ash Consumption Used in Glass Production (kt)	4-18
Table 4-13: Approach 2 Quantitative Uncertainty Estimates for CO ₂ Emissions from Glass Production (MMT CO ₂ Eq. and Percent).....	4-19
Table 4-14: CO ₂ Emissions from Other Process Uses of Carbonates (MMT CO ₂ Eq.)	4-21
Table 4-15: CO ₂ Emissions from Other Process Uses of Carbonates (kt)	4-21
Table 4-16: Limestone and Dolomite Consumption (kt)	4-22
Table 4-17: Soda Ash Consumption Not Associated with Glass Manufacturing (kt)	4-23

Table 4-18: Approach 2 Quantitative Uncertainty Estimates for CO ₂ Emissions from Other Process Uses of Carbonates (MMT CO ₂ Eq. and Percent)	4-23
Table 4-19: CO ₂ Emissions from Ammonia Production (MMT CO ₂ Eq.)	4-25
Table 4-20: CO ₂ Emissions from Ammonia Production (kt)	4-25
Table 4-21: Ammonia Production, Recovered CO ₂ Consumed for Urea Production, and Urea Production (kt) ...	4-26
Table 4-22: Approach 2 Quantitative Uncertainty Estimates for CO ₂ Emissions from Ammonia Production (MMT CO ₂ Eq. and Percent).....	4-27
Table 4-23: CO ₂ Emissions from Urea Consumption for Non-Agricultural Purposes (MMT CO ₂ Eq.).....	4-29
Table 4-24: CO ₂ Emissions from Urea Consumption for Non-Agricultural Purposes (kt)	4-29
Table 4-25: Urea Production, Urea Applied as Fertilizer, Urea Imports, and Urea Exports (kt)	4-30
Table 4-26: Approach 2 Quantitative Uncertainty Estimates for CO ₂ Emissions from Urea Consumption for Non-Agricultural Purposes (MMT CO ₂ Eq. and Percent)	4-31
Table 4-27: N ₂ O Emissions from Nitric Acid Production (MMT CO ₂ Eq. and kt N ₂ O)	4-32
Table 4-28: Nitric Acid Production (kt)	4-34
Table 4-29: Approach 2 Quantitative Uncertainty Estimates for N ₂ O Emissions from Nitric Acid Production (MMT CO ₂ Eq. and Percent).....	4-35
Table 4-30: N ₂ O Emissions from Adipic Acid Production (MMT CO ₂ Eq. and kt N ₂ O).....	4-36
Table 4-31: Adipic Acid Production (kt)	4-38
Table 4-32: Approach 2 Quantitative Uncertainty Estimates for N ₂ O Emissions from Adipic Acid Production (MMT CO ₂ Eq. and Percent).....	4-38
Table 4-33: N ₂ O Emissions from Caprolactam Production (MMT CO ₂ Eq. and kt N ₂ O).....	4-40
Table 4-34: Caprolactam Production (kt)	4-41
Table 4-35: Approach 2 Quantitative Uncertainty Estimates for N ₂ O Emissions from Caprolactam, Glyoxal and Glyoxylic Acid Production (MMT CO ₂ Eq. and Percent)	4-41
Table 4-36: CO ₂ and CH ₄ Emissions from Silicon Carbide Production and Consumption (MMT CO ₂ Eq.).....	4-43
Table 4-37: CO ₂ and CH ₄ Emissions from Silicon Carbide Production and Consumption (kt)	4-43
Table 4-38: Production and Consumption of Silicon Carbide (Metric Tons).....	4-44
Table 4-39: Approach 2 Quantitative Uncertainty Estimates for CH ₄ and CO ₂ Emissions from Silicon Carbide Production and Consumption (MMT CO ₂ Eq. and Percent).....	4-45
Table 4-40: CO ₂ Emissions from Titanium Dioxide (MMT CO ₂ Eq. and kt)	4-46
Table 4-41: Titanium Dioxide Production (kt)	4-47
Table 4-42: Approach 2 Quantitative Uncertainty Estimates for CO ₂ Emissions from Titanium Dioxide Production (MMT CO ₂ Eq. and Percent)	4-47
Table 4-43: CO ₂ Emissions from Soda Ash Production (MMT CO ₂ Eq. and kt CO ₂)	4-49
Table 4-44: Soda Ash Production (kt).....	4-50
Table 4-45: Approach 2 Quantitative Uncertainty Estimates for CO ₂ Emissions from Soda Ash Production (MMT CO ₂ Eq. and Percent).....	4-50
Table 4-46: CO ₂ and CH ₄ Emissions from Petrochemical Production (MMT CO ₂ Eq.).....	4-52
Table 4-47: CO ₂ and CH ₄ Emissions from Petrochemical Production (kt)	4-53
Table 4-48: Production of Selected Petrochemicals (kt)	4-55

Table 4-49: Approach 2 Quantitative Uncertainty Estimates for CH ₄ Emissions from Petrochemical Production and CO ₂ Emissions from Petrochemical Production (MMT CO ₂ Eq. and Percent)	4-56
Table 4-50: HFC-23 Emissions from HCFC-22 Production (MMT CO ₂ Eq. and kt HFC-23)	4-59
Table 4-51: HCFC-22 Production (kt)	4-59
Table 4-52: Approach 2 Quantitative Uncertainty Estimates for HFC-23 Emissions from HCFC-22 Production (MMT CO ₂ Eq. and Percent)	4-60
Table 4-53: CO ₂ Emissions from CO ₂ Consumption (MMT CO ₂ Eq. and kt)	4-61
Table 4-54: CO ₂ Production (kt CO ₂) and the Percent Used for Non-EOR Applications	4-63
Table 4-55: Approach 2 Quantitative Uncertainty Estimates for CO ₂ Emissions from CO ₂ Consumption (MMT CO ₂ Eq. and Percent)	4-64
Table 4-56: CO ₂ Emissions from Phosphoric Acid Production (MMT CO ₂ Eq. and kt)	4-65
Table 4-57: Phosphate Rock Domestic Consumption, Exports, and Imports (kt)	4-66
Table 4-58: Chemical Composition of Phosphate Rock (Percent by Weight)	4-66
Table 4-59: Approach 2 Quantitative Uncertainty Estimates for CO ₂ Emissions from Phosphoric Acid Production (MMT CO ₂ Eq. and Percent)	4-67
Table 4-60: CO ₂ Emissions from Metallurgical Coke Production (MMT CO ₂ Eq.)	4-69
Table 4-61: CO ₂ Emissions from Metallurgical Coke Production (kt)	4-69
Table 4-62: CO ₂ Emissions from Iron and Steel Production (MMT CO ₂ Eq.)	4-69
Table 4-63: CO ₂ Emissions from Iron and Steel Production (kt)	4-70
Table 4-64: CH ₄ Emissions from Iron and Steel Production (MMT CO ₂ Eq.)	4-70
Table 4-65: CH ₄ Emissions from Iron and Steel Production (kt)	4-70
Table 4-66: Material Carbon Contents for Metallurgical Coke Production	4-71
Table 4-67: Production and Consumption Data for the Calculation of CO ₂ Emissions from Metallurgical Coke Production (Thousand Metric Tons)	4-72
Table 4-68: Production and Consumption Data for the Calculation of CO ₂ Emissions from Metallurgical Coke Production (Million ft ³)	4-72
Table 4-69: Material Carbon Contents for Iron and Steel Production	4-73
Table 4-70: CH ₄ Emission Factors for Sinter and Pig Iron Production	4-73
Table 4-71: CO ₂ Emission Factors for Sinter Production, Direct Reduced Iron Production and Pellet Production	4-74
Table 4-72: Production and Consumption Data for the Calculation of CO ₂ and CH ₄ Emissions from Iron and Steel Production (Thousand Metric Tons)	4-74
Table 4-73: Production and Consumption Data for the Calculation of CO ₂ Emissions from Iron and Steel Production (Million ft ³ unless otherwise specified)	4-75
Table 4-74: Approach 2 Quantitative Uncertainty Estimates for CO ₂ and CH ₄ Emissions from Iron and Steel Production and Metallurgical Coke Production (MMT CO ₂ Eq. and Percent)	4-76
Table 4-75: CO ₂ and CH ₄ Emissions from Ferroalloy Production (MMT CO ₂ Eq.)	4-78
Table 4-76: CO ₂ and CH ₄ Emissions from Ferroalloy Production (kt)	4-78
Table 4-77: Production of Ferroalloys (Metric Tons)	4-79
Table 4-78: Approach 2 Quantitative Uncertainty Estimates for CO ₂ Emissions from Ferroalloy Production (MMT CO ₂ Eq. and Percent)	4-80

Table 4-79: CO ₂ Emissions from Aluminum Production (MMT CO ₂ Eq. and kt)	4-81
Table 4-80: PFC Emissions from Aluminum Production (MMT CO ₂ Eq.).....	4-82
Table 4-81: PFC Emissions from Aluminum Production (kt)	4-82
Table 4-82: Production of Primary Aluminum (kt)	4-85
Table 4-83: Approach 2 Quantitative Uncertainty Estimates for CO ₂ and PFC Emissions from Aluminum Production (MMT CO ₂ Eq. and Percent).....	4-86
Table 4-84: SF ₆ , HFC-134a, FK 5-1-12 and CO ₂ Emissions from Magnesium Production and Processing (MMT CO ₂ Eq.)	4-86
Table 4-85: SF ₆ , HFC-134a, FK 5-1-12 and CO ₂ Emissions from Magnesium Production and Processing (kt) ...	4-87
Table 4-86: SF ₆ Emission Factors (kg SF ₆ per metric ton of magnesium)	4-89
Table 4-87: Approach 2 Quantitative Uncertainty Estimates for SF ₆ , HFC-134a and CO ₂ Emissions from Magnesium Production and Processing (MMT CO ₂ Eq. and Percent).....	4-90
Table 4-88: CO ₂ Emissions from Lead Production (MMT CO ₂ Eq. and kt)	4-92
Table 4-89: Lead Production (Metric Tons)	4-93
Table 4-90: Approach 2 Quantitative Uncertainty Estimates for CO ₂ Emissions from Lead Production (MMT CO ₂ Eq. and Percent).....	4-93
Table 4-91: CO ₂ Emissions from Zinc Production (MMT CO ₂ Eq. and kt)	4-95
Table 4-92: Zinc Production (Metric Tons).....	4-95
Table 4-93: Approach 2 Quantitative Uncertainty Estimates for CO ₂ Emissions from Zinc Production (MMT CO ₂ Eq. and Percent).....	4-98
Table 4-94: PFC, HFC, SF ₆ , NF ₃ , and N ₂ O Emissions from Semiconductor Manufacture (MMT CO ₂ Eq.)	4-100
Table 4-95: PFC, HFC, SF ₆ , NF ₃ , and N ₂ O Emissions from Semiconductor Manufacture (kt)	4-101
Table 4-96: F-HTF Emissions Based on GHGRP Reporting (MMT CO ₂ Eq.).....	4-101
Table 4-97: Top 10 F-HTF Compounds with Largest Emissions Based on GHGRP Reporting (tons).....	4-101
Table 4-98: Approach 2 Quantitative Uncertainty Estimates for HFC, PFC, SF ₆ , NF ₃ and N ₂ O Emissions from Semiconductor Manufacture (MMT CO ₂ Eq. and Percent) ^a	4-110
Table 4-99: Emissions of HFCs and PFCs from ODS Substitutes (MMT CO ₂ Eq.)	4-112
Table 4-100: Emissions of HFCs and PFCs from ODS Substitution (Metric Tons)	4-112
Table 4-101: Emissions of HFCs and PFCs from ODS Substitutes (MMT CO ₂ Eq.) by Sector	4-113
Table 4-102: Approach 2 Quantitative Uncertainty Estimates for HFC and PFC Emissions from ODS Substitutes (MMT CO ₂ Eq. and Percent)	4-115
Table 4-103: U.S. HFC Supply (MMT CO ₂ Eq.)	4-117
Table 4-104: Averaged U.S. HFC Demand (MMT CO ₂ Eq.).....	4-119
Table 4-105: SF ₆ Emissions from Electric Power Systems and Electrical Equipment Manufacturers (MMT CO ₂ Eq.)	4-121
Table 4-106: SF ₆ Emissions from Electric Power Systems and Electrical Equipment Manufacturers (kt)	4-121
Table 4-107: Transmission Mile Coverage (Percent) and Regression Coefficients (kg per mile).....	4-125
Table 4-108: Approach 2 Quantitative Uncertainty Estimates for SF ₆ Emissions from Electrical Transmission and Distribution (MMT CO ₂ Eq. and Percent).....	4-126
Table 4-109: N ₂ O Production (kt)	4-128

Table 4-110: N ₂ O Emissions from N ₂ O Product Usage (MMT CO ₂ Eq. and kt)	4-129
Table 4-111: Approach 2 Quantitative Uncertainty Estimates for N ₂ O Emissions from N ₂ O Product Usage (MMT CO ₂ Eq. and Percent).....	4-130
Table 4-112: NO _x , CO, and NMVOC Emissions from Industrial Processes and Product Use (kt)	4-132
Table 5-1: Emissions from Agriculture (MMT CO ₂ Eq.)	5-2
Table 5-2: Emissions from Agriculture (kt).....	5-2
Table 5-3: CH ₄ Emissions from Enteric Fermentation (MMT CO ₂ Eq.).....	5-3
Table 5-4: CH ₄ Emissions from Enteric Fermentation (kt)	5-3
Table 5-5: Approach 2 Quantitative Uncertainty Estimates for CH ₄ Emissions from Enteric Fermentation (MMT CO ₂ Eq. and Percent).....	5-7
Table 5-6: CH ₄ and N ₂ O Emissions from Manure Management (MMT CO ₂ Eq.).....	5-10
Table 5-7: CH ₄ and N ₂ O Emissions from Manure Management (kt)	5-11
Table 5-8: Approach 2 Quantitative Uncertainty Estimates for CH ₄ and N ₂ O (Direct and Indirect) Emissions from Manure Management (MMT CO ₂ Eq. and Percent)	5-15
Table 5-9: IPCC (2006) Implied Emission Factor Default Values Compared with Calculated Values for CH ₄ from Manure Management (kg/head/year).....	5-15
Table 5-10: CH ₄ Emissions from Rice Cultivation (MMT CO ₂ Eq.)	5-18
Table 5-11: CH ₄ Emissions from Rice Cultivation (kt).....	5-18
Table 5-12: Rice Area Harvested (1,000 Hectares)	5-20
Table 5-13: Average Ratooned Area as Percent of Primary Growth Area (Percent).....	5-21
Table 5-14: Approach 2 Quantitative Uncertainty Estimates for CH ₄ Emissions from Rice Cultivation (MMT CO ₂ Eq. and Percent).....	5-22
Table 5-15: N ₂ O Emissions from Agricultural Soils (MMT CO ₂ Eq.).....	5-25
Table 5-16: N ₂ O Emissions from Agricultural Soils (kt).....	5-25
Table 5-17: Direct N ₂ O Emissions from Agricultural Soils by Land Use Type and N Input Type (MMT CO ₂ Eq.)	5-25
Table 5-18: Indirect N ₂ O Emissions from Agricultural Soils (MMT CO ₂ Eq.).....	5-26
Table 5-19: Quantitative Uncertainty Estimates of N ₂ O Emissions from Agricultural Soil Management in 2017 (MMT CO ₂ Eq. and Percent)	5-40
Table 5-20: Emissions from Liming (MMT CO ₂ Eq.).....	5-42
Table 5-21: Emissions from Liming (MMT C)	5-42
Table 5-22: Applied Minerals (MMT).....	5-44
Table 5-23: Approach 2 Quantitative Uncertainty Estimates for CO ₂ Emissions from Liming (MMT CO ₂ Eq. and Percent).....	5-44
Table 5-24: CO ₂ Emissions from Urea Fertilization (MMT CO ₂ Eq.)	5-45
Table 5-25: CO ₂ Emissions from Urea Fertilization (MMT C).....	5-45
Table 5-26: Applied Urea (MMT).....	5-45
Table 5-27: Quantitative Uncertainty Estimates for CO ₂ Emissions from Urea Fertilization (MMT CO ₂ Eq. and Percent).....	5-46
Table 5-28: CH ₄ and N ₂ O Emissions from Field Burning of Agricultural Residues (MMT CO ₂ Eq.).....	5-47

Table 5-29: CH ₄ , N ₂ O, CO, and NO _x Emissions from Field Burning of Agricultural Residues (kt).....	5-48
Table 5-30: Agricultural Crop Production (kt of Product)	5-51
Table 5-31: U.S. Average Percent Crop Area Burned by Crop (Percent)	5-52
Table 5-32: Parameters for Estimating Emissions from Field Burning of Agricultural Residues	5-52
Table 5-33: Greenhouse Gas Emission Ratios and Conversion Factors	5-53
Table 5-34: Approach 2 Quantitative Uncertainty Estimates for CH ₄ and N ₂ O Emissions from Field Burning of Agricultural Residues (MMT CO ₂ Eq. and Percent)	5-54
Table 6-1: Net CO ₂ Flux from Land Use, Land-Use Change, and Forestry (MMT CO ₂ Eq.).....	6-2
Table 6-2: Emissions from Land Use, Land-Use Change, and Forestry by Gas (MMT CO ₂ Eq.).....	6-3
Table 6-3: Emissions and Removals (Net Flux) from Land Use, Land-Use Change, and Forestry (MMT CO ₂ Eq.)	6-4
Table 6-4: Emissions and Removals from Land Use, Land-Use Change, and Forestry (MMT CO ₂ Eq.).....	6-5
Table 6-5: Emissions and Removals from Land Use, Land-Use Change, and Forestry (kt)	6-6
Table 6-6: Managed and Unmanaged Land Area by Land-Use Categories for All 50 States (Thousands of Hectares)	6-9
Table 6-7: Land Use and Land-Use Change for the U.S. Managed Land Base for All 50 States (Thousands of Hectares).....	6-10
Table 6-8: Data Sources Used to Determine Land Use and Land Area for the Conterminous United States, Hawaii, and Alaska	6-16
Table 6-9: Total Land Area (Hectares) by Land-Use Category for U.S. Territories	6-22
Table 6-10: Net CO ₂ Flux from Forest Ecosystem Pools in <i>Forest Land Remaining Forest Land</i> and Harvested Wood Pools (MMT CO ₂ Eq.)	6-26
Table 6-11: Net C Flux from Forest Ecosystem Pools in <i>Forest Land Remaining Forest Land</i> and Harvested Wood Pools (MMT C)	6-26
Table 6-12: Forest Area (1,000 ha) and C Stocks in <i>Forest Land Remaining Forest Land</i> and Harvested Wood Pools (MMT C)	6-27
Table 6-13: Estimates of CO ₂ (MMT per Year) Emissions from Forest Fires in the Conterminous 48 States and Alaska ^a	6-29
Table 6-14: Quantitative Uncertainty Estimates for Net CO ₂ Flux from <i>Forest Land Remaining Forest Land</i> : Changes in Forest C Stocks (MMT CO ₂ Eq. and Percent)	6-33
Table 6-15: Recalculations of Forest Area (1,000 ha) and C Stocks in <i>Forest Land Remaining Forest Land</i> and Harvested Wood Pools (MMT C).....	6-35
Table 6-16: Recalculations of Net C Flux from Forest Ecosystem Pools in <i>Forest Land Remaining Forest Land</i> and Harvested Wood Pools (MMT C).....	6-35
Table 6-17: Non-CO ₂ Emissions from Forest Fires (MMT CO ₂ Eq.) ^a	6-37
Table 6-18: Non-CO ₂ Emissions from Forest Fires (kt) ^a	6-37
Table 6-19: Quantitative Uncertainty Estimates of Non-CO ₂ Emissions from Forest Fires (MMT CO ₂ Eq. and Percent) ^a	6-37
Table 6-20: N ₂ O Fluxes from Soils in <i>Forest Land Remaining Forest Land</i> and <i>Land Converted to Forest Land</i> (MMT CO ₂ Eq. and kt N ₂ O).....	6-39
Table 6-21: Quantitative Uncertainty Estimates of N ₂ O Fluxes from Soils in <i>Forest Land Remaining Forest Land</i> and <i>Land Converted to Forest Land</i> (MMT CO ₂ Eq. and Percent)	6-40

Table 6-22: Non-CO ₂ Emissions from Drained Organic Forest Soils ^{a,b} (MMT CO ₂ Eq.).....	6-41
Table 6-23: Non-CO ₂ Emissions from Drained Organic Forest Soils ^{a,b} (kt).....	6-41
Table 6-24: States identified as having Drained Organic Soils, Area of Forest on Drained Organic Soils, and Sampling Error	6-42
Table 6-25: Quantitative Uncertainty Estimates for Non-CO ₂ Emissions on Drained Organic Forest Soils (MMT CO ₂ Eq. and Percent) ^a	6-43
Table 6-26: Net CO ₂ Flux from Forest C Pools in <i>Land Converted to Forest Land</i> by Land Use Change Category (MMT CO ₂ Eq.).....	6-44
Table 6-27: Net C Flux from Forest C Pools in <i>Land Converted to Forest Land</i> by Land Use Change Category (MMT C)	6-45
Table 6-28: Quantitative Uncertainty Estimates for Forest C Pool Stock Changes (MMT CO ₂ Eq. per Year) in 2017 from <i>Land Converted to Forest Land</i> by Land Use Change.....	6-47
Table 6-29: Recalculations of the Net C Flux from Forest C Pools in Land Converted to Forest Land by Land Use Change Category (MMT C).....	6-49
Table 6-30: Net CO ₂ Flux from Soil C Stock Changes in <i>Cropland Remaining Cropland</i> (MMT CO ₂ Eq.)	6-51
Table 6-31: Net CO ₂ Flux from Soil C Stock Changes in <i>Cropland Remaining Cropland</i> (MMT C).....	6-51
Table 6-32: Approach 2 Quantitative Uncertainty Estimates for Soil C Stock Changes occurring within <i>Cropland Remaining Cropland</i> (MMT CO ₂ Eq. and Percent).....	6-58
Table 6-33: Net CO ₂ Flux from Soil, Dead Organic Matter and Biomass C Stock Changes in <i>Land Converted to Cropland</i> by Land Use Change Category (MMT CO ₂ Eq.)	6-60
Table 6-34: Net CO ₂ Flux from Soil, Dead Organic Matter and Biomass C Stock Changes in <i>Land Converted to Cropland</i> (MMT C).....	6-61
Table 6-35: Approach 2 Quantitative Uncertainty Estimates for Soil, Dead Organic Matter and Biomass C Stock Changes occurring within <i>Land Converted to Cropland</i> (MMT CO ₂ Eq. and Percent)	6-63
Table 6-36: Net CO ₂ Flux from Soil C Stock Changes in <i>Grassland Remaining Grassland</i> (MMT CO ₂ Eq.).....	6-66
Table 6-37: Net CO ₂ Flux from Soil C Stock Changes in <i>Grassland Remaining Grassland</i> (MMT C)	6-66
Table 6-38: Approach 2 Quantitative Uncertainty Estimates for C Stock Changes Occurring Within <i>Grassland Remaining Grassland</i> (MMT CO ₂ Eq. and Percent)	6-70
Table 6-39: CH ₄ and N ₂ O Emissions from Biomass Burning in Grassland (MMT CO ₂ Eq.)	6-71
Table 6-40: CH ₄ , N ₂ O, CO, and NO _x Emissions from Biomass Burning in Grassland (kt)	6-71
Table 6-41: Thousands of Grassland Hectares Burned Annually	6-72
Table 6-42: Uncertainty Estimates for Non-CO ₂ Greenhouse Gas Emissions from Biomass Burning in Grassland (MMT CO ₂ Eq. and Percent)	6-73
Table 6-43: Net CO ₂ Flux from Soil, Dead Organic Matter and Biomass C Stock Changes for <i>Land Converted to Grassland</i> (MMT CO ₂ Eq.)	6-74
Table 6-44: Net CO ₂ Flux from Soil, Dead Organic Matter and Biomass C Stock Changes for <i>Land Converted to Grassland</i> (MMT C).....	6-75
Table 6-45: Approach 2 Quantitative Uncertainty Estimates for Soil, Dead Organic Matter and Biomass C Stock Changes occurring within <i>Land Converted to Grassland</i> (MMT CO ₂ Eq. and Percent).....	6-78
Table 6-46: Emissions from <i>Peatlands Remaining Peatlands</i> (MMT CO ₂ Eq.)	6-81
Table 6-47: Emissions from <i>Peatlands Remaining Peatlands</i> (kt).....	6-81
Table 6-48: Peat Production of Lower 48 States (kt).....	6-83

Table 6-49: Peat Production of Alaska (Thousand Cubic Meters)	6-83
Table 6-50: Peat Production Area (Hectares)	6-83
Table 6-51: Approach 2 Quantitative Uncertainty Estimates for CO ₂ , CH ₄ , and N ₂ O Emissions from <i>Peatlands Remaining Peatlands</i> (MMT CO ₂ Eq. and Percent)	6-85
Table 6-52: CO ₂ Flux from C Stock Changes in <i>Vegetated Coastal Wetlands Remaining Vegetated Coastal Wetlands</i> (MMT CO ₂ Eq.).....	6-87
Table 6-53: CO ₂ Flux from C Stock Changes in <i>Vegetated Coastal Wetlands Remaining Vegetated Coastal Wetlands</i> (MMT C)	6-88
Table 6-54: CH ₄ Emissions from <i>Vegetated Coastal Wetlands Remaining Vegetated Coastal Wetlands</i> (MMT CO ₂ Eq. and kt CH ₄).....	6-88
Table 6-55: Approach 1 Quantitative Uncertainty Estimates for C Stock Changes and CH ₄ Emissions occurring within <i>Vegetated Coastal Wetlands Remaining Vegetated Coastal Wetlands</i> (MMT CO ₂ Eq. and Percent).....	6-89
Table 6-56: CO ₂ Flux from C Stock Changes in <i>Vegetated Coastal Wetlands Converted to Unvegetated Open Water Coastal Wetlands</i> (MMT CO ₂ Eq.).....	6-91
Table 6-57: CO ₂ Flux from C Stock Changes in <i>Vegetated Coastal Wetlands Converted to Unvegetated Open Water Coastal Wetlands</i> (MMT C)	6-91
Table 6-58: Approach 1 Quantitative Uncertainty Estimates for CO ₂ Flux Occurring within <i>Vegetated Coastal Wetlands Converted to Unvegetated Open Water Coastal Wetlands</i> (MMT CO ₂ Eq. and Percent)	6-92
Table 6-59: CO ₂ Flux from C Stock Changes from <i>Unvegetated Open Water Coastal Wetlands Converted to Vegetated Coastal Wetlands</i> (MMT CO ₂ Eq.).....	6-94
Table 6-60: CO ₂ Flux from C Stock Changes from <i>Unvegetated Open Water Coastal Wetlands Converted to Vegetated Coastal Wetlands</i> (MMT C)	6-94
Table 6-61: Approach 1 Quantitative Uncertainty Estimates for C Stock Changes Occurring within <i>Unvegetated Open Water Coastal Wetlands Converted to Vegetated Coastal Wetlands</i> (MMT CO ₂ Eq. and Percent)	6-95
Table 6-62: N ₂ O Emissions from Aquaculture in Coastal Wetlands (MMT CO ₂ Eq.).....	6-96
Table 6-63: Approach 1 Quantitative Uncertainty Estimates for N ₂ O Emissions for Aquaculture Production in Coastal Wetlands (MMT CO ₂ Eq. and Percent)	6-97
Table 6-64: CO ₂ Flux from C Stock Changes in <i>Land Converted to Vegetated Coastal Wetlands</i> (MMT CO ₂ Eq.) 6-98	
Table 6-65: CO ₂ Flux from C Stock Changes in <i>Land Converted to Vegetated Coastal Wetlands</i> (MMT C).....	6-98
Table 6-66: CH ₄ Emissions from <i>Land Converted to Vegetated Coastal Wetlands</i> (MMT CO ₂ Eq. and kt CH ₄). 6-98	
Table 6-67: Approach 1 Quantitative Uncertainty Estimates for C Stock Changes occurring within <i>Land Converted to Vegetated Coastal Wetlands</i> (MMT CO ₂ Eq. and Percent)	6-100
Table 6-68: Net CO ₂ Flux from Soil C Stock Changes in <i>Settlements Remaining Settlements</i> (MMT CO ₂ Eq.). 6-102	
Table 6-69: Net CO ₂ Flux from Soil C Stock Changes in <i>Settlements Remaining Settlements</i> (MMT C)	6-102
Table 6-70: Thousands of Hectares of Drained Organic Soils in <i>Settlements Remaining Settlements</i>	6-102
Table 6-71: Uncertainty Estimates for CO ₂ Emissions from Drained Organic Soils in <i>Settlements Remaining Settlements</i> (MMT CO ₂ Eq. and Percent)	6-103
Table 6-72: Net C Flux from Settlement Trees (MMT CO ₂ Eq. and MMT C)	6-104
Table 6-73: Carbon Storage (kg C/m ² tree cover), Gross and Net Sequestration (kg C/m ² tree cover/year) and Tree Cover (percent) among Sampled U.S. Cities (see Nowak et al. 2013).	6-106

Table 6-74: Estimated Annual C Sequestration (Metric Tons C/Year), Tree Cover (Percent), and Annual C Sequestration per Area of Tree Cover (kg C/m ² / year) for settlement areas in United States by State and the District of Columbia (2017)	6-108
Table 6-75: Approach 2 Quantitative Uncertainty Estimates for Net C Flux from Changes in C Stocks in Settlement Trees (MMT CO ₂ Eq. and Percent)	6-110
Table 6-76: Comparison of Settlement, Developed and Urban Land Area for Conterminous United States	6-110
Table 6-77: N ₂ O Emissions from Soils in <i>Settlements Remaining Settlements</i> (MMT CO ₂ Eq. and kt N ₂ O)	6-112
Table 6-78: Quantitative Uncertainty Estimates of N ₂ O Emissions from Soils in <i>Settlements Remaining Settlements</i> (MMT CO ₂ Eq. and Percent)	6-114
Table 6-79: Net Changes in Yard Trimmings and Food Scrap Carbon Stocks in Landfills (MMT CO ₂ Eq.).....	6-116
Table 6-80: Net Changes in Yard Trimmings and Food Scrap Carbon Stocks in Landfills (MMT C)	6-116
Table 6-81: Moisture Contents, C Storage Factors (Proportions of Initial C Sequestered), Initial C Contents, and Decay Rates for Yard Trimmings and Food Scraps in Landfills	6-118
Table 6-82: C Stocks in Yard Trimmings and Food Scraps in Landfills (MMT C)	6-119
Table 6-83: Approach 2 Quantitative Uncertainty Estimates for CO ₂ Flux from Yard Trimmings and Food Scraps in Landfills (MMT CO ₂ Eq. and Percent).....	6-119
Table 6-84: Net CO ₂ Flux from Soil, Dead Organic Matter and Biomass C Stock Changes for <i>Land Converted to Settlements</i> (MMT CO ₂ Eq.).....	6-121
Table 6-85: Net CO ₂ Flux from Soil, Dead Organic Matter and Biomass C Stock Changes for <i>Land Converted to Settlements</i> (MMT C)	6-122
Table 6-86: Approach 2 Quantitative Uncertainty Estimates for Soil, Dead Organic Matter and Biomass C Stock Changes occurring within <i>Land Converted to Settlements</i> (MMT CO ₂ Eq. and Percent)	6-124
Table 7-1: Emissions from Waste (MMT CO ₂ Eq.)	7-1
Table 7-2: Emissions from Waste (kt)	7-2
Table 7-3: CH ₄ Emissions from Landfills (MMT CO ₂ Eq.)	7-5
Table 7-4: CH ₄ Emissions from Landfills (kt).....	7-5
Table 7-5: Approach 2 Quantitative Uncertainty Estimates for CH ₄ Emissions from Landfills (MMT CO ₂ Eq. and Percent).....	7-13
Table 7-6: Materials Discarded ^a in the Municipal Waste Stream by Waste Type from 1990 to 2015 (Percent) ^b ..	7-17
Table 7-7: CH ₄ and N ₂ O Emissions from Domestic and Industrial Wastewater Treatment (MMT CO ₂ Eq.).....	7-20
Table 7-8: CH ₄ and N ₂ O Emissions from Domestic and Industrial Wastewater Treatment (kt)	7-20
Table 7-9: U.S. Population (Millions) and Domestic Wastewater BOD ₅ Produced (kt)	7-23
Table 7-10: Domestic Wastewater CH ₄ Emissions from Septic and Centralized Systems (2017, MMT CO ₂ Eq. and Percent).....	7-23
Table 7-11: Industrial Wastewater CH ₄ Emissions by Sector (2017, MMT CO ₂ Eq. and Percent).....	7-24
Table 7-12: U.S. Pulp and Paper, Meat, Poultry, Vegetables, Fruits and Juices, Ethanol, Breweries, and Petroleum Refining Production (MMT).....	7-24
Table 7-13: Variables Used to Calculate Percent Wastewater Treated Anaerobically by Industry (Percent)	7-25
Table 7-14: Wastewater Flow (m ³ /ton) and BOD Production (g/L) for U.S. Vegetables, Fruits, and Juices Production.....	7-27
Table 7-15: Wastewater Treatment Distribution for Breweries.....	7-29

Table 7-16: U.S. Population (Millions), Population Served by Biological Denitrification (Millions), Fraction of Population Served by Wastewater Treatment (percent), Available Protein (kg/person-year), Protein Consumed (kg/person-year), and Nitrogen Removed with Sludge (kt-N/year).....	7-32
Table 7-17: Approach 2 Quantitative Uncertainty Estimates for CH ₄ Emissions from Wastewater Treatment (MMT CO ₂ Eq. and Percent).....	7-33
Table 7-18: CH ₄ and N ₂ O Emissions from Composting (MMT CO ₂ Eq.)	7-36
Table 7-19: CH ₄ and N ₂ O Emissions from Composting (kt).....	7-36
Table 7-20: U.S. Waste Composted (kt).....	7-36
Table 7-21: Tier 1 Quantitative Uncertainty Estimates for Emissions from Composting (MMT CO ₂ Eq. and Percent)	7-37
Table 7-22: Emissions of NO _x , CO, and NMVOC from Waste (kt).....	7-38
Table 9-1: Revisions to U.S. Greenhouse Gas Emissions (MMT CO ₂ Eq.).....	9-3
Table 9-2: Revisions to U.S. Greenhouse Gas Emissions and Removals (Net Flux) from Land Use, Land-Use Change, and Forestry (MMT CO ₂ Eq.).....	9-5

Figures

Figure ES-1: Gross U.S. Greenhouse Gas Emissions by Gas (MMT CO ₂ Eq.)	ES-4
Figure ES-2: Annual Percent Change in Gross U.S. Greenhouse Gas Emissions Relative to the Previous Year ..	ES-5
Figure ES-3: Cumulative Change in Annual Gross U.S. Greenhouse Gas Emissions Relative to 1990 (1990=0, MMT CO ₂ Eq.).....	ES-5
Figure ES-4: 2017 U.S. Greenhouse Gas Emissions by Gas (Percentages based on MMT CO ₂ Eq.).....	ES-9
Figure ES-5: 2017 Sources of CO ₂ Emissions (MMT CO ₂ Eq.)	ES-10
Figure ES-6: 2017 CO ₂ Emissions from Fossil Fuel Combustion by Sector and Fuel Type (MMT CO ₂ Eq.)....	ES-11
Figure ES-7: 2017 End-Use Sector Emissions of CO ₂ from Fossil Fuel Combustion (MMT CO ₂ Eq.)	ES-11
Figure ES-8: Electric Power Generation (Billion kWh) and Emissions (MMT CO ₂ Eq.).....	ES-13
Figure ES-9: 2017 Sources of CH ₄ Emissions (MMT CO ₂ Eq.)	ES-15
Figure ES-10: 2017 Sources of N ₂ O Emissions (MMT CO ₂ Eq.)	ES-16
Figure ES-11: 2017 Sources of HFCs, PFCs, SF ₆ , and NF ₃ Emissions (MMT CO ₂ Eq.).....	ES-17
Figure ES-12: U.S. Greenhouse Gas Emissions and Sinks by Chapter/IPCC Sector (MMT CO ₂ Eq.).....	ES-18
Figure ES-13: 2017 U.S. Energy Consumption by Energy Source (Percent).....	ES-20
Figure ES-14: U.S. Greenhouse Gas Emissions Allocated to Economic Sectors (MMT CO ₂ Eq.).....	ES-23
Figure ES-15: U.S. Greenhouse Gas Emissions with Electricity-Related Emissions Distributed to Economic Sectors (MMT CO ₂ Eq.).....	ES-25
Figure ES-16: U.S. Greenhouse Gas Emissions Per Capita and Per Dollar of Gross Domestic Product (GDP)..	ES-26
Figure ES-17: 2017 Key Categories (MMT CO ₂ Eq.) ^a	ES-28
Figure 1-1: National Inventory Arrangements Diagram Inventory Process Inventory Process	1-12
Figure 1-2: U.S. QA/QC Plan Summary	1-22
Figure 2-1: Gross U.S. Greenhouse Gas Emissions by Gas (MMT CO ₂ Eq.)	2-1
Figure 2-2: Annual Percent Change in Gross U.S. Greenhouse Gas Emissions Relative to the Previous Year ..	2-2

Figure 2-3: Cumulative Change in Annual Gross U.S. Greenhouse Gas Emissions Relative to 1990 (1990=0, MMT CO ₂ Eq.)	2-2
Figure 2-4: U.S. Greenhouse Gas Emissions and Sinks by Chapter/IPCC Sector (MMT CO ₂ Eq.)	2-7
Figure 2-5: 2017 Energy Chapter Greenhouse Gas Sources (MMT CO ₂ Eq.)	2-9
Figure 2-6: 2017 U.S. Fossil Carbon Flows (MMT CO ₂ Eq.)	2-10
Figure 2-7: 2017 CO ₂ Emissions from Fossil Fuel Combustion by Sector and Fuel Type (MMT CO ₂ Eq.)	2-13
Figure 2-8: 2017 End-Use Sector Emissions of CO ₂ from Fossil Fuel Combustion (MMT CO ₂ Eq.)	2-13
Figure 2-9: Electric Power Generation (Billion kWh) and Emissions (MMT CO ₂ Eq.)	2-14
Figure 2-10: 2017 Industrial Processes and Product Use Chapter Greenhouse Gas Sources (MMT CO ₂ Eq.)	2-16
Figure 2-11: 2017 Agriculture Chapter Greenhouse Gas Sources (MMT CO ₂ Eq.)	2-18
Figure 2-12: 2017 LULUCF Chapter Greenhouse Gas Sources and Sinks (MMT CO ₂ Eq.)	2-20
Figure 2-13: 2017 Waste Chapter Greenhouse Gas Sources (MMT CO ₂ Eq.)	2-22
Figure 2-14: U.S. Greenhouse Gas Emissions Allocated to Economic Sectors (MMT CO ₂ Eq.)	2-24
Figure 2-15: U.S. Greenhouse Gas Emissions with Electricity-Related Emissions Distributed to Economic Sectors (MMT CO ₂ Eq.)	2-27
Figure 2-16: U.S. Greenhouse Gas Emissions Per Capita and Per Dollar of Gross Domestic Product	2-34
Figure 3-1: 2017 Energy Chapter Greenhouse Gas Sources (MMT CO ₂ Eq.)	3-1
Figure 3-2: 2017 U.S. Fossil Carbon Flows (MMT CO ₂ Eq.)	3-2
Figure 3-3: 2017 U.S. Energy Use by Energy Source (Percent)	3-8
Figure 3-4: U.S. Energy Use (Quadrillion Btu)	3-8
Figure 3-5: 2017 CO ₂ Emissions from Fossil Fuel Combustion by Sector and Fuel Type (MMT CO ₂ Eq.)	3-9
Figure 3-6: Annual Deviations from Normal Heating Degree Days for the United States (1950–2017, Index Normal = 100)	3-10
Figure 3-7: Annual Deviations from Normal Cooling Degree Days for the United States (1950–2017, Index Normal = 100)	3-10
Figure 3-8: Fuels Used in Electric Power Generation (TBtu) and Total Electric Power Sector CO ₂ Emissions	3-16
Figure 3-9: Electric Power Retail Sales by End-Use Sector (Billion kWh)	3-16
Figure 3-10: Industrial Production Indices (Index 2012=100)	3-18
Figure 3-11: Fuels Used in Residential and Commercial Sectors (TBtu), Heating Degree Days, and Total Sector CO ₂ Emissions	3-19
Figure 3-12: Fuels Used in Transportation Sector (TBtu), Onroad VMT, and Total Sector CO ₂ Emissions	3-21
Figure 3-13: Sales-Weighted Fuel Economy of New Passenger Cars and Light-Duty Trucks, 1990–2017 (miles/gallon)	3-22
Figure 3-14: Sales of New Passenger Cars and Light-Duty Trucks, 1990–2017 (Percent)	3-23
Figure 3-15: Mobile Source CH ₄ and N ₂ O Emissions (MMT CO ₂ Eq.)	3-26
Figure 3-16: U.S. Energy Consumption and Energy-Related CO ₂ Emissions Per Capita and Per Dollar GDP	3-33
Figure 4-1: 2017 Industrial Processes and Product Use Chapter Greenhouse Gas Sources (MMT CO ₂ Eq.)	4-2
Figure 4-2: U.S. HFC Consumption (MMT CO ₂ Eq.)	4-118
Figure 5-1: 2017 Agriculture Chapter Greenhouse Gas Emission Sources (MMT CO ₂ Eq.)	5-1

Figure 5-2: Annual CH ₄ Emissions from Rice Cultivation, 2012 (MMT CO ₂ Eq./Year).....	5-19
Figure 5-3: Sources and Pathways of N that Result in N ₂ O Emissions from Agricultural Soil Management	5-24
Figure 5-4: Crops, 2012 Annual Direct N ₂ O Emissions Estimated Using the Tier 3 DAYCENT Model (MMT CO ₂ Eq./year)	5-27
Figure 5-5: Grasslands, 2012 Annual Direct N ₂ O Emissions Estimated Using the Tier 3 DAYCENT Model (MMT CO ₂ Eq./year).....	5-28
Figure 5-6: Crops, 2012 Annual Indirect N ₂ O Emissions from Volatilization Using the Tier 3 DAYCENT Model (MMT CO ₂ Eq./year).....	5-29
Figure 5-7: Grasslands, 2012 Annual Indirect N ₂ O Emissions from Volatilization Using the Tier 3 DAYCENT Model (MMT CO ₂ Eq./year)	5-30
Figure 5-8: Crops, 2012 Annual Indirect N ₂ O Emissions from Leaching and Runoff Using the Tier 3 DAYCENT Model (MMT CO ₂ Eq./year)	5-31
Figure 5-9: Grasslands, 2012 Annual Indirect N ₂ O Emissions from Leaching and Runoff Using the Tier 3 DAYCENT Model (MMT CO ₂ Eq./year)	5-32
Figure 5-10: Comparison of Measured Emissions at Field Sites and Modeled Emissions Using the DAYCENT Simulation Model and IPCC Tier 1 Approach (kg N ₂ O per ha per year)	5-41
Figure 6-1: 2017 LULUCF Chapter Greenhouse Gas Sources and Sinks (MMT CO ₂ Eq.).....	6-4
Figure 6-2: Percent of Total Land Area for Each State in the General Land-Use Categories for 2017.....	6-12
Figure 6-3: Changes in Forest Area by Region for <i>Forest Land Remaining Forest Land</i> in the conterminous United States and Alaska (1990-2017, Million Hectares)	6-25
Figure 6-4: Estimated Net Annual Changes in C Stocks for All C Pools in <i>Forest Land Remaining Forest Land</i> in the Conterminous U.S. and Alaska (1990-2017, MMT C per Year)	6-28
Figure 6-5: Total Net Annual Soil C Stock Changes for Mineral Soils under Agricultural Management within States, 2012, <i>Cropland Remaining Cropland</i>	6-52
Figure 6-6: Total Net Annual Soil C Stock Changes for Organic Soils under Agricultural Management within States, 2012, <i>Cropland Remaining Cropland</i>	6-53
Figure 6-7: Total Net Annual Soil C Stock Changes for Mineral Soils under Agricultural Management within States, 2012, <i>Grassland Remaining Grassland</i>	6-67
Figure 6-8: Total Net Annual Soil C Stock Changes for Organic Soils under Agricultural Management within States, 2012, <i>Grassland Remaining Grassland</i>	6-67
Figure 7-1: 2017 Waste Chapter Greenhouse Gas Sources (MMT CO ₂ Eq.).....	7-1
Figure 7-2: Management of Municipal Solid Waste in the United States, 2015.....	7-16
Figure 7-3: MSW Management Trends from 1990 to 2015	7-17
Figure 7-4: Percent of Degradable Materials Diverted from Landfills from 1990 to 2015 (Percent).....	7-18

Boxes

Box ES-1: Methodological Approach for Estimating and Reporting U.S. Emissions and Removals	ES-1
Box ES-2: EPA's Greenhouse Gas Reporting Program	ES-2
Box ES-3: Improvements and Recalculations Relative to the Previous Inventory	ES-5
Box ES-4: Use of Ambient Measurements Systems for Validation of Emission Inventories	ES-14
Box ES-5: Recent Trends in Various U.S. Greenhouse Gas Emissions-Related Data	ES-25

Box 1-1: Methodological Approach for Estimating and Reporting U.S. Emissions and Removals	1-2
Box 1-2: The <i>IPCC Fifth Assessment Report</i> and Global Warming Potentials	1-9
Box 1-3: IPCC Reference Approach	1-16
Box 2-1: Methodology for Aggregating Emissions by Economic Sector.....	2-32
Box 2-2: Recent Trends in Various U.S. Greenhouse Gas Emissions-Related Data.....	2-33
Box 2-3: Sources and Effects of Sulfur Dioxide	2-36
Box 3-1: Methodological Approach for Estimating and Reporting U.S. Emissions and Removals.....	3-4
Box 3-2: Energy Data from EPA's Greenhouse Gas Reporting Program	3-4
Box 3-3: Weather and Non-Fossil Energy Effects on CO ₂ from Fossil Fuel Combustion Trends	3-9
Box 3-4: Uses of Greenhouse Gas Reporting Program Data and Improvements in Reporting Emissions from Industrial Sector Fossil Fuel Combustion.....	3-31
Box 3-5: Carbon Intensity of U.S. Energy Consumption	3-31
Box 3-6: Reporting of Lubricants, Waxes, and Asphalt and Road Oil Product Use in Energy Sector.....	3-50
Box 3-7: Carbon Dioxide Transport, Injection, and Geological Storage	3-79
Box 4-1: Methodological Approach for Estimating and Reporting U.S. Emissions and Removals.....	4-6
Box 4-2: Industrial Processes Data from EPA's Greenhouse Gas Reporting Program	4-7
Box 5-1: Methodological Approach for Estimating and Reporting U.S. Emissions and Removals	5-2
Box 5-2: Surrogate Data Method.....	5-21
Box 5-3: Tier 1 vs. Tier 3 Approach for Estimating N ₂ O Emissions	5-33
Box 5-4: Surrogate Data Method.....	5-34
Box 5-5: Comparison of the Tier 2 U.S. Inventory Approach and IPCC (2006) Default Approach	5-43
Box 5-6: Comparison of Tier 2 U.S. Inventory Approach and IPCC (2006) Default Approach	5-50
Box 6-1: Methodological Approach for Estimating and Reporting U.S. Emissions and Removals.....	6-7
Box 6-2: Preliminary Estimates of Land Use in U.S. Territories	6-21
Box 6-3: CO ₂ Emissions from Forest Fires	6-28
Box 6-4: Surrogate Data Method.....	6-54
Box 6-5: Tier 3 Approach for Soil C Stocks Compared to Tier 1 or 2 Approaches	6-55
Box 6-6: Grassland Woody Biomass Analysis.....	6-71
Box 7-1: Methodological Approach for Estimating and Reporting U.S. Emissions and Removals	7-2
Box 7-2: Waste Data from EPA's Greenhouse Gas Reporting Program.....	7-2
Box 7-3: Nationwide Municipal Solid Waste Data Sources	7-15
Box 7-4: Overview of the Waste Sector	7-16
Box 7-5: Description of a Modern, Managed Landfill	7-18